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REVISED

PROCEDURES FOR PREPARING EMISSION FACTOR DOCUMENTS

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CHAPTER 1

PURPOSE OF THIS DOCUMENT

The purposes of this document are to describe the procedures, technical criteria, and standards and specifications for developing and reporting air pollutant emission factors or equations for publication in either the *Compilation Of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources,* (AP-42) or the *Locating and Estimating Air Toxic Emissions from (or of) (Source Category of Substance)* (L&E) document series. Both AP-42 Volume I and the L&E series are published by the Emission Factor and Inventory Group (EFIG) in EPA's Office of Air Quality Planning and Standards (OAQPS). The procedures in this document may be different than those described for AP-42 *Volume II: Mobile Sources,* produced by EPA's Office of Mobile Sources in Ann Arbor, Michigan.

Previous editions of this manual have served as a guide for EPA personnel and their contractors preparing AP-42 sections. This edition has been revised to include guidance for preparing L&E documents and to assist industry, trade associations, and state and local agencies that may be involved in developing or revising emission factors or equations. Guidance has also been added to describe how to report the factors developed for AP-42 or an L&E document into EPA's electronic distribution mechanisms. The material in this document is intended as guidance that should be followed when practicable .

Emission factors have long been used as a cost-effective means to develop area-wide emission inventories. Emission inventories are fundamental tools for air quality management. They are used for identifying major contributors of atmospheric pollutants, developing emission control strategies, determining applicability of permitting programs, and other related applications by an array of users including federal, State, and local agencies, consultants, and industry.

AP-42 has been published since 1972 as the primary compilation of EPA's emission factor information. It contains emission factors and process information for more than 200 air pollution source categories. A source category is a specific industry sector or group of similar emitting sources. The emission factors have been developed and compiled from source test data, material balance studies, and engineering estimates. The Fifth Edition of AP-42 was published in January 1995. Supplements to the Fifth Edition will be published approximately annually and will contain new sections on additional source categories as well as revisions to existing sections.

The L&E series was initiated in 1984, and now consists of 36 individual documents. Unlike the source category organization of AP-42, most L&E documents focus on all sources of a specific hazardous air pollutant or related group of pollutants. L&E documents make use of AP-42 emission factors where applicable. and they also revise or supplement those emission factors when necessary to present the most complete assessment of the sources of the specific air pollutant. In addition to providing emission factors and process descriptions, the most recently published L&E documents attempt to quantify the national emissions of the pollutant.

Chapter 2 provides background on emission factors and their uses and limitations. It describes the pollutant terminology used in AP-42 and discusses some of the emission test methods used to measure these pollutants. The reasons and procedures for initiating revisions to emission factors are also discussed.

Chapter 3 provides an overview of the sequential tasks involved in revising or developing emission factors. It describes the update procedures ans discusses EPA's various tools for disseminating information.

Chapter 4 provides the details on how the tasks outlined in Chapter 3 can best be accomplished, from data collection through data evaluation and external reviews, to the determination of final emission factors. Sections are included on typical contents, data collection, data review, developing and presenting emission factors, and background documentation.

Appendix A presents a typical AP-42 section and an L&E document as examples of the editorial specifications to be used. Specifications are given for both the published paper copy and electronic versions of the documents. Appendix B contains EFIG's Public Participation Plan and Appendix C contains a description of using the F-factor method for determining pollutant emission rates using pollutant concentrations in the exhaust stream of a combustion source and the oxygen concentration. Appendix D is a listing of the 188 Hazardous Air Pollutants.

<u>Notice to Users of this Guidance</u> - Section 130 of the 1990 Amendments to the CAA provides for public participation in the development of emission factors. This is discussed further in Appendix B. Since no two emission factor development situations are exactly the same, EPA strongly encourages users of this document to maintain close coordination with EPA and appropriate State/local/Tribal Agencies to ensure that EPA will be able to use their work products. Also, this document will be revised periodically and the user is encouraged to obtain the latest version of this document.

CHAPTER 2

INTRODUCTION TO EMISSION FACTORS

2.1 DEFINITION OF AN EMISSION FACTOR

An emission factor is a tool that is used to estimate air pollutant emissions to the atmosphere. It relates the quantity of pollutants released from a source to some activity associated with those emissions. Emission factors are usually expressed as the weight of pollutant emitted divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., pounds of particulate matter emitted per ton of coal burned). Emission factors are used to estimate a source's emissions by the general equation:

$$E = A \times EF \times [1-(ER/100)]$$

where:

E = emissions,
A = activity rate,
EF = uncontrolled emission factor, and
ER = overall emission reduction efficiency, %.

(ER is the product of the control device destruction or removal efficiency and the capture efficiency of the control system. When estimating emissions for a long time period (e.g., 1 year), both the device and the capture efficiency terms should account for upset periods as well as routine operations.)

In most cases, these emission factors are simply averages of available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category (i.e., a population average). Usually, the available data are insufficient to indicate the influence of various process parameters, such as temperature and reactant concentrations. For a few cases, however, such as in estimating emissions from petroleum storage tanks, the AP-42 document contains empirical formulas (or emission models) that relate emissions to variables such as tank diameter, liquid temperature, and wind velocity. Emission factor formulas that account for the influence of such variables tend to yield more realistic estimates (if information for all variables is accurate) than would emission factors that do not consider those parameters. Emission factor ratings in the AP-42 or L&E document series provide indications of the robustness, or appropriateness, of emission factors for estimating average emissions for a source activity.

2.2 USES AND LIMITATIONS OF EMISSION FACTORS

Emission factors in AP-42 or L&E documents are appropriate to use in developing emission estimates for emission inventories. These inventories have many purposes including ambient dispersion modeling and analysis, control strategy development, and screening of sources for compliance determinations. However, because emission factors represent average emission rates for an entire source category, they are **not** recommended as emission limits or standards for any specific source. Actual test results from source-specific tests or continuous emission monitoring systems (CEMS), when properly done, are more indicative of actual emissions for a specific source. When source-specific information is not available, use of emission factors may be necessary. Whenever AP-42 or L&E emission factors are used, one should be aware of their limitations in accurately representing the emissions from a particular facility, and the risks of using emission factors in such situations should be evaluated against the costs of further testing or analyses.

Before simply applying AP-42 or L&E emission factors to predict emissions from new or planned sources, or to make other source-specific emission assessments, the user should review the latest literature and technology to see how the new technology differs from those of other, typical existing sources. The source type and design, controls, and raw material input in particular should be reviewed. The age of the information and the user's knowledge of the technology advances in the source category should also be considered.

Estimates of short-term or peak (e.g., daily or hourly) emissions for specific sources are often needed for regulatory purposes. Using emission factors to estimate short-term emissions will add further uncertainty to the emission estimate. Short-term emissions from a single specific source often vary significantly with time (i.e., within-source variability) because of fluctuations in process operating conditions, control device operating conditions, raw materials, ambient conditions, and other such factors. Emission factors generally are developed to represent long-term average emissions, so testing is usually conducted at normal operating conditions. Thus, using emission factors to estimate short-term or otherwise atypical emissions will result in even greater uncertainty. The AP-42 and L&E user should be aware of this limitation and should evaluate the possible effects on the particular application.

For some sources, emission factors may be presented for processes having air pollution control equipment in place. Emission factors noted as being for controlled sources do not necessarily reflect the best available or state-of-the-art emissions levels for those control devices, but rather reflect the level of typical control for which data were available at the time the tests were performed.

The fact that an emission factor for a pollutant or process is not available in AP-42 does not necessarily mean that the source does not emit that pollutant or that the source should not be inventoried. It may be simply be that no data for that source category are available for analysis. The question of whether the source likely emits enough of a pollutant to warrant developing an emission estimate by some other method must necessarily be made on a case-by-case basis, taking account of the needs or requirements of the applicable air program.

Some emission factors are determined by using a material balance approach, which may provide reliable average emission estimates for certain sources. For some sources, a material balance may provide a better estimate of emissions than emission tests would. In general, material balances are appropriate for use in situations where a high percentage of material is lost to the atmosphere (e.g., sulfur in fuel, or solvent loss in an uncontrolled coating process.) In contrast, material balances may be inappropriate where material is consumed or chemically combined in the process, or where losses to the atmosphere are a small portion of the total process throughput. As the term implies, one needs to account for all the materials going into and coming out of the process and for the uncertainty of each of the measured variables to make a credible and reliable estimate of emissions.

Figure 2-1 depicts various emission estimation approaches that one should consider when analyzing the tradeoffs between the cost of obtaining the estimates and the quality of the resulting estimates. Note that Figure 2-1 only indicates a typical relationship between cost and reliability and that there is a wide range of reliability possible for any one approach. Typically, using an emission factor to estimate emissions is cheaper than a source test, but the emission estimate may not be as reliable, although an “A-rated” emission factor may be as reliable as a CEMS. Selecting the protocol to be used to estimate source-specific emissions warrants a case-by-case analysis considering the costs and risks in the specific situation. All sources and regulatory agencies should be aware of these risks and costs and should assess them accordingly.

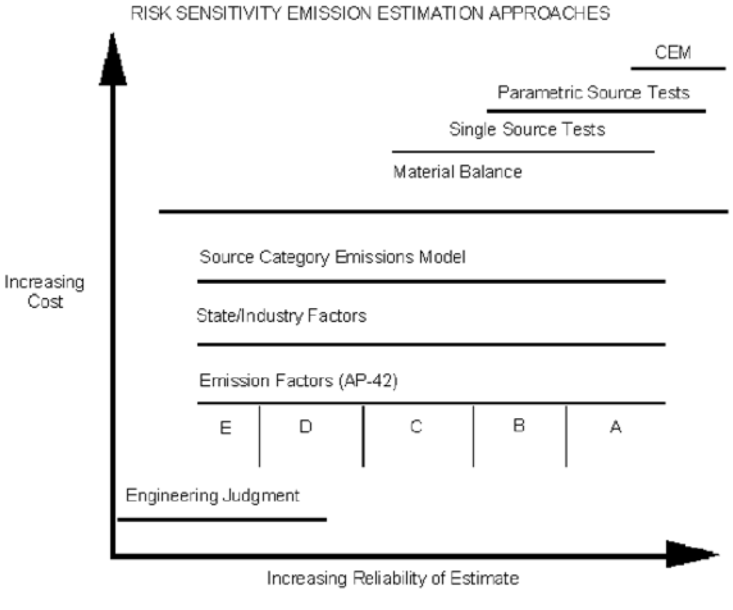


Figure 2-1. Approach to emission estimation.

2.3 VARIABILITY OF EMISSIONS

Average emissions differ significantly from source to source and, therefore, emission factors frequently may not provide adequate estimates of the average emissions for a specific source. The extent of between-source variability that exists, even among similar individual sources, can be large depending on process, control system, and pollutant. Although some of the causes of this variability may be considered in emission factor development, this type of information is seldom included in emission test reports used to develop AP-42 or L&E emission factors. As a result, some emission factors are derived from tests whose results may vary by orders of magnitude. Even when the major process variables are accounted for, the emission factors developed may be the result of averaging source test results that differ significantly.

Air pollution control devices also may cause differing emission characteristics. The design criteria of air pollution control equipment affect the resulting emissions. Design criteria include such items as the type of wet scrubber used, the pressure drop across a scrubber, the plate area of an electrostatic precipitator, and the alkali feed rate to an acid gas scrubber. Often, design criteria are not included in emission test reports (at least not in a form conducive to detailed analysis of how varying process parameters can affect emissions) and therefore may not be accounted for in the resulting emission factors.

In addition to the source-to-source variability discussed above, a single emission source will also exhibit within-source variability. To assess within-source variability and the range of short-term emissions from a source, one needs either a number of tests performed over an extended period of time or continuous monitoring data from an individual source. Generally, material balance data are not likely to be sufficient for assessing short-term emission variability because the accuracy of a material balance is greatly reduced for shorter time intervals. In fact, one of the advantages of a material balance approach is that it averages out all of the short-term fluctuations to provide a good long-term average.

2.4 POLLUTANTS REPRESENTED

The following sections describe the pollutant terminology and conventions typically used in AP-42 and L&E documents, and some of the difficulties in deriving emission factors for those pollutants from the standard methods. .

2.4.1 Pollutant Terminology

The AP-42 document provides emission factors for three main classifications of air pollutants: criteria pollutants and their precursors, hazardous air pollutants (HAPs), and greenhouse gases. Additionally, ammonia and stratospheric ozone depleters are mentioned. The criteria pollutants are the most extensively covered, because they were the original focus of AP-42 and the Agency's regulatory efforts. Emission factors for HAPs and greenhouse gases are being added as resources and available data allow.

Any information on the individual chemical species which make up a pollutant category, such as VOC, particulate matter (PM), or polycyclic organic matter (POM), may be included, even though the quantification may not be as robust as for the total class. When individual compounds that comprise a class are identified (e.g., benzo(a)pyrene, anthracene, etc. as congeners of POM), they should be grouped as subsets of the class for clarity of presentation to the reader and to avoid double counting of emission totals. Information on the split of organic compounds or particulate matter into more specific categories or individual compounds is very useful for some applications and should be included in the documents to the extent possible.

It is often the case that the ideal measure of a pollutant may not be available, or even possible, because of test method or data limitations, costs, or other problems. When such qualifications exist, they should be noted in the document. There may also be some potential overlap in measuring some compounds (e.g., organic condensable PM and VOC). Acknowledgment of this should be noted in the document in either the text or in a footnote to an emission factor table.

Criteria Pollutants and Precursors. The six criteria pollutants are sulfur dioxide, nitrogen oxides, carbon monoxide, lead, particulate matter less than 10 microns in diameter, and ozone (Note that at the time of this printing the EPA is considering changing the basis of the ambient standard from PM10 to PM2.5). Nitrogen oxides, carbon monoxide, and volatile organic compounds (VOC) are considered important because they are precursors of the pollutant ozone. Additionally, ammonia, SO_2, nitrogen oxides, and VOC are also considered precursors of PM.

Sulfur Dioxide (SO_2) - The primary form of sulfur from the combustion of sulfur-containing fossil fuels is sulfur dioxide, SO_2. However, other oxidation states are usually formed as well. Emission factors can be reported separately for SO_2 and SO_3, or a combined emission factor for sulfur oxides (SO_x), can be presented. A combined factor for SO_x should be reported on the basis of the molecular weight of SO_2. This means that an SO_3 emission factor should be multiplied by the ratio of the molecular weights of SO_2 to SO_3 (64/80) before being added to the SO_2 emission factor. Sulfates (SO_4) should be reported separately.

Nitrogen Oxides (NO_x) - Another combustion byproduct is nitrogen oxide (NO). However, several other nitrogen compounds are usually emitted at the same time (nitrogen dioxide (NO_2), nitrous oxide (N_2O), etc.), and these may or may not be distinguishable in available test data. They are usually in a rapid state of flux, with NO_2 being, in the short term, the ultimate product emitted or formed shortly downstream of the stack. The convention followed in emission factor documents is to report the distinctions wherever possible, but to report total NO_x on the basis of the molecular weight of NO_2.

Carbon Monoxide (CO) - Emission factors for CO are straightforward, since there is only one compound involved. The emission factors are reported on the basis of the molecular weight of CO.

Lead (PB) - Lead is emitted and measured as particulate matter and often will be reported for a process both separately and as a component of the particulate matter emission factor. The lead may exist as elemental lead or as lead compounds (considered a HAP). The convention followed in emission factor documents is that the total emissions of lead and lead compounds are expressed as the weight of the elemental lead. Lead compounds can also be reported on the basis of the weight of those compounds if the distinction can be made.

Particulate Matter (PM) - Emission factor documents contain emission factors for various types and sub-types of PM. PM is typically defined by the test method. Total PM refers to the amount of PM collected in EPA Method 5 plus an EPA Method 202 sampling trains. Total filterable PM is the filter catch in the Method 5 train. PM10 refers to the amount of PM that is less than or equal to an aerodynamic diameter of 10 microns, and is usually the sum of the PM collected in EPA Method 201A and 202 sampling trains (Note that the filter catch of 201A is sometimes referred to as “PM10", but is more correctly identified as “filterable PM10"). There is no EPA Reference Method for PM2.5, but inertial size fractionation devices, such as cascade impactors and cyclones, can be used to determine the filterable, or in-stack, portion of PM that is less than an aerodynamic diameter of 2.5 microns. As in the case of PM10, condensable emissions should be added to the in-stack emissions for a total PM2.5 emission rate.

Unless noted, it is reasonable to assume that the PM emission results for processes that operate above ambient temperatures are for filterable particulate matter, as defined by EPA Method 5 or its equivalent (a filter temperature of 250°F). Attempts to differentiate total particulate matter and its subcomponents, are made throughout the L&E and AP-42, where possible. Because of test method and data limitations, and because some sources may not generate such components, the distinction is not always made.

Volatile Organic Compounds (VOC) - Many organic compounds react photochemically along with nitrogen oxides and carbon monoxide to form the criteria pollutant ozone. EPA regulates a class of compounds called VOC defined (in Title 40, Code of Federal Regulations, Part 51.100, February 3, 1992) as "any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric chemical reactions." A number of compounds are deemed to have "negligible photochemical reactivity," and are therefore exempt from the definition of VOC. The list of exempt compounds is occasionally expanded by subsequent Federal Register notices. As of June 1995, the list includes methane, ethane, methylene chloride, methyl chloroform, acetone, many chlorofluorocarbons, and certain classes of perfluorocarbons.

For AP-42 sections, the goal is to present emission factors for VOC as a minimum. Emission Factors for any of the exempted compounds, particularly methane as a greenhouse gas, may also be presented if sufficient data are available. Emission factors for "total organic compounds" (TOC) may also be presented, although not as a substitute for the desired VOC emission factors. TOC is a term used to mean all organics, including non-photoreactive compounds.

In many cases, data are not available to identify and quantify either the total mass of VOC (due to some oxygenated compounds that are not completely measured by many common test methods) or the specific components of TOC which should be subtracted to yield VOC. In such cases, the VOC emission factor is annotated in an effort to provide clear and unambiguous data to the user. It is important for the emission factor document author to note the test method and any assumptions that were used to develop the emission factors.

When possible, report the emission factors in terms of actual weight of the emitted substance. When the actual organic species present in the emissions are unknown, attempt an educated guess at the composition and report as appropriate. If the actual species are unknown and an educated guess is not feasible, calculate the VOC emissions at an assumed molecular weight of 44, and report “as propane”.

Many organic compounds are also HAPs. Where individual HAP species can be quantified, an emission factor representing their individual mass should be developed. This quantity should also be included in the VOC or TOC emission factors, as appropriate.

<u>Hazardous Air Pollutants (HAPs)</u>. Title III of the Clean Air Act Amendments of 1990 lists 188 toxic air pollutants defined for EPA regulatory purposes as HAPs. Appendix D provides a list of these pollutants along with an indication of those in the Urban Air Toxics program (note that many states and other authorities designate additional toxic or hazardous compounds). Although EPA may not have a published reference method for all of these compounds, test methods are available to allow reasonably reliable quantification of many compounds. Emission factors for such compounds should represent the actual total mass of the compounds as emitted, not just the major element's mass (note that many test methods quantify only the major element's mass, such as chromium or mercury). PM and VOC emission factors should include any component species which are also separately identified and quantified as HAPs.

<u>Greenhouse Gases</u>. Carbon dioxide, methane, and nitrous oxide (N_2O) are the principal greenhouse gases being reported in AP-42 in addition to NO_x, VOC, and CO. Each should be reported on the basis of the compound's total molecular weight. Thus, modelers wishing to convert CO_2 inventories given in tons will be correct by assuming a molecular weight of 44. Note that this is not consistent with the convention used in some applications of only accounting for the carbon mass of the emissions. CO_2 emission factors for fuel combustion are usually based on the assumption that essentially all of a fuel's carbon content is converted to $CO_{2.}$ Industrial processes which produce CO_2 emissions only from the combustion of fuel rather than from the chemical reaction of some other raw material do not need to have CO_2 emission factors developed and reported in AP-42, since the emissions could be better estimated from the processes' fuel usage.

2.4.2 Test Methods

Historically, source tests have been the basis for the development of emission factors. EPA has published reference methods for measuring emissions of PM/PM-10, SO_2, NO_x, CO, inorganic lead, and VOC. The reference methods, given in the 40 CFR Part 60, Appendix A, and Part 51, Appendix M, define and describe the test equipment, materials, and procedures to be used in stack tests for the various criteria pollutants. Methods for estimating HAP emissions are published in 40 CFR 61, Appendix B and EPA's SW-846. The EPA publication, *Screening Methods for the Development of Air Toxics Emission Factors*, EPA-450/4-91-021 Sept 91, presents an overview of the use of these reference methods for specific HAPs. For further information, the reader can consult with the Emission Measurement Technical Information Center (EMTIC), which provides technical guidance on stationary source emission testing. Individuals may access EMTIC on the EPA's Technology Transfer BBS (919 541-5742) or the web site (www.epa.gov/oar/ttn-bbs.html) or by calling EMTIC staff directly at (919) 541-0200.

Most of the EPA reference test methods were developed as a result of a standards development project such as for a New Source Performance Standard (NSPS), National Emission Standard for Hazardous Air Pollutant (NESHAP) or Maximum Achievable Control Technology (MACT). The test methods developed for these projects were used as indicators of the level of control achieved when investigated during the standards development effort. Two pollutants where this is most evident are PM and VOCs. Typically, U.S. EPA Method 5 or one of its variants was used to judge whether a facility was meeting the PM standard and Method 25A was used to judge whether a facility was meeting the VOC standard.

In some cases, the source test method is an unbiased estimator of the actual emissions from a process. Some examples of test methods that directly measure actual emissions are the EPA reference test methods for CO, SO_2, and NO_x. The use of continuous emissions monitoring systems (CEMS) for these pollutants will not only provide instantaneous or integrated estimates of emissions but may provide clues as to the inherent variability of the emissions and can provide insight on those process variables that may have a significant impact on the emissions. However, there are cases, such as with VOC and PM, where the test method does not measure the pollutant exactly or only measures subsets of the pollutant. It is up to the developer to be aware of the uses and limitations of test methods.

There are other test methods that do not directly measure the pollutant. This applies to EPA reference test methods as well as others. In many cases, this lack of direct measurement will have to be accepted by the applicant, the permitting authority, and the reviewers, and they will have to recognize the fact that the method is the best that is available. However, often an understanding of the method can overcome shortcomings of the method.

Typically, EPA reference test methods for PM (EPA Methods 17, 5, or 5x) measure only that material that is collected on or ahead of the filter media of the sampling device. The material collected depends upon the temperature at which the filter media are maintained. The filter media of EPA Method 17 is at stack temperature whereas the filter media of EPA Method 5 or 5x is maintained at about 250° F (or the temperature specified in the method). As a result, these test methods only capture the non-gaseous material and do not capture the vaporous material that will condense in the atmosphere. This material is referred to as the filterable particulate matter because it is the material that can be filtered out of the gas stream at the indicated temperature.

EPA Method 17 is similar to EPA Method 5 except that the filter is maintained at the temperature of the flue gas. As a result of this usually higher filter temperature, somewhat less particulate matter is collected than would be in an EPA Method 5 sampling train. Other methods that are similar to Methods 5 and 17 are the PM10 methods, EPA Methods 201 and 201A. These methods measure in-stack PM10 and the difference in these sampling trains is that the probe nozzle is replaced by a cyclone which has a aerodynamic cut size of 10µm. The method requires only that the material collected behind the cyclone up to the filter be recovered and analyzed. Some source testers recover and weigh the material that is collected in and ahead of the cyclone. The summing of this material with the material following the cyclone up to the filter will result in a value similar to EPA Method 17. However, as with EPA Method 17, it may not give the same results as EPA Method 5.

EPA Method 202 will determine the condensible PM emissions and will, when combined with the results of EPA Methods 17, 201 or 201A, or 5, approximate the PM emissions that will exist in the ambient environment. In the Method 202 analysis, the material that is collected in the impingers is extracted with methylene chloride and separated into two fractions; an organic fraction and an aqueous or inorganic fraction.. The organic fraction is evaporated at room temperature and then quantitatively weighed. The water in the aqueous fraction is boiled off to leave the inorganic material which is also quantitatively weighed. By combining all of the portions of quantitatively weighed material, the total particulate matter emissions that would occur in the ambient air can be determined. In combining all of these weighings, it should be noted that there may be errors in combining data from different test methods. For example, the combination of EPA Method 5 data with EPA Method 202 data following an EPA Method 17 sampler would result in greater emissions than may actually occur. This is because some of the material collected in EPA Method 5 would also be collected in the impinger portion following EPA Method 17. This difference becomes greater as the differences between the stack temperature and the EPA Method 5 filter temperature becomes greater and also as the relative amount of condensable material becomes greater.

The test methods that have been used to estimate organic emissions may not determine the actual emissions of the pollutant defined as VOC. The test methods that are available for quantifying organic emissions are EPA Methods 18, 25, and 25A. Each of these test methods measures organic compounds differently. These differences depend upon the basic response factor of the instrument used and on assumptions about the molecular weight of the compounds being determined.

EPA Method 18 has the potential to come the closest to estimating actual emissions of all of the pollutants that are in the gas stream in major quantities. This is because each constituent is separated and quantified individually, allowing the individual constituents molecular weights to be used in quantifying the total mass emitted. If the instrument is correctly calibrated for each of the major species present in the stream, the sum of all of the species can be an accurate measure of VOC or TOC. However, it is often not possible to identify all of the species present and to calibrate for each one. This test method is seldom used because of its complexity of operation and the time required to perform the analysis. Additionally, the test may have been terminated prior to all compounds being measured.

EPA Method 25 separates the methane from the non-methane and converts all of the non-methane organics to methane prior to being analyzed. As a result, the detector only sees methane, so the response factor is constant and the total number of carbon atoms can be accurately determined. However, there is a high minimum detectable limit (50 ppm as carbon) and a potential error is introduced when estimating the total mass of the compounds as emitted because of errors in estimating the number of chlorine, oxygen, hydrogen, or other atoms associated with each carbon atoms. Note that modifications of this method are often used to measure only the non-methane organic compounds. However, ethane and other non-reactive compounds would still he counted by this modified method, leading to an overestimate of VOCs if non-reactive species are present in any significant quantity.

EPA Method 25A is the most commonly used test method for organic emissions. It is used because it can provide continuous emissions measurement once it is set up and its operation is relatively straight-forward. However, the response factors for this method vary for the different compounds that exist in the flue gas. The presence of oxygen or halogens depresses the response. In fact, the method has almost no response to small chlorinated or oxygenated compounds, such as formaldehyde. Therefore, the results of a Method 25A test should be augmented by the amount of any formaldehyde determined by a separate method when developing a VOC emission factor for sources where formaldehyde is present. Because Method 25A does measure methane, ethane, and some other non-reactive compounds, VOCs may be overestimated even when the response factors are corrected for the problem compounds. Thus care should be taken to evaluate what compounds are expected from a source before labeling Method 25A results as “VOC”.

Table 2-1 contains a list of the preferred methodologies, by pollutant, available for determining HAP and criteria pollutant emissions from stack sampling.

2.5 REASONS AND METHODS FOR INITIATING SECTION PREPARATION AND REVISION

The Clean Air Act Amendments of 1990 added greatly to the number of air pollution sources for which emission factor development was required, and also called for the improvement of existing emission factors. This increased emphasis on emission factor availability and quality contributed extensively to the formation of EFIG.

Given this new emphasis on expanding the coverage and quality of emission factors, it is important to rank emission factor needs so that the Agency's limited resources are best applied. Assignment of priorities regarding development or revision of emission factors may be affected by the following:

Table 2-1. RECOMMENDED TEST METHODOLOGIES FOR HAZARDOUS AIR POLLUTANTS AND CRITERIA POLLUTANTS

Pollutant	Test Method
SO_2	EPA Method 6 and CEM Method
NO_x	EPA Method 7 and CEM Method
O_2/CO_2	EPA Method 3 and CEM Method
CO	EPA Method 10B
VOC *	*EPA Methods 25A and 0011 (formaldehyde) or *EPA Method 25
Speciated organics	EPA Methods 18, 0030, and 0010
Metals and metal compounds (including lead)	EPA Method 12
PM, filterable	EPA Methods 5 and 17
PM, condensable (considered ≤ 1 µm in size)	EPA Method 202
PM-10, filterable	EPA Methods 201 and 201A

* . *No test method directly measures VOC unless it is known that the source does not emit formaldehyde or any of the non-photochemically reactive organics. Care should be taken to adjust for these species where they are suspected of being significant.

<u>Outside requests</u> for better source and emission factor information, or for information on a category or pollutant not already addressed. Requests may come from other Groups within OAQPS, EPA laboratories and regional offices, state agencies, trade associations, special interest groups, or private individuals. The requests may take the form of directives, letters, oral inquiries, or comments on published emission factors.

<u>New information</u> developed initially for Emission Standard Division (ESD) background documents involving New Source Performance Standards, Maximum Achievable Control Technologies (MACT), National Emissions Standards For Hazardous Air Pollutants (NESHAP), and Control Techniques Guidelines (CTG), and from reports by various EPA laboratories.

Contractor or consultant expertise on a source category may have developed during previous work, either for EPA or for other clients, and may warrant considering a relatively low-expense update and expansion of available information.

Also, EFIG periodically performs assessments of the source activities covered by the AP-42 and L&E document series and those not included to determine which, if any, source categories warrant future efforts either to update an existing document or to develop a new one. In addition to these possibilities, Section 130 of the Clean Air Act Amendments (related to photochemical pollutants) emphasizes the process through which any party may submit valid information to EFIG for review and publication (see paragraph 2.7).

The tasks of emission factor document preparation have historically been done either by Agency personnel or by a contractor, depending on cost, time, and contractor qualifications, as the EFIG Leader directs. Industry trade groups and industry groups have also been partners with EFIG in developing new factors. These tasks include compilation or generation of data, data evaluation, and preparation of the draft document, as well as EPA review, coordination of outside review, final editing and formatting, and publication. As a results of section 130 of the CAAA, many of these tasks may be performed by an industry group or a State or local agency.

2.6 MECHANISMS FOR INITIATING REVISIONS TO AP-42

2.6.1 Internal Prioritizations/EPA Needs

The AP-42 Team relies on several processes to establish the priorities for selecting the source categories and sections to update or initiate. A prioritization scheme reflecting the impact of the particular source category on national emissions, number of sites, localized problems, and other measures has been used in the past.

2.6.2 State/Local Emission Factor Initiatives

Beginning in the FY 96 budget year, Section 105 funding was identified for possible use by States and local agencies for activities leading to the development and adoption of emission factors. These emission factors may be developed to meet a unique situation within the jurisdiction (customized to meet those specific conditions) or as a special effort to improve emission factors that are utilized by many. The EFIG staff expects to be heavily involved in coordinating and consulting with these activities as they develop and the expectation is that the EFIG staff will actually finalize the incoming revisions in AP-42 or will be the final reviewer and quality assurance for guaranteeing that the information put into AP-42 is correct and complete. One of the major roles of the EFIG staff in this area will be the conduct of these reviews and steering activities to assure that funds spent on development of emission factors is carried out efficiently and with technical integrity, and that they become available to the user community at large.

2.6.3 Industry Initiatives

There has been increased interest and efforts to work jointly with industry, usually a trade association, to develop new and improved emission factors. This process will develop over time, but there is a likelihood that there will be increased efforts on the part of industry to fund testing, propose new emission factors, and even develop proposed new sections for AP-42. Part of the purpose of this document will be to provide a clear understanding between the EPA and industry staffs of their roles and responsibilities (and limits of flexibility) and the steps that must be followed to maintain integrity, believability and realization of needs. This is the area that best addresses the public participation aspects of this work as referred to in Section 130 of the Clean Air Act (1990) and discussed next.

2.7 EPA'S PUBLIC PARTICIPATION PROCEDURES

EPA provides opportunities to participate in establishing, evaluating, and revising emission factors through a public review process. These emission factors are made available for external review and comment before publication. External reviewers include representatives of affected industries and trade associations, state and local air pollution control agencies, and environmental groups. EPA has worked cooperatively with trade associations to gather data in developing emission factors and plans to continue to do so.

EPA's published emission factors are intended to provide an affordable method of estimating emissions, particularly to characterize total emissions of a large geographic area containing many individual facilities. Therefore, these emission factors attempt to represent a typical or average facility or process in a given industry. EPA recognizes that other methods of obtaining emission estimates may be more accurate than industry-average emission factors, and it encourages the use of better methods whenever a source and/or the state or local regulating authority is able to support those methods, which include continuous emission monitoring, source testing, material balances, and engineering calculations.

Anyone with valid information is encouraged to submit data to establish new emission factors, revise existing emission factors, or demonstrate improved emissions estimating techniques. Information may be submitted at any time, regardless of whether a subject source is currently addressed. The Agency encourages all interested parties to take every opportunity to review emission factors and to provide information for factor quality improvement. Specific details on participating in the public review of emission factors appears in *Public Participation Procedures for EPA's Emissions Estimation Guidance Materials*, which appears in Appendix B.

CHAPTER 3

UPDATE PROCEDURES AND INFORMATION FLOW

This chapter provides an overview of the process and the steps required to develop a new, or update an existing, emission factor document. (See Figure 3-1.) A more detailed discussion of how to accomplish these steps is presented in Chapter 4.

3.1 PRELIMINARY DATA SCREENING

A preliminary screening of in-house Emission Factor and Inventory Group (EFIG) information is conducted to determine if an new or update section is warranted. This screening may be triggered by the reasons discussed in section 2.5. This screening involves assembling and reviewing all data in hand and searching for additional available information. This task entails a review of all information in EFIG internal files, including those for AP-42, the Locating and Estimating (L&E) documents, Source Test Information Retrieval System (STIRS), Factor Information Retrieval System (FIRE) and EPA's Air Emissions Species Data Base SPECIATE. Additional information may be available from EPA’s Emission Standards Division, the Office of Research and Development, trade associations, and other sources, as detailed in Section 4.3. After review of this information, a decision is made by the EPA project leader on whether to proceed with the section development or revision or to stop work.

3.2 ADDITIONAL DATA COLLECTION

Following a decision to proceed, a request is made to external organizations to review existing information and to supply any additional data. This request is made to trade association(s) representing the source categories covered, a focused list of state and local agencies and selected environmental interest groups. The industry associations and state and local agencies may be able to contribute process descriptions, source emission tests, and additional information on emission controls.

3.3 DRAFTING DOCUMENTS

Following receipt of additional information, revision of an existing emission factor document or development of a new document is begun. An internal draft is expected in about 6 months unless a significant amount of new information is identified through industry or state and local agency contacts. Existing text should be used if possible, with technical accuracy or editorial inadequacies improved where needed. Extensive information describing the preparation process is given in Chapter 4 of this document.

If an AP-42 section is being drafted or updated, work on the background document discussing all primary references, calculations, and other pertinent information (as well as the related files) is done concurrently. The background document should identify all data, discuss their quality rating(s), and document all decisions on their use. Analyses and any statistical manipulations of the data should also be clearly documented. The background document for a revised section should clearly indicate which emission factors were deleted, revised, or added.

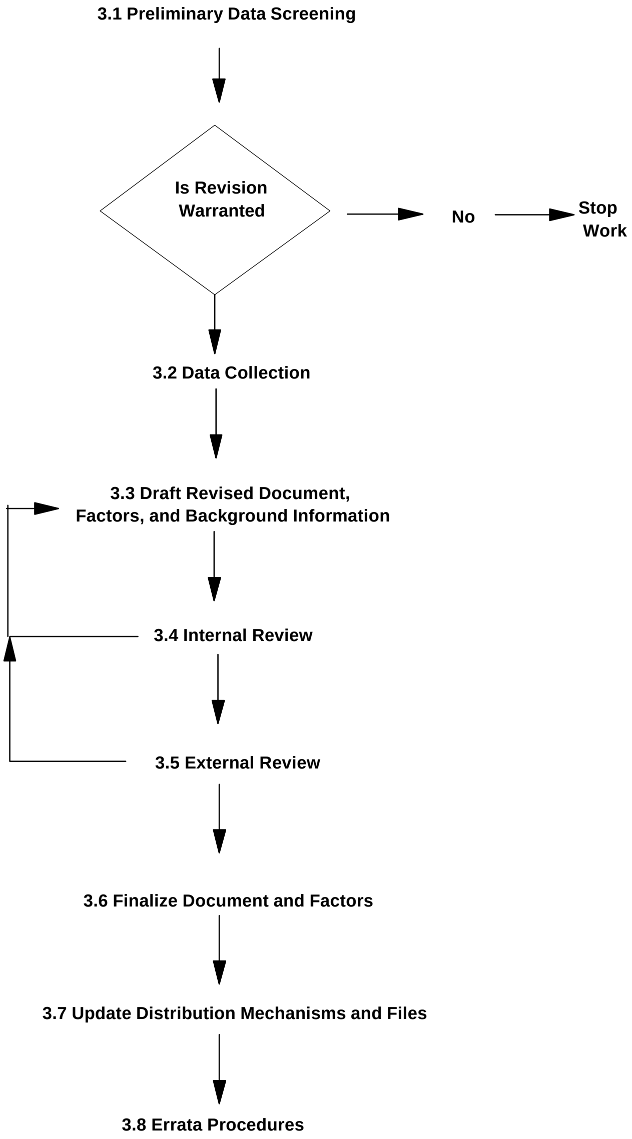


Figure 3-1. Overview of the emission factor document preparation process.

3.4 INTERNAL REVIEW

All documents should be reviewed for clarity, technical accuracy, and thoroughness. The EPA project leader's review should be completed in about 2 weeks and should be followed by distribution for internal review by other relevant Agency personnel. This internal review should be completed in 30 days. The project leader should collect and maintain all comments on this review draft and ensure that all comments are addressed and incorporated within 30 days. After the project leader's review and approval that this draft is technically satisfactory, it is then ready for external review. If the project leader cannot approve a revised draft because of technical deficiencies, then additional drafts, revisions, and reviews may be necessary before proceeding to external review.

3.5 EXTERNAL REVIEW

After internal review is complete, the document is now ready for external review. In general, anyone who supplied technical data for the document is asked to review it. External reviewers should include appropriate representatives of industry, state or local agencies, environmental organizations, and other technical experts who will agree to provide comments.

For external review, the project leader should provide an electronic edition of the revised draft AP-42 section and the revised background document to the Clearinghouse for Inventories and Emission Factors (CHIEF) Sysop for posting on the CHIEF Bulletin Board. The AP-42 electronic section should contain all graphics and tables that are to be part of the paper version. The revised background document should include any files used for the development of the section such as spreadsheets, results and statistical analyses and data bases). A "caution" page should be included as the first page of each draft AP-42 section, emphasizing the fact that this is draft information that is subject to change, and should not be cited, quoted, or used for regulatory purposes. The external review draft is posted only for the purposes of soliciting comments, corrections, and additional data. External review is projected to take about 45 days unless additional review time is approved by the project leader. When significant or extensive changes are made in response to review comments, further review(s) of additional drafts may be necessary and would be accompanied by the appropriate CHIEF Bulletin Board notices.

3.6 FINALIZATION OF DOCUMENT

All external review comments should be sent to the EPA project leader for review and resolution. All revisions necessary to address technical comments should be approved by the EPA project leader. After the approved revisions are incorporated, the final draft document should be reviewed by the EPA project leader to ensure satisfactory resolution and incorporation of all technical comments. Any editorial corrections should be made at this point and the draft is then considered final and ready for distribution. The EPA project leader should produce a final master paper copy from the electronic files in order to ensure that all distributed versions will be consistent and to ensure that the electronic file is complete and usable. The EPA project leader is the responsible authority for distribution of the completed document.

3.7 DISTRIBUTION MECHANISMS

The EPA project leader authorizes final distribution of the document by submitting the electronic file to the CHIEF Sysop and a paper copy, generated from this file, to Info CHIEF for placement on Fax CHIEF. The electronic file will be posted on the CHIEF BBS and will be used for the periodic update of the Air CHIEF CD-ROM and for the publication copy of the next AP-42 supplement.

It is extremely important that all electronic and paper versions of the AP-42 sections agree. Distribution procedures are to be strictly followed to ensure this. L&E documents are ready for publication and distribution when completed and have no annual update cycle like the AP-42; except possibly the updates on the Air CHIEF CD-ROM.

Upon receiving the final, approved electronic file(s) from the project leader, the CHIEF Sysop then notifies the individual(s) responsible for both the Air CHIEF CD-ROM and paper supplements to AP-42 that these updates are complete and ready for updating of the electronic and paper media. The Sysop is responsible for copying the final electronic file of an AP-42 section onto the writable disks that have been specially designated for only final, approved versions of AP-42 sections. The Air CHIEF CD-ROM is used as the archival copy of all the sections of AP-42. The Sysop will maintain master files between printings of the Air CHIEF CD-ROM.

3.7.1 Hard Copy

Individual new or revised AP-42 sections will be held for publication together as a supplement to the Fifth Edition. L&E documents will be printed and made available as they are ready.

Because all items within emission factor documents are to be prepared and made available electronically, including graphics, the hard-copy outputs of the electronic files should be of good quality and satisfactory as camera-ready copy suitable for a printing master.

3.7.2 Fax CHIEF

Fax CHIEF is a fax-on-demand service containing the printed version of all final AP-42 sections, (but not L&E’s). A separate document is maintained on the Fax CHIEF listing all AP-42 sections changed since the last publication of an edition or supplement. Fax CHIEF can be accessed at (919) 541-5626 or 541-0548.

3.7.3 CHIEF Bulletin Board System (BBS)

The CHIEF BBS is an electronic repository of the most up-to-date information on inventories and emission factors, including AP-42 sections, L&E documents, and FIRE. It is accessible on the OAQPS

Technology Transfer Network (TTN), phone number (919) 541-5742.

The CHIEF BBS contains electronic files of the most current versions of final emission factor documents. A separate Errata File (see Section 3.8) is also maintained on the CHIEF BBS. Historical or archival copies of both AP-42 and L&E electronic files will not be maintained on the CHIEF BBS.

For final AP-42 sections, the CHIEF BBS will also be the repository for the electronic files of background information to support the assignment of emission factors and ratings. The background file shall contain the following electronic files:

- The full text of the background document;
- All spreadsheet and data base files used in the development or documentation of information contained in the AP-42 section or background document;
- Graphics files in the native format of the software used to generate those files and any exported format that was necessary to enable retrieval into WordPerfect® Version 6.1 for Windows, and that were used in the AP-42 section contained on the CHIEF BBS or the background document; and
- Any other electronic file designated by the EPA project leader as germane for documentation purposes.

3.7.4 FIRE

The FIRE data base contains emission factors from final, not draft, AP-42 sections and L&E documents that are available at the time of the annual FIRE update. The FIRE project leader is responsible for incorporating any new or revised emission factors from new or updated AP-42 sections or L&E documents into FIRE.

3.7.5 Air CHIEF CD-ROM

The Air CHIEF CD-ROM contains the most recent electronic version of final emission factor documents as of the cutoff date for CD-ROM production. The Air CHIEF CD-ROM will serve as the archival copy of the electronic version of AP-42 sections and L&E documents as new or revised editions are prepared.

3.8 ERRATA PROCEDURES

In the event that errors are detected in a final AP-42 section a notation will be added to the errata file available on the CHIEF BBS. The electronic file should be corrected and the correct version should replace the erroneous version immediately on the CHIEF BBS. The next printed supplement must also contain the corrected copy.

The project leader is responsible for any necessary changes, including updating document footer dates, and preparing notices to be posted on the CHIEF BBS and Fax CHIEF, and *The CHIEF Newsletter*, if deemed necessary. The project leader will notify the CHIEF Sysop of what material on the CHIEF BBS must be revised and will provide the corrected electronic file for the section, in addition to an Errata File notice to be posted on the CHIEF BBS. The project leader will also submit the corrected paper version to update Fax CHIEF. The project leader is responsible for the same reviews for consistency between the electronic and paper versions as in a full, regular update. The project leader must also prepare a memo to be attached to the paper and electronic copies of the background document to record any such revisions.

CHAPTER 4

FACTOR DEVELOPMENT AND PRESENTATION DETAILS

This chapter is intended as a compilation of procedures to be used as a guide for the individuals who prepare or revise emission factor documents to be published as AP-42 sections or Locating and Estimating (L&E) documents. Such new or revised emission factor documents are continually being prepared. Following a standard technical and editorial approach to preparing and revising, these documents will maintain internal consistency within each document and will help to make the information presented in both document series more consistent in format. Since the procedures for AP-42 and the L&E documents are similar, they will be discussed on the same basis hereafter except where specific differences need to be noted.

Format and style specifications for both AP-42 and L&E documents appear in Appendix A and should be reviewed early in the course of preparing a new or revised AP-42 section or L&E document, by both the prospective author and the clerical staff who will produce the final section.

Because the AP-42 and L&E document series contain many sections produced at different times by different authors, uniform reporting and editorial practices are essential. This chapter sets forth standards to be followed in document format and electronic publishing requirements.

4.1 CONTENT AND FORMAT OF A TYPICAL AP-42 SECTION

The typical AP-42 section consists of the following elements:

- General process description, with flow diagram(s) indicating emission points and pollutants,
- Discussion of emissions and any applicable or typical control devices
- Table of emission factors and/or equations for calculating emission factors
- Dated listing of changes since last revision
- List of references

The emission factor table(s), usually presented toward the end of the emission discussion portion of the section, will be the most critical component of the section. The text and flow diagrams explain and qualify the tabulated emission factor data. While the text provides general information on the process and pollutants, users often turn first to the tables to obtain the emission factors. If the tabular information is not clear, the user may then consult the diagram or the text and, if need be, the references. The emission factor table should provide the user with emission factors for a source and should give the user all the information needed to apply the emission factors correctly. The user is assumed to have an engineering or other technical background, to be somewhat familiar with the source operations, and to need information about any qualifications placed on the emission factors. The most important part of an AP-42 section, therefore, is its emission factor table(s), which must be able to stand alone in terms of clear technical content for use by the reasonably well-informed user. The less well informed user is expected to familiarize themselves by reading the text describing the process, sources of emissions and controls employed. A principal point to keep in mind in table preparation is to report emission factors for as many different subcategories within the source activity as reasonably possible. Source Classification Codes (SCCs) should be included in the tables for each emission source.

Footnotes to tables should be provided to explain any and all qualification of emission factors and conversions. These notes may be as brief as a recommendation to read the text before applying a particular emission factor, or as lengthy as necessary to assist with correct emission factor usage.

For a simple process, a flow diagram may not be necessary. When provided, it should be designed to complement the emission factor tables. The same terminology should be used in the table and the diagram. Emission sources not covered in the table, either because the emissions are insignificant or because data are unavailable, should be shown on the flow diagram for the user's information. Detailed process schematics are preferred, instead of simple block diagrams, if they do not detract from the primary purpose of complementing the emission factor table. However, be aware that all schematics and diagrams must be in a certain format, as discussed later, in order to be compatible with the electronic distribution of the final documents..

The process description text explains the flow diagram and gives a general idea of the process. It is not intended to give a complete description of the industry, and may refer the reader to specific references where more information can be obtained, if needed. The emission and controls portion of the text explains the information given in the emission factor table.

The references for an AP-42 or L&E section can be extremely important to a user who wishes to apply an emission factor to a specific source. Although emission factors do not apply to specific sources with absolute accuracy, the additional process characterization and other information found in the references may enable a user to more accurately estimate emissions. A good reference list, including a background document containing basic information, will be quite helpful to the user. The information in any proper reference citation will identify the reference clearly, and provide the reader with sufficient information to obtain a copy.

The single, most important point about the format of any emission factor document is that all elements including, but not limited to, text, tables, figures, diagrams, and reference lists, must be prepared electronically, and the final version must be suitable as a camera-ready master for printing and electronic distribution. The Emission Factor and Inventory Group (EFIG) has designated that the word processing software, WordPerfect® for Windows, be used for all emission factor documents. (Currently, Version 6.1 is recommended.) Any graphic drawings or figures should be prepared in a software, such as Freelance® for Windows, that is compatible for producing a camera-ready master without significant additional effort.

4.2 CONTENT AND FORMAT OF A TYPICAL L&E DOCUMENT

The major purposes of L&E documents are to identify the significant sources of the pollutant of interest and to identify techniques for estimating emissions for these sources. Each L&E document typically begins with an executive summary listing an overview of the primary categories of emissions. This summary should include a table presenting the national emission estimates developed for the predominant categories emitting the pollutant. Due to the evolving nature of toxic air pollutant programs, it is often difficult to develop supportable national emission estimates for all source categories. As new information is developed, the magnitude of the national total emissions will be adjusted as well as the relative rankings of source categories.

The first section, usually entitled "Purpose of Document," states general information about the series of L&E documents and contains a current list of pollutants for which published L&E documents exist and their EPA publication numbers. The remainder of Section 1.0 provides details on any relevant standards, their history and their current status, issued by EPA or possibly other agencies, such as the Occupational Safety and Health Administration (OSHA) or the U.S. Consumer Product Safety Commission, and which may affect emissions of the pollutant of interest. This section concludes with paragraphs advising readers about how to best use the document, cautions about the data, and opportunities for document review and comment as well as providing additional data.

The second section begins with an overview of the entire document, which briefly outlines the main focus of each subsequent section and any appendices. The remainder of Section 2.0 describes the ratings assigned to emission factors and the criteria for assigning these ratings, and also describes the criteria for data quality ratings for source tests from which the emission factors were derived. Chemical and physical property data are typically included in Section 3.0.

The remaining sections may vary and will be structured according to the types of sources and processes that emit the pollutant being addressed. Information such as how the substance is created or prepared for use, or any manufacturing operations in which it is used are discussed. Like AP-42, L&E sections include process flow diagrams, discussion of emissions and controls, and emission factor table(s). Where appropriate, it is acceptable to use the process descriptions from other L&E or AP-42 sections.

The last section in an L&E document prior to the references describes typical sampling and analytical methods for the pollutant in question. The last text section usually lists the references used to prepare the L&E document.

Required appendices include one in which methods for estimating the national emissions are described, and another containing a summary table of all emission factors (by SCC) presented in the L&E document. Details regarding format for L&E documents can be found in Appendix A.

4.3 DATA COLLECTION

The first step in characterizing sources and pollutants for emission factor documents involves a search for and collection of available emissions information associated with the sources or pollutants of interest. The purpose of this effort is to gather current information that can be used to write process descriptions, identify facilities, pollutants, and emission points, and develop emission factors and emission estimates. This information search should include the following sources: (1) current AP-42 background files; (2) technical papers (e.g., trade journals, conference reports); (3) emission factor data bases and bulletin boards; (4) EPA and other federal agency contacts; (5) State and local agency contacts; and (6) industry contacts and trade associations.

4.3.1 AP-42 Background Files

The AP-42 background files are the beginning point for any AP-42 section update effort and should be reviewed for any section being updated. The file contains the background document for the existing section, copies of emission test reports used to establish the emission factors, copies of other emission test reports cited in the background report, as well as copies of other references. The file may also contain recent information or test reports accumulated by various EPA personnel.

4.3.2 Literature Search

A search of technical papers for source test and background information should be conducted for the emission source category or pollutants in question. This search can be conducted by EPA library services. The request for a search from Agency library services should be made directly through the EPA project leader. It should be noted, however, that the EPA search may be limited and may need to be supplemented by additional external searches.

The following references and documents are examples of sources of information that should be reviewed. The project leader should develop a list of the best places to look.

- Background Information Documents (BIDs) for New Source Performance Standards (NSPS) and National Emission Standards for Hazardous Air Pollutants (NESHAP) or Maximum Achievable Control Technology (MACT) standards;

- Locating and Estimating (L&E) documents;

- Control Techniques Guidelines (CTG) documents:
- Control Technology Center (CTC) and EPA’s Office of Research and Development documents;
- References in the National Technical Information Service (NTIS);
- References in the Compendex Plus computerized data file in DIALOG, a computerized bibliographic utility;
- *Kirk-Othmer Encyclopedia of Chemical Technology* (for process information);
- Mannsville *Chemical Products Synopsis*;
- SRI *Directory of Chemical Producers*;
- *Chemical Marketing Reporter: Chemical Profiles*;
- Technical Trade Associations;
- AWMA’s Engineering Manual and Journal Articles;
- University libraries;
- Emission factor reports produced by States or local agencies or Europe and elsewhere;
- Information in AP-42 background files pending review;
- Factor Information REtrieval System (FIRE) data base; and
- State data bases, permit files, and source tests.
- BACT analysis

4.3.3 Emission Factor Data Bases

The following data bases and bulletin boards are sources of emission factors and supporting data. A search of these data bases early in the data collection process can identify data leads and possible sources of information to characterize a particular industry.

- EPA's Factor Information Retrieval (FIRE) System - a consolidation of criteria and HAP emission factors from the AP-42 Fifth Edition, L&E documents, state source test reports, and Aerometric Information Retrieval System (AIRS)-Facility Subsystem (AFS);

- VOC/PM Speciation data base Management System (SPECIATE) - clearinghouse for speciation profiles (not emission factors) for VOCs and PM used primarily for atmospheric modeling;

- Toxic Release Inventory (TRI) data base. Most useful for preparing L&E documents, but it can also help in identifying facilities related to an AP-42 section and it may identify additional toxics being emitted by those facilities;

- National Air Toxics Information Clearinghouse (NATICH) data base;

- Source Test Information Retrieval System (STIRS) - A databse of stack test reports collected from states by the EPA and stored electonically on CD-ROM disks.

- The emissions estimation code in the AIRS data base may identify which States have developed their own emission factor or rely on individual source tests to estimate emissions for the category of interest; and

- Source Characterization Group source test files, including the Test Method Storage and Retrieval (TSAR) data base.

4.3.4 EPA and Other Federal Agency Contacts

Various EPA offices and other Federal Agencies may also be able to provide information characterizing emissions and should be contacted. Potential sources of information include EPA’s Emission Standards Division (ESD), EPA research laboratories, the Department of Energy, the Department of Defense, and the Department of Agriculture.

The ESD of OAQPS is responsible for developing and promulgating regulations for stationary sources of air pollutants. In doing this, ESD produces numerous source test reports, background information documents, and other useful technical reports. ESD reports should be reviewed for data on the industry in question. In addition, EFIG, the CTC, and the EPA’s Air Quality Strategies and Standards Division should be contacted for information that may be pertinent to emissions document development.

Other parts of the Agency, such as the Acid Rain Division of EPA's Office of Air and Radiation, and Climate Change Division of the Office of Policy Planning and Evaluation should be contacted by the project leader in seeking information on a source category.

The EPA laboratories that might provide useful data include the Risk Reduction Engineering Laboratory (RREL) in Cincinnati, the Air Pollution Prevention and Control Division (APPCD) and the National Exposure Research Laboratory (formerly AREAL) in Research Triangle Park (RTP), NC. These laboratories are generally more research oriented than OAQPS, and often develop and report emission data that are usable in emission factor documents.

The EPA Regional Offices can be surveyed for general data and source test reports, if there are reasons to believe such data exist. This information may be especially pertinent when a source category under review is concentrated in a particular Region. Examples would be anthracite coal in Region III, sulfite paper mills in Regions I and X, and bagasse-fired boilers in Regions IV and IX.

Initial requests should be specific. It is helpful to find personnel who have visited the sources being studied and who can offer valuable detailed information on equipment configurations, control devices, emissions, etc., that may not be otherwise available. Avoid recontacting and recollecting the same data already solicited and incorporated into STIRS and other data bases. The project leader should also make the initial contact to other Federal Agencies.

4.3.5 State and Local Agency Contacts

State and local agencies are contacted if a source category is concentrated in certain states, with initial contact made by the project leader. As with the EPA Regions, it is desirable to contact someone who has visited the source types of concern. The Federal Report Act dictates that no more than nine state agencies or private entities may be contacted by EPA or EPA contractors with the same request without an information request approved by the Office of Management and Budget. State agency contacts may be obtained through the respective EPA Regional Offices or STAPPA/ALAPCO. In order to avoid redundancy, make all requests in the context of work already done.

4.3.6 Industry Contacts and Trade Associations

Companies may be contacted to obtain copies of test reports and process information. To select which companies to contact, a list of plants can be compiled from current directories and the companies with the most plants can then be identified. By contacting the headquarters of such companies, requests can be centralized and coordinated and information can be collected on a large number of plants and pollutants. In cases where contacting the major companies would not provide sufficient information, additional companies may be identified.

Occasionally, affected trade associations possess current process information, including successful process modifications, control devices, etc, that may be helpful in developing a section. Whenever possible, these associations should be consulted, especially for comments on the draft version of a section or document. The EFIG maintains a computerized list of potential and past contacts, by section, and their phone numbers and addresses that should be used as a starting point when contacting these associations. Due to the dynamic nature of individuals and organizations, this information is often dated and must be augmented by direct contact with individuals to ensure currency of information. In addition, many relevant trade association are listed in the *National Trade and Professional Associations of the United States* directory.

4.4 DATA EVALUATION AND ANALYSIS

After the data have been collected, the next step is to review and analyze the data to determine which data should be used for the development of emission factors and how that data should be grouped. The analyst must evaluate the validity of individual emission source assessments (source tests, mass balances, etc), how well the tested sources represent the source category as a whole, and whether subdividing the source category is warranted. The results of each assessment must have a data quality rating assigned. A clearly written summary of all data evaluated, any necessary assumptions that were made, and all decisions reached are incorporated into the background report. Both the data that is excluded from eventual use in any emission factor and the data that are used should be described in a concise manner.

4.4.1 Evaluation of Primary and Secondary Data

Emission factors in AP-42 sections and L&E documents are typically based on data obtained from a variety of sources including, but not limited to, published technical papers and reports, documented emission test results, and personal communication. The data obtained may vary from single values to ranges of minimum and maximum values, and even to data from replicated source tests. Some data sources provide complete details about their collection and analysis procedures, while others provide relatively little information in this regard.

Source test reports should be reviewed and summarized for at least the items listed below. The reviewer should also make note of any other items about the facility, test method, or the test report that might have affected the total emissions or the emissions per thruput unit.

- process, feedstock, or fuel type
- plant capacity and operating rate during the test
- control devices and their operating parameters
- the age of the facility and the control devices
- any process or control device upsets during the test
- the pollutants tested for and the test methods used

- any deficiencies and/or deviations in the test procedures
- the number and duration of test runs
- the representativeness of the source tested within its industry
- the completeness of QA/QC documentation

Two EPA publications may be used to assist the reviewer in examining source test reports, *Guidebook: Preparation and Review of Emission Test Reports*, and *Guidebook: Preparation and Review of Site-Specific Test Plans*. These references are designed to acquaint the reader with common protocols employed for source testing, including information on test programs, sampling locations, quality assurance/quality control activities, sampling and analytical procedures, and reporting and data reduction requirements. These guidebooks may be accessed through the Emission Measurement Technical Information Center (EMTIC) on the OAQPS TTN electronic bulletin board, dial up access, (919) 541-5742; internet access http://ttnwww.rtpnc.epa.gov. The reviewer should also be familiar with the EPA reference test methods as well as the pollutant definitions and conventions used in the AP-42 and L&E documents, and with some of the difficulties in deriving emission factors for the pollutants of interest from the available source tests. Section 2.4 describes the pollutant terminology preferred for emission factors and how the available test methods relate to those pollutants.

In reviewing source test reports, the following general criteria can be used to avoid analyzing excessive amounts of data and to ensure that proper data are used in updating emissions documents.

- Emissions data should be obtained from a primary source (i.e., test reports) whenever possible. It is necessary to assess the primary references in order to develop accurate data quality ratings and to ensure that valid assumptions and procedures were followed in calculating the facility's emission rates. Report summaries should not be used, unless no other primary source is available.

- If sufficient data exist, focus efforts on test reports for those technologies and emission controls that are most commonly used in the industry. Processes and controls at some industries change periodically due to market trends, improvements in production efficiency or product quality and pressures to reduce pollution. Test reports that are less than 10 years old are more likely to be representative of the most common technologies and emission controls. However, this may vary depending on the specific industry, so some knowledge of changes in the industry is necessary in deciding how best to use older data. Although efforts should focus on current technologies, information on older technologies is of value for the purpose of tracking historical trends in emissions.

- Source tests where more than one test run was performed at each site are preferred.

- Test reports should contain sufficient detail to evaluate both the testing procedures (e.g., sampling methodologies and test methods used) and the source's operating conditions (e.g., charge rate or thruput data).

- Source test data should normally be used only if the data were obtained under conditions that are representative of operating conditions typically encountered at the source in question.

- The following data are usually excluded from further consideration:

    - Test series reported in units that cannot be converted to the selected reporting units using reasonable assumptions that will not significantly increase the uncertainty of the emissions rate;

    - Test series in which the process or emission source or control device is not clearly identified and described; and

    - Test series in which it is not clear whether the emissions measured were controlled or uncontrolled, or if other emission sources may have contributed to the measurements.

If actual production data for the time period of the test series are not available, production rates for periods of similar operations or an annual average production rate can be used. If such alternative production rate data are used, an attempt should be made to confirm and document that the facility was operating near the alternative production rate. Note that the data quality rating should be reduced if actual production rates for the test period are not available and surrogate methods for determining production are not reliable or are not documented.

For fuel combustion sources, the F-factor method can also be used to determine emission factors from stack concentration data when fuel thruput rates are not available. This method relies on the fact that the CO_2 concentration in the stack can be closely correlated to the heat input rate. The heat content of a fuel is closely related to its carbon content and almost all carbon is converted to CO_2 in an efficient combustor. The F-factor for a specific fuel or fuel type allows a pollutant concentration to be expressed as an emission factor in units of pounds per British Thermal Unit (BTU). For most fuels a conversion to pounds per weight or volume of fuel combusted can be made, if desired, by using an average heat content for the fuel. Appendix C contains a detailed description of how to use the F-factors.

There are also situations where thruput data are not necessary or even desirable for use in an emission factor. The pollutant concentration by itself may be the best way to express an emission factor for the outlet of many control devices and air conveying systems. In such a case, the air flow from the device becomes the thruput.

4.4.2 Assign Data Quality Ratings

After reviewing the test reports, it should be possible to assign a data quality rating to the emission data for each pollutant test series. **The data quality ratings for the individual tests are not to be confused with the overall emission factor ratings**. The data quality ratings are an appraisal of the reliability of the emissions data that will be used later to develop the emission factor. The emission factor rating is an appraisal of the ability of the overall average factor to represent a national annual average emission rate for the source category. Emission factor rating determinations are discussed in Section 4.6.8.

Test data quality is rated A through D, based on the following criteria:

A - Tests are performed by using an EPA reference test method, or when not applicable, a sound methodology. Tests are reported in enough detail for adequate validation, and, raw data are provided that can be used to duplicate the emission results presented in the report.

B - Tests are performed by a generally sound methodology, but lacking enough detail for adequate validation. Data are insufficient to completely duplicate the emission result presented in the report.

C - Tests are based on an unproven or new methodology, or are lacking a significant amount of background information.

D - Tests are based on a generally unacceptable method, but the method may provide an order-of-magnitude value for the source.

The quality rating of test data helps identify good data, even when it is not possible to extract a emission factor representative of a typical source in the category from those data. For example, the data from a given test may be good enough for a data quality rating of "A," but the test may be for a unique feed material, or the production specifications may be either more or less stringent than at the typical facility.

In following the general guidelines discussed above, four specific criteria can be considered to evaluate the emission data to ensure that the data are based on a sound methodology, and documentation provides adequate detail. A test series is initially rated A through D in each of the following four areas.

- <u>Source operation</u>. If the manner in which the source was operated is well documented in the report, and the source was operating within typical parameters during the test, an A rating should be assigned. If the report stated parameters were typical, but lacked detailed information, a B rating is assigned. If there is reason to believe operation was not typical, a C or D rating is assigned.

- Test method and sampling procedures. In developing ratings, the estimated accuracy and precision of the test method as well as the adequacy of the documentation are considered. In general, if a current EPA reference test method, appropriate for the source, was followed, the rating should be higher (A or B). If other methods are used, an assessment is made of their validity. If it is judged that the method was likely to be inaccurate or biased, a lower rating (C or D) is given. A complete report should indicate whether any procedures deviated from standard methods and explain any deviations. If deviations were reported, an evaluation is made of whether these were likely to influence the test results.

- Process information. During testing, many variations I the process can occur without warning and sometimes without being noticed. Such variations can induce wide deviations in sampling results. If a large variation between test run results cannot be explained by information contained in the site test report or from test reports of other sources, the data are suspect and are given a lower rating or excluded. However, it should be recognized that a process may have highly variable emissions and a lower rating may not be appropriate solely on the basis of wide deviations in sampling results.

- Analysis and calculations. Ideally, test reports should contain original raw data sheets and other documentation such as, gas parameters (dscfm, O_2%), calculation sheets, or example calculations describing how the calculated emission results were obtained. If there are data sheets, the nomenclature and equations used are compared with those specified by EPA to establish equivalency. The depth of review of the calculations is dictated by the reviewers' confidence in the ability and conscientiousness of the tester, based on such factors as consistency of results and completeness of other areas of the test report. Reports may indicate that raw data sheets were available but were not included. If the test report is of high quality based on the other criteria, the quality rating should not be lowered due to a lack of data sheets.

An overall emission data quality rating is developed considering the scores on the four criteria. There is no single equation or method for the relative weighting of the factors, because each report presents different issues, and the rating system needs to allow the flexibility to consider the strengths and weaknesses of each test series individually and reach a judgment on the overall rating. The two criteria, (1) the test method and sampling procedures and (2) the process information, should be weighted heavily when reaching this judgement. If either of these two criteria are assigned a low rating, this low rating should be assigned as the overall data quality rating, no matter how complete the other documentation. Because ratings are somewhat subjective, detailed comments describing the rationale for assigning the overall test report rating should be included in the background documentation. The rationale should be explained regardless if there are discrepancies in the tests.

After assigning a preliminary emission data quality rating based on the four criteria, the quality of the production data is considered. Production data quality can affect the emission data quality rating. General guidelines for maintaining or reducing the preliminary data quality rating are described below. The emission data rating may be lowered by as many as three quality levels. However, if the emission data quality is already low (e.g., had a C rating) the lowest rating that can be assigned to the final data is a D. This approach is reasonable because the D rating reflects data that may be in error by an order of magnitude and it is unlikely that production data would affect this significantly. The alternative approach is to exclude the data from use in developing emission factors. The guidelines for reviewing production data and assigning final data quality ratings are the following:

- Do not change preliminary emission data quality rating if production was measured during the test series or during the testing period. (If measured during the testing period but not during the test series, it can reasonably be assumed that the facility continued to operate at the same rate throughout the test period.)

- Reduce quality rating to one level below preliminary emission data rating if production was measured during a different period other than the test period and it can reasonably be assumed that the facility was operated at a similar rate during both periods.

- Reduce quality rating to two levels below preliminary emission data rating if the production data presented in the report is an estimate based an annual production or capacity and the number of hours of operation annually.

- Reduce quality rating to a D rating if production data are based on annual capacity or annual production data, and it is necessary to use assumptions that can not be confirmed in estimating the production rate at the time of the emission test.

4.5 GROUP THE EMISSION DATA

After the individual data points have been reviewed and rated, the data must be grouped into related clusters for which the average emission factors will be developed. It may be straightforward to group the data for industries where similar processes are used by most of the facilities tested, but it is more likely that considerable review and evaluation of the data will be required to group some of the emission points in the source category. The developer should use an understanding of the processes used by the industry and a consideration of the parameters that might significantly affect the emissions to group similar data together. Statistical techniques may be used to refine the initial groupings where there are sufficient data. Examples of some of the criteria to be considered when grouping the data are given below.

- Source Category. Among the test data for the specific source category under review there may be some test data for generic emission sources, such as combustion sources. If the combustion gases do not contact the industry's process material and there is no reason to believe that the combustion equipment used is peculiar to the industry, then the combustion data might be better grouped with a potentially larger data base for combustors in all industries.

- Process Type. In most cases, data from two or more distinct processes used to produce the same product, such as wet and dry processes for cement manufacturing, should be put in separate groups.

- Representativeness of Source. Data from some sources may be considered for a separate grouping based on the facility's size or age. However, such a separation should be verified by a comparison of the data sets as well as consideration of why the size or age of the facility might affect emissions.

- Emission Source. Emission data for primary crushers should not be grouped with emission data from downstream size reduction equipment; smelting furnace emissions should not be grouped with refining furnaces.

- Equipment Design. Direct-fired versus indirect-fired heaters, countercurrent versus parallel flow dryers.

- Operating Conditions. Dryer temperatures, moisture start and end points, batch versus continuous operations, wet scrubber pressure drop, also affect emissions data grouping.

- Raw Material or Fuel Characteristics. Moisture content, sulfur content, hardness, and type of fuel should be considered when grouping emission data. Emission data from different fuel types are not grouped together.

- Control Devices. Do not group emissions data from different control devices together, except where the pollutant emissions are not expected to be affected by those devices. (But note that the comparison of controlled to uncontrolled for the same test series may be extremely useful.) Also note that emissions of some pollutants should be grouped with "uncontrolled" data even though they were measured downstream of a device which controlled other pollutants, such as NO_x or CO after a baghouse.

- Test Method Used. The test method used defines what pollutant was actually measured. For example, do not group Method 25 (NMOC) data with Method 25A (TOC) data unless it can be assumed that the compounds which are not detected by either method are not likely present. Also, a test method may produce different results if run at differing stack temperatures.

The discussion in the next section on handling of data outliers may also be of use in determining if a data point is non-representative due to some of the criteria given above. All data found should be rated, grouped, and identified in the background document. A clear description of what data were grouped together and why should be provided in the background document. Any data which could not be rated or grouped should also be identified in the background document.

4.6 DEVELOP CANDIDATE EMISSION FACTORS AND DRAFT SECTION

After the emissions data have been grouped, the author develops the candidate emission factors that represent each process or grouping. This process may involve eliminating some data from further consideration or converting some data to a different format in order to allow for averaging. It may also involve adjusting some of the grouping choices made earlier, depending on the quantity or quality of data available. In this regard, the author should keep in mind that the goal is not to calculate and present a number of unrelated averages, but to present an internally consistent representation of emission factors, especially when those factors are related. For example, PM-10 emission factors should always be less than or equal to total particulate emission factors, and controlled emission factors should always be less than uncontrolled emission factors. As always, any decisions on how or if any data were used should be clearly documented in the background report. The purpose of this section is not to present a statistical treatise, but merely to describe the conventions and preferences which have been used in developing emission factors. Deviations from these practices are allowable as dictated by the specific situation.

4.6.1 Averaging of Data

An emission factor should represent the expected emissions from a collection of emission sources of a similar type. It can be based on emission source testing, material balance, or engineering analysis, and it can be presented as a simple average or mean, or as a formula which accounts for the significant parameters affecting emissions. The presentation may include additional information on ranges, confidence intervals, and other measures of uncertainty or variability, depending upon the extent of data available. The arithmetic mean is usually used for emission factor development and is the preferred method unless there are strong reasons to use an alternative method.

Before grouping emission factors to develop an average factor for a source category, a single average emission rate for each single source should be determined. Therefore, the results of individual test runs on a given source are reduced to a single emission factor for that source using the arithmetic mean. That means, if multiple tests of the same source are available, they are combined into a single emission factor to represent that source. The average emission factor for the source category is then determined by computing the arithmetic mean of the single emission factors for each source tested. In this way, an emission factor from one facility does not disproportionately affect the average emission factor for the source category.

In some cases, the data available may exhibit characteristics suggesting that a geometric mean is a more appropriate for developing the average emission factor for a source category. Also, there are cases where the median emission factors may be more representative of typical emissions. The rationale for utilizing a geometric mean or median, instead of the arithmetic mean, should be decided with the project leader and the rationale should be documented in the background report. An explanatory footnote should also be added to the emission factor table indicating the method used to develop the emission factor if it was not an arithmetic mean.

Emission factors should be represented as a single value whenever possible, or as a formula where significant effects of other parameters can be quantified. If a formula is presented, it is good practice to also include example calculations of emission factors using the formula, and typical ranges or default values for the variables. An indication of the variability, such as a range of values, may accompany an emission factor if it will contribute to an understanding of the scatter of the data. Any insights into how the range can be further sub-categorized or explained should be included. If necessary and supportable by the data, the author can break the emission source into smaller sub-source types based on age, size, operating temperatures or other parameters, and present separate emission factors rather than ranges for each sub-type.

Confidence intervals can be used to provide valuable information on the uncertainty and variability of emission factor data. However, rarely are there sufficient data to allow valid confidence intervals to be generated. Prudent application of statistical procedures precludes the development and presentation of confidence intervals in emission factor documents unless the following conditions are met:

- the sample of sources from which the emission factor was determined is representative of the total population of such sources;

- the data collected at an individual source are representative of that source (i.e., the source is operating at typical conditions); and

- the measurement method was properly applied at each source tested.

When developing an emission factor, the author should always be sensitive to situations where data are sufficient (probably only when there are about 10 or more data points and they are predominantly rated A or B) for such intervals to be meaningful and valid. When sufficient data are available to develop confidence intervals, the author should provide the resulting confidence interval information in the background document and the AP-42 section or L&E document. Documentation such as data plots (histograms) may be included with the background information if desired.

4.6.2 Combining Tests of Different Quality Ratings

In the emission data review process, individual source tests were each given a data quality rating of A to D (Section 4.4.2 above). In developing the average emission factors from these rated source tests, the author should attempt to develop the most reliable factor by using only the most reliable tests. In the ideal situation, a large number of A-rated source tests for typical sources are reduced to a single value for each individual source by computing the arithmetic mean of each test set. The emission factor is then computed by calculating the arithmetic mean of the individual source values. No B-, C-, or D-rated test sets are used in the calculation of the emission factor, because the number of A-rated tests is sufficient. This ideal method of calculating an emission factor is rarely possible due to the shortage of A-rated data. If the number of A-rated tests is such that the inclusion of B-rated tests would increase the confidence of the emission factor, then B-rated test data are included in the calculation of the average emission factor. It is also possible to include C- or even D-rated test data with the A- and B-rated data in some situations. This should only be done where the number of A- and B-rated tests is so small that the representativeness of those tests is suspect and where the author has determined that the lower-rated tests do not appear to be biased versus the better documented and higher-rated tests. In such a case the inclusion of more tests, even of a lower quality, is warranted because it increases the confidence that the average is representative of the source category as a whole. Unrated ("U") test data are used only when no better data are available, and should not be combined with any rated test data.

4.6.3 Controlled Emission Factors

An effort should be made to obtain and present data for both uncontrolled and controlled emissions in emission estimation documents. Emission factors should be clearly identified as uncontrolled or controlled by a specific control device, either in the table heading or in individual entries in the table. For example, “fabric filter” is a specific control device, while “PM control” is not. One method of showing both controlled and uncontrolled emission factors in a table is to give the process name with its Source Classification Code (SCC) on one line and use indented lines underneath this overall process name to indicate the uncontrolled scenario and each controlled scenario by specifying the control device. (See example AP-42 section in Appendix A.)

If a device that limits or reduces product loss (emissions) is an integral part of a process; the emissions from the process should not be labeled "controlled". However, the emission factor table and the text should describe the standard process equipment in use. Example of such devices are cyclones used to separate products from air in pneumatic conveying systems, cyclones used to recover catalyst in petroleum catalytic crackers, and chillers added to degreasers in order to reduce solvent loss.

The text should present information on applicable control techniques and should reference Control Techniques Guidelines (CTG), Alternative Control Techniques (ACT), New Source Performance Standards (NSPS) Background Information Documents, or other documents that contain details on application of these techniques to the source category. The text should also note if there is a probability of rapid developments in control technology which may alter any typical control efficiencies mentioned in the text.

The information presented should enable the user to estimate both controlled and uncontrolled emissions wherever possible. This may be accomplished by either presenting both the controlled and uncontrolled emission factors, or by presenting only one factor (either controlled or uncontrolled) and providing a default control efficiency. The author should exercise caution and judgement in deciding how to determine and present emission factors and control efficiencies. If both controlled and uncontrolled emission factors are presented, the control efficiency implied by the ratio of the controlled to the uncontrolled source emissions should be reviewed to determine the plausibility of the implied control efficiency. Alternatively, the average control efficiency can be determined and shown explicitly, rather than a controlled emission factor, in cases where tests are available for both pre- and post-control situations on the same sources. Also, the preparer should verify that the process conditions for both controlled and uncontrolled emissions data are comparable.

A limited discussion of the typical range of control efficiencies and the parameters affecting the implied or default emission factor should be included in the Section if the information is available. Note that this discussion of the control efficiencies is generally not necessary for straight-forward applications of traditional control devices.

A basic description of the techniques typically used by industry to control PM/PM-10, VOCs, SO_2, NO_X, CO and HAPs can be found in the following EPA documents:

Control Techniques for Particulate Emissions from Stationary Sources - *Volume I*,
EPA 450/3-81-005a, September 1982

Control Techniques for Particulate Emissions from Stationary Sources- *Volume 2*,
EPA 450/3-81-005b, September 1982

Control Techniques for Sulfur Oxide Emissions from Stationary Sources, EPA 450/3-81-004, April 1981

Control Techniques for Carbon Monoxide Emissions from Stationary Sources, EPA 450/3-79-006, June 1979

Control Techniques for Nitrogen Oxide Emissions from Stationary Sources- Revised - Second Edition, EPA 450/3-83-002, January 1983

Control Techniques for Volatile Organic Compound Emissions from Existing Stationary Sources, EPA 450/2-78-022, May 1978.

Handbook: Control Technologies for Hazardous Air Pollutants (HAP Manual), EPA-625/6-91-014, NTIS # PB92-135904

These documents briefly describe the efficiencies commonly achieved by major types of control devices in current use and describe how to estimate emission reductions of these systems. A computer software program, HAP-PRO, can also be used to estimate control efficiencies of various devices for Hazardous Air Pollutants. This computer software program is available on the OAQPS Technology Transfer Network Bulletin Board in the Control Technologies Center Area.

Some control devices reduce emissions of another pollutant besides the one for which they were designed and intended. This is known as secondary or coincidental control. For example, venturi scrubbers have been known to reduce SO_x and lead emissions as well as particulate matter emissions. There are also cases where the application of controls for one pollutant may slightly increase emissions of another pollutant, such as NO_x controls leading to increased CO or VOC emissions. Secondary control emission reductions should be noted in the text, and, if quantifiable, should be included in the emission factor table or its footnotes.

Tables should be designed or footnoted so that those pollutants not affected by a particular control device are not labeled as "controlled" and do not have an emission factor presented for them unless it is different than the uncontrolled emission factor. For example, SO_x emissions would not be considered "controlled" if the control device were a flare, and the table should reflect that distinction.

4.6.4 Outliers

An outlier is a data point that does not conform to the pattern established by other data. Generally, a suspected outlier is much smaller or larger than the other data points. There are three basic ways an outlier can occur: (1) mistakes in readings, (2) different processes being lumped together, and (3) actual deviation.

Mistakes in readings can occur during any stage of the data processing or in the data measurement process. Transcription errors and calculational errors are common, but unusual readings from instruments may be caused by power failures, improper calibration, malfunctioning instruments, contamination of samples, leaks, chemical interaction, etc. Not adhering to an experimental design or a standard operating procedure (SOP) can also affect recorded data. Because many hand calculations are needed to derive an emission rate per production rate from the initial concentration and flow measurements, these should also be checked for any data point that appears suspect. Many mistaken readings can never be detected or verified.

An apparent outlier may not, in fact, be an outlier at all, but rather an unusually high (or low) value that is real - a rare deviation that is legitimate. Moreover, the rare deviation may be a datum of vital interest in assessing human or environmental risks.

A number of statistical tests are available for treatment of outliers. Most of the statistical tests allow selection of a level of significance that is related to the probability of being correct, if the test concludes that a datum is an outlier. It is recommended that a statistician be consulted on the appropriate outlier test to use, and what the results of the test mean.

No datum should be rejected or deleted solely on the basis of statistical tests, since there is always a predictable risk of rejecting a value that represents actual emissions. Only if a mistake can be identified and verified should an apparent outlier reasonably be rejected. Suspected outliers should remain in the data base and be clearly identified as suspected or confirmed outliers (i.e., whether they are included or excluded from calculation of the average emission factor). Even though statistical tests are a key component in justifying the exclusion of datum that is believed to be nonrepresentative of the source category, exclusion of a suspected outlier requires more than a statistical test; it also requires experience and judgment on the part of the technical personnel reviewing the data set. In emission factor work, incorrectly grouping sources into different sub-types (or into one general type) may be responsible for producing the suspected outliers.

4.6.5 Detection Limits

Sometimes the result of a stack test is not an emission rate, but the knowledge that the pollutant was not present at or above the limit of detection of the test method. Given below are some guidelines on how to use method detection limits (MDLs) for developing emission factors in such cases. Note that a run is a single, complete traverse of the stack, and a test is the average of several runs, usually three.

- Determining a facility's average emission rate from a single test. If all of the runs from a test are below the MDL, record the emission rate for that test as BDL (below method detection limits), with the MDL clearly referenced. For clarity, the MDL should be expressed in emission factor units, i.e., lb/ton coal. If some of the runs are above detection limits and some are below, use half of the MDL for the runs that were below in the calculation of the facility's average emission rate (unless the BDL run's MDL was higher than the other runs' detection values).

- Determining a source category emission factor from multiple tests. If all facilities have their average emission rate recorded as BDL, report the average emission factor as BDL, with the MDL clearly referenced. If there is a mixture of BDL's and numeric average emission rates, use half of the test MDL for each BDL test as that facility's average emission rate, and include that rate for the facility in the calculation of the average source category emission factor (unless the BDL test's MDL was much higher than the other tests' detect values).

- Determining an emission factor when the MDL varies among tests or runs. Some tests or runs may have much higher MDLs than others in the same data set. This can potentially lead to a situation where averaging in half of a high MDL will bias the average high. If half of the MDL for a BDL test is higher than all other single run detect values for the other tests in the data set, then disregard the BDL test in calculating the average emission factor. If half of the MDL for a BDL run is higher than all other single run detect values for that test series, then disregard the BDL run in calculating the facility's average emission rate.

The following example illustrates these principles for the case where tests are available for three facilities:

Test A : Three runs (all BDL); DL=50 mg/kg coal.
Report the results as "BDL, DL=50 mg/kg coal".

Test B : Three runs (7, 9, and 11 mg/kg coal); DL=5 mg/kg coal.
Report the emission rate for the test as the average of the three runs, which is 9 mg/kg coal.

Test C : Three runs (6 and 10 mg/kg coal, and one run BDL; DL=5 mg/kg coal.
Report the emission rate for the test as the average of the three runs, using 2.5 for the run that was BDL, i.e., (6+10+2.5)/3=6.2 mg/kg coal.

To determine an overall emission factor from the three tests, use only the Test B and C data because in Test A, half of the DL (50) is 25, and that value is greater than any other single run detect value from Tests B and C. Therefore, (9+6.2)/2 = overall emission factor = 7.6 mg/kg coal.

- If a statistical outlier test is to be performed to determine whether any data points should be eliminated from further analysis, then half of the MDL should be used as a numeric value for those cases where a pollutant was below method detection limits.

- There are no "standard" criteria concerning how far above the MDL the data must be to be considered quantitative rather than qualitative (e.g., 4 x MDL or 5 x MDL). The data would not necessarily be considered non-quantitative if they were less than four or five times the MDL. However, the precision of the values would be decreased the closer the data are to the MDL, thus increasing the uncertainty of the values. The data would still be quantitative but should be used with more caution.

4.6.6 Use of Blanks

When reviewing source test reports, blank analysis results should be noted to determine the existence and magnitude of contamination problems. The criteria for evaluating blank results apply to any blank (method, field, etc.) associated with the samples. If problems with any blank exist, all data associated with the test report must be carefully evaluated to determine whether or not the information should be use.

Guidelines for blanks analysis to be followed when evaluating test reports are:

- Positive sample results should be treated as suspect if the concentration of the compound in the sample is not at least 10 times the amount in any blank for the following common contaminants: methylene chloride, acetone, toluene, 2-butanone, and common phthalate esters; or at least five times the amount for other compounds.

- In instances where more than one blank is associated with a given sample, qualification should be determined by a comparison with the associated blank having the highest concentration of a contaminant.

- If a compound is found in a blank but not found in the sample, no action is necessary.

- The resulting data should reflect the source test report's treatment of blanks. For example, if in a test, results were corrected by subtracting any blank values, use the blank corrected values for developing emission factors. If, however, test results were not blank corrected, do not adjust the results, but use the uncorrected values for developing emission factors.

4.6.7 Units of Measure and Activity Parameter Selection

An emission factor is an estimate of the amount of a pollutant emitted due to some activity divided by some measure of the level of that activity (commonly labeled as "thruput units"). In order to be useful, an emission factor must be reasonably accurate and easy to apply. The emission factor preparer should consider the following guidelines before choosing both the activity on which to base the emission factor and the measurement units for the activity.

- Choose an activity that directly influences the emissions, rather than an overall process or activity given in the test reports. Emission factors for fugitive dust from haul roads are thus typically given in terms of vehicle miles traveled rather than tons of production. Combustion-only emissions should usually be related to fuel use rather than to tons of production. Reasonable assumptions should be made by the emission factor preparer when necessary to convert test report units to a common or more appropriate basis.

- Choose an activity such that a facility that does things differently, or more or less efficiently than the tested facilities, will have these differences reflected in the resulting emissions estimate. In the example above, a facility with longer haul roads but the same production tonnage would show larger dust emissions. If a more energy-efficient dryer were used, the combustion emissions would be lower.

- If an additional parameter significantly influences emissions, consider including it in the emission factor. Sulfur oxide emissions from fuel combustion are usually based on both the amount of fuel burned and the sulfur content of the fuel, because the emissions depend on the amount of sulfur burned, not the amount of fuel burned. Similarly, surface coating emission factors based on the amount of solvent in a coating, rather than just the amount of the coating, will provide a more representative estimate for more facilities.

- Choose an activity which can be easily tracked by the facilities in the source category, and use measurement units which the industry uses if possible. If the industry uses its own unique terminology or if the industry is moving towards metric units, those terms and units can be used for an emission factor.

- For revisions to existing source category documents, try to use the activity and measurement units which have historically been used, if they are still appropriate. The AIRS AFS data base has thruput units associated with each existing SCC. These units can also be found in the SCC list included as part of the FIRE data base.

- If possible, use units which can be readily converted between metric and English. An emission factor in units of lbs/1000 lb is the same in units of kg/Mg, and one emission factor table with both units in the title can suffice. Units of lb/ton can be quickly converted to kg/Mg, especially where a footnote reminds the reader to divide by two.

- Due to their continued common usage, English units are preferred for emission factor tables. Conversions for metric units can be handled by one of the methods cited above, or separate columns or tables for metric units can be added, at the discretion of the emission factor preparer. When revising existing sections or documents, evaluate whether it makes sense to revise duplicate tables.

- Satisfy needs for other units by providing conversion factors in footnotes. It is also helpful to document the assumptions used in deriving values within the tables in the footnotes, e.g., the BTU content of fuels or the thermal efficiency of engines.

4.6.8 Assign Emission Factor Ratings

The emission factor rating is an overall assessment of how good a factor is, based on both the quality of the test(s) or information that is the source of the factor and on how well the factor represents the emission source. Higher ratings are for emission factors based on many unbiased observations, or on widely accepted test procedures. For example, 20 or more source tests on different randomly selected plants would likely be assigned an "A" rating if all tests are conducted using a single valid reference measurement method. Likewise, a single observation based on questionable methods of testing would be assigned an "E". Emission factors extrapolated from higher-rated factors for similar processes would be assigned a rating based on the amount of similarity of the processes. The extrapolated factor would thus be rated no higher than the original factor, and more likely lower, depending upon the similarity of the processes.

Material balance (such as combustion SOx or solvent loss) and theory-based emission factors (such as vapor displacement equation) are special cases. Generally, material balance factors can be assigned an A rating if the process emissions are consistent and well-characterized. Lower ratings should be assigned if the material loss is variable or difficult to characterize.

Emission factor ratings are best characterized as follows:

A = Excellent. Emission factor is developed primarily from A- and B-rated source test data taken from many randomly chosen facilities in the industry population. The source category population is sufficiently specific to minimize variability.

B = Above average. Emission factor is developed primarily from A- or B-rated test data from a moderate number of facilities. Although no specific bias is evident, is not clear if the facilities tested represent a random sample of the industry. As with the A rating, the source category population is sufficiently specific to minimize variability.

C = Average. Emission factor is developed primarily from A-, B-, and C-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with the A rating, the source category population is sufficiently specific to minimize variability.

D = Below average. Emission factor is developed primarily from A-, B- and C-rated test data from a small number of facilities, and there may be reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source population.

E = Poor. Factor is developed from C- and D-rated test data from a very few number of facilities, and there may be reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population.

U = Unrated (Only used in the L&E documents). Emission factor is developed from source tests which have not been thoroughly evaluated, research papers, modeling data, or other sources that may lack supporting documentation. The data are not necessarily "poor," but there is not enough information to rate the factors according to the rating protocol. "U" ratings are commonly found in L&E documents and FIRE rather than in AP-42.

Because the assignment of these ratings is subjective, the reasons for each rating are documented in the background information. Calculation of individual confidence limits is encouraged for all variables associated with a factor in assigning the A through E ratings. Stringent adherence to these criteria sound be coupled with knowledge and experience with the industry, and the rater should apply good engineering judgement to the assignment of ratings and to whether any quantitative statistics would be meaningful. Documentation for this determination is to be presented n the background information.

4.6.9 Rounding and Significant Figures

To express numbers with the proper number of significant figures, it is frequently necessary to "round" numbers. However, rounding of data should be done only when presenting the final emission factor data in the tables, after all the calculations with a particular data set have been completed. Therefore, carry as many digits as possible throughout the calculations from beginning to the end. When it is time to summarize and tabulate the final results, the final numbers should be rounded to the appropriate significant figures.

To round a number, if the left-most digit to be removed is 5 or greater, then round up the right-most digit. If the digit to be removed is less than 5, the right-most digit remains the same. For example, when rounding the following numbers to two significant figures:

3.43	rounds to	3.4;
3.45	rounds to	3.5; and
3.46	rounds to	3.5.

The term "significant figures" refers to how a number is described. For example 232,000 is a number with three significant figures. All of the following numbers have three significant figures:

204,000; 204; 20.4; 0.204; 0.000204; and 2.04×10^{-3}.

However, 204.0 implies that there are four significant figures. It should be noted that numbers less than 1.0 should have a leading zero as 0.204, not .204 without the leading zero. Leading zeros (0.204, 0.0204, or 0.00204) are not considered to be significant figures. With numbers like 100, or 100., it is not possible to know how many significant figures the number contains unless it is expressed as 1.00×10^{2}, which implies that there are three significant figures.

It is suggested that for consistency when rounding numbers for final emission factor tables, the values be rounded to two significant figures, where possible. In some cases, the data may permit rounding to three significant figures. A general rule of rounding is that the final rounded figure should contain no more significant digits than the number with the least number of significant digits used in the calculations.

4.7 BACKGROUND DOCUMENTATION

4.7.1 Background Documents

Concurrent with AP-42 section preparation, a background document discussing all references, calculations, and other pertinent information is prepared to undergo external review along with the section. The background document should identify all data, discuss their quality ratings, and document all decisions on their use. Analysis and any statistical manipulations of the data should also be clearly documented. If estimates of data accuracy or precision can be derived, it should be clearly noted here.

Each piece of information that is evaluated for use in developing the section should be summarized. Emission test report summaries should include the available description of the process being tested, existing controls, individual test results for all pollutants evaluated, problems identified by the test contractor, and problems identified during the review of the test by the section author.

Each emission factor should be documented so that the basis for the factor is clear. Specific material to be summarized and contained in the background document is as follows:

- Text describing the results of the data gathering effort. Items to address are where the data come from, the type of sources tested, all relevant process design and operational data available in the report, the quality of the data, the test methods used, the size of the units tested, how well does the data represent the source category, etc.

- A summary of each emission test report, with a list of all relevant data for each individual test run used in calculating the emission factor, with specific references to page or table numbers in the material in which these data were found. Note that for updates to AP-42 sections this may include older, but still relevant, data. Any corrections or adjustments that were made to a test report should be noted and explained.

- A complete description of the calculations. If appropriate, sample calculations are highly recommended. (A hard copy of all electronic spreadsheets should be included in the background files).

- A complete record of all assumptions, technical procedures, and rationale used in calculating or reducing the data.

- A list of the primary references actually cited in the emission factor document as listed in the AP-42 section and L&E document

- A list of secondary references used for background information during development of the emission factor document but not cited explicitly.

- The draft AP-42 section for external review, clearly labeled as such.

- A summary of the significant comments received on the external review draft, the resolution of those comments, and any other significant changes made to the draft to create the final published section. This summary is added to the background document after external review.

The wordprocessing package of choice is WordPerfect® Version 6.1 for Windows. The background document on Portland Cement (BC11S06.ZIP) is available from the CHIEF Website or on the Air CHIEF CD for guidance on format and content.

In order to help Website users find the files and to avoid having electronic section and background files overwritten on the Website due to duplicate names, the following file naming conventions are suggested:

For Background Documents: BXXSYY-Z.WPD

For Final AP-42 Sections: CXXSYY-Z.WPD

For Draft AP-42 Sections: DXXSYY-Z.WPD

where: XX is Chapter number
YY is Section number, and
Z is Subsection

Note that all of the files will appear on the CHIEF Website with a .ZIP extension.

4.7.2 Background Files

A file containing all of the references (test reports, journal articles, etc) should be maintained to provide the basis for current emission factors and supporting references when the applicability or accuracy of emission factors is questioned. For instance, transcripts of personal and telephone communications should be made and included. If only a few pages from a lengthy work are cited, only these need to be copied and included in the file. When pertinent source test results are summarized in a few pages, include this summary as well as the source test itself. In copying tables, graphs, and test results, the specific information that is used directly from the reference is identified. This saves time (and may avoid ambiguity) if the document is revised at a later date. For ease of use, this file should be labeled according to the section numbering system used in AP-42. For L&E documents, the pollutant name should be clearly labeled. Note that the EPA has a long range goal of storing all of the background files electronically. The background file should include the following information, clearly labeled and stored in the following categories.

- The current AP-42 section or L&E document.

- The version of the background document supporting the current version of the AP-42 section or L&E document.

- A copy of any electronic spreadsheets used to perform emission factor calculations or statistical analyses.

- Previous published versions of the AP-42 section in reverse chronological order (newest first, oldest last)

- A marked-up copy of the previous published AP-42 section, if appropriate, clearly showing the revisions.

- A list of the people and organizations that were requested to review the latest document.

- Copies of comments received from reviewers.

- All references cited.

- References not cited in the background document but that provide supporting information for future use.

4.8 AFTER EXTERNAL REVIEW

After external review comments have been received, the author should meet with the project leader to discuss how the comments will be addressed and whether extensive changes to the draft are warranted. If sufficient additional data becomes available during the external review period, or if extensive changes are otherwise needed, a revised draft should be prepared for a second external review. If a second external review is not needed the section can be finalized by addressing the comments, adding Source Classification Codes (SCCs) to the document, and preparing a summary of the emission factor changes to be made to the Factor Information REtrieval (FIRE) System data base.

4.8.1 SCC/AMS Code Assignments

Source Classification Codes (SCCs) are a means of organizing air pollutant sources into related groups. Because they are used as a key identifier for emission sources by both inventory preparers and permit reviewers, it is desirable to assign these identifiers to the emission factors as well. Emission factors must be tied to an SCC in order to appear in the AIRS or FIRE systems. The emission factor developer should use his or her familiarity with the source category to recommend revision or additions to the SCCs in AIRS and FIRE where necessary to improve the clarity of the data presented. Address such recommendation to Ronald Ryan, Emission Factor and Inventory Group, MD-14, The Environmental Protection Agency, Research Triangle Park, NC 27711. The SCCs should be included in the emission factor tables. It is suggested that they appear on the flow diagrams as well. Addition of the SCC codes should be done after the section has been externally reviewed if extensive changes are anticipated, or it can be done earlier if the author is confident with the process description and the subcategorization of the data.

The SCC is an eight-digit code divided into four fields in the pattern "1-22-333-44," with each level having a corresponding description as follows:

- Field 1 - the major emissions type;
- Field 2 - the major industry;
- Field 3 - the fuel consumed or the end product; and
- Field 4 - specific combustion equipment or unit operations.

SCCs vary in the amount of detail. For some processes, there are SCCs for individual release points within the process. In other cases, an entire process may be represented by a single SCC. In addition, an emission source may be represented both individually and as part of an overall process SCC. SCCs should not be used to distinguish all of the add-on control devices that may be used and which will have different emission factors. The SCC is used to identify the process, not the level of control. However, different process designs which result in different emissions levels should be assigned different SCCs.

Area and mobile sources are sources for which emission estimated are not made for each individual source, but are instead estimated as an aggregation of individual sources (e.g., architectural coating, pesticide application, and on-road motor vehicles). To "extend" the SCC system of codes to area and mobile sources, EPA developed a separate coding system, called Area and Mobile Source (AMS) codes, that follows the same general structure as SCCs, but instead uses a 10-digit code patterned "11-22-333-444."

The complete and current version of the SCC and AMS codes resides on EPA's mainframe computer in tables within AIRS. The FIRE data base also contains a file of the combined SCC and AMS codes current as of the FIRE release date. The emission factor developer should review the FIRE SCC list to assign SCC or AMS codes to each emission source included in AP-42 and L&E tables. Full 8- or 10-digit SCCs or AMS codes should be identified. If there is no existing code for an emission source, or if the description for an existing code needs to be revised for clarity, the author should contact EFIG to have an SCC assigned to the source.

4.8.2 FIRE Data Entry

The Factor Information REtrieval (FIRE) System data base is EPA's electronic listing of rated and unrated emission factors, including those from AP-42 and L&E documents. It is used by EPA's AIRS mainframe and by many States and private software vendors as the source of updated emission factors for their computer systems. Therefore, it is essential that the results of any AP-42 or L&E updates be accurately reflected in FIRE. This requires that the emission factor document be unambiguous, that SCC codes be assigned and used in the emission factor document, and that the information related to each emission factor update be submitted to the Emission Factor and Inventory Group in the form that it should appear in FIRE. Submittal of all updates in such a form will also allow EPA to explicitly tell users what has been added, deleted, or revised as a result of an AP-42 Supplement or L&E document publication. In addition to just getting new emission factors into FIRE, the author should insure that existing factors are revised, deleted, or confirmed as being still valid. These decisions should already have been addressed throughout the factor development process if the author checked the FIRE data base for existing information at the start of the project.

Preparation of the materials described below should occur as part of the final revisions to the factor document. Any needed SCC codes must already have been assigned per the preceding section, and no updates to FIRE will be made until the AP-42 section or L&E document has been placed on the CHIEF Website as "Final". The author should prepare and submit a Lotus spreadsheet file containing the information shown below. Actual entry of the data into FIRE will be done by EPA. The file should contain the following columns, with each row representing all of the information for a given emission factor.

ACT	New, rev, del, or ok
SCC	8-digit code, or 10-digit AMS code with A preceding
POL	Pollutant name (from existing FIRE list, if possible)
CTL1	Primary control device (from existing FIRE list, if possible)
CTL2	Secondary control device (from existing FIRE list, if possible)
REC_ID	FIRE record id number, if applicable
OLD_EF	Existing emission factor
OLD_STD	T if units are standard for SCC, or F if not, with non-standard units given
NEW_EF	New or revised emission factor
NEW_STD	T if units are standard for SCC, or F if not, with non-standard units given
REF	Primary reference code (?? if not yet in FIRE, w/footnote)
QUAL	New factor's quality rating
RANGE	Lowest and highest facility averages (optional)
TESTS	Number of facilities averaged (optional)
METH	Test method used (optional)
NOTES	Any notes necessary to use the factor

PARAM	Any process parameters that may have influenced emissions
EXPLN	Explanations for OLD_STD or NEW_STD entries, or to identify what was revised if not the emission factors - does not go into FIRE

For revised records, all columns should be filled in with the information to appear in FIRE. The last six columns are optional. The same applies to any new records, except OLD_EF and REC_ID will be left blank by the author. EPA will fill in the REC_ID. For deleted and ok records, only the first eight columns should be filled in.

APPENDIX A
AP-42/L&E STYLE GUIDE AND EXAMPLE SECTION

AP-42/L&E FORMAT/STYLE SPECIFICATION SHEET

These are the style guidelines used to produce the AP-42 5th Edition and should also be followed to produce L&E documents. This style sheet consists of three sections, the first intended as an aid for technical writers and editors, and the second as an aid for secretaries preparing sections, and the third for use for word processing and graphics support.

ATTACHMENTS TO THIS STYLESHEET:

- Example disk with file templates.

- Example from AP-42 5th Edition (Note that because of the recent decision to use the same style for L&E documents that is now used for AP-42 sections, L&E documents will not resemble those prepared so far.)

SECTION 1: GUIDELINES FOR WRITERS AND EDITORS

SECTION 2: GUIDELINES FOR TYPISTS

SECTION 3: ELECTRONIC PUBLISHING REQUIREMENTS

SECTION 1: GUIDELINES FOR WRITERS AND EDITORS

SECTION HEADINGS

- Number all section headings through the 3rd level. It is acceptable not to number 4th- or 5th-order headings if few occur in a section. Do not number the heading for references.

- ALL words initial caps always (including the words "**and**, **of**, **to**, **for**", etc.) for ALL levels of headings after chapter titles

ACRONYMS

- Always introduce in parentheses after the first use in a section, as singular even if plural in context, then use as singular or plural depending on context, e. g., VOC or VOCs not VOC's. It is OK to start sentences with acronyms after introduced, e. g., "EPA. . ." (*note:* not "The EPA. . .") and "CO emissions decrease. . ."

- Specific cases:
  - NA = not applicable (ONLY; not "not available"; if "NA = not available" is used, change it to ND)
  - ND = no data
  - PM-10, not PM_{10}
  - SCC = Source Classification Code

SPELLING

Use standard and check variants, e. g., use phosphorus, not phosphorous.

- Specific cases:
  - add-on (not addon or add on)
  - byproduct (not by-product)
  - condensable (not condensible)
  - data base (not database)
  - feedstock (not feed stock)
  - firebox (not fire-box)
  - flow rate (not flowrate)
  - fly ash (not flyash)
  - half-life (not halflife or half life)
  - offgas (not off gas)
  - waste water (not wastewater)
- Capitalization specifics:
  - federal (not Federal)
  - state (not State)

- The correct definition of PM-10 is particles "equal to or less than 10 micrometers in aerodynamic diameter."

- Regarding mentions of particulate matter, the term "particulate" is preferred over "particulates".

HYPHENATION

- Use legitimate hyphens within text and at end of lines. Usually delete for prefixes and avoid; be consistent with terms throughout document.

UNITS AND THEIR ABBREVIATIONS

If the unit and correct abbreviations for emission factors used in tables are not introduced in the text, they should be added as follows: "Factors are expressed in units of. . .[spelled out version, followed by abbreviation in parentheses]".

- <u>Always</u> spell units out the first time used, except for temperatures, then introduce the abbreviation in parentheses, and then use abbreviation consistently thereafter. For temperatures only, use #°F and do not spell out Celsius or Fahrenheit; also see below

- Specific cases:
  - ○ liter (L) <u>not</u> lower case "L" (l) or script "l"
  - ○ micrometer (µm), <u>not</u> micron
  - ○ Temperature: <u>always</u> "solid" (no spaces): 572°F <u>not</u> 572 °F, etc.

- Scientific notation and decimals are both acceptable within a table

TABLES

- AP-42 tables should use English units common to the source category described. Conversion factors to metric units can be given in footnotes or metric emission factors can be given in a separate table or in the same table as the English factors, space allowing.

- Standard text for Clean Air Act HAPs footnote: "Hazardous air pollutant in the *Clean Air Act*."

REFERENCES

- <u>Always</u> place all author's initials first or first name first (<u>not</u> inverted, with last name first)

- <u>Always</u> italicize "*et al.*,"; if ≥ 3 authors, delete all but first author's name, then a comma, "*et al.*,"

- Titles of documents and publishing organization: Use initial caps for all words (e. g., "Oregon Department <u>O</u>f Environmental Quality"). <u>Always</u> italicize titles

The following are selected examples of the reference format used in AP-42.

Legislation:

1. *The Rehabilitation Act Of 1973*, §504, 29 U.S.C. 794.

EXAMPLE ENGLISH UNIT TABLE

Source Category	Pollutant	Emission Factor (Units are lb of pollutant/ton Al produced.)	EMISSION FACTOR RATING	Notes
Aluminum Production Soderberg Process	CO_2	1.83 - 1.85	C	Assumes carbon consumption of 0.50 lb C/lb Al produced.
Prebake Process	CO_2	1.54 - 1.77	C	Assumes carbon consumption if 0.42 lb C/lb Al produced.
Aluminum Production	CF_4	0.6 - 1.8	E	Varies with duration of anode effect, frequency, and current efficiency.
Aluminum Production	C_2F_6	0.06 - 0.18	E	Varies with duration of anode effect, frequency, and current efficiency.

[a] References 11,14-15. To convert from lb/ton to kg/Mg, multiply by 0.5.

***Federal Register* Notice (Vol 53, p. 5573):**

2. *Standards Of Performance For New Stationary Sources: New Residential Wood Heaters*, 53 FR 5573, February 26, 1988.

***Code Of Federal Regulations* Notice (Title 40, Part 60, Subpart N):**

3. "Standards Of Performance For Iron And Steel Plants", 40 CFR 60.N.

EPA publications (with an EPA document number):

4. R. Gay and J. Shah, *Technical Support Document For Residential Wood Combustion*, EPA-450/4-85-012, U.S. Environmental Protection Agency, Research Triangle Park, NC, February 1986.

With three or more authors:

5. C.A. Simons, *et al.*, *Woodstove Emission Sampling Methods Comparability Analysis And In-situ Evaluation Of New Technology Woodstoves*, EPA-600/7-89-002, U.S. Environmental Protection Agency, Cincinnati, OH, January 1989.

One of a bound collection of papers:

6. D.C. Current, "Commercial Bakeries As A Major Source Of Reactive Volatile Organic Gases", *Emission Inventory/Factor Workshop: Volume I*, EPA-450/3-78-042a, U.S. Environmental Protection Agency, Research Triangle Park, NC, August 1978.

With contract number only (if no EPA document number is assigned):

7. *Particulate And Lead Emission Measurements From Lead Oxide Plants*, EPA Contract No. 68-02-9999, Bimbo Research Corp., Youpon, OH, August 1973.

Unnumbered:

8. S. Wyatt, *et al.*, *Preferred Standards Path Analysis On Lead Emissions From Stationary Sources*, Office Of Air Quality Planning And Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC, September 1974.

Source test:

9. *Source Testing Of A Waste Heat Boiler*, EPA-75-CBK-3, U.S. Environmental Protection Agency, Research Triangle Park, NC, January 1975.

Non-EPA Source test:

10. S.G. Barnett, *In-home Evaluation Of Emissions From Masonry Fireplaces And Heaters*, OMNI Environmental Services, Inc., Beaverton, OR, September 1991.

Other Agency reports:

11. S.G. Barnett and P.G. Fields, *In-home Performance Of Exempt Pellet Stoves In Medford, Oregon*, U.S. Department Of Energy, Oregon Department Of Energy, Tennessee Valley Authority, and Oregon Department Of Environmental Quality, Salem, OR, July 1991.

Privately published report:

12. S. Dernbach, *Woodstove Field Performance In Klamath Falls, OR*, Wood Heating Alliance, Washington, DC, April 1990.

Periodical:

13. D.G.T. Beauregard, *et al*., "Concentration And Size Of Trace Metal Emissions From A Power Plant, A Steel Plant, And A Cotton Gin", *Environmental Science And Technology*, 9(7):643-67, July 1975.

Paper:

14. J.A. Rau and J.J. Huntzicker, "Composition And Size Distribution Of Residential Wood Smoke Aerosols", Presented at the 21st Annual Meeting of the Air And Waste Management Association, Pacific Northwest International Section, Portland, OR, November 1984.

Book:

15. L. Sullivan Agnew, *et al.*, *Flow Of Information In Visionary Heavy Metal*, *Volume I: Notwithstanding The Rumor*, Purdue University, West Lafayette, IN, June 1973.

Privileged information:

16. Confidential test data, Bozo Contractors, Inc., Caries, NC, December 10, 1941.

Personal or official conversation:

17. Written (or Telephone) communication from (or between or among) Michael Hamlin, U.S. Environmental Protection Agency, Research Triangle Park, NC, to (or and) Joan de la Chaumette, Bureau Of Mines, U.S. Department Of The Interior, Washington, DC, January 15, 1993.

SECTION 2: GUIDELINES FOR TYPISTS

INITIAL CODES

● Software Text:	WordPerfect® Version 6.1 for Windows
● Document Font:	Times New Roman 11 pt
● Superscripts and Subscripts (83% in text and tables)	Times New Roman 9 pt
● Left/Right Margin	1"/1"
● Top/Bottom Margin for Chapter Introduction Page only:	2"/.5"
● Top/Bottom Margin for First Page of Section only:	1.5"/.5"
● Top/Bottom Margin for Subsequent Pages:	1"/.5"
● Footer A/Footer B	See Section on Footers
● Tabs: Absolute (w/first tab at 1", every 0.5")	1"/.5"
● Text Spacing:	1"
● Justification:	Left
● Widow/Orphan Protection:	On
● Table and Figure Options: Borders	None
● Figure Options: Captions	Placed Below Figure

- Print Options in Initial Settings:

1	Binding Offset		0"
2	Number of Copies		1
	Multiple Copies Generated by		WordPerfect
3	Graphics Quality		High
4	Text Quality		High
5	Redline Method		Printer Dependent
6	Size Attribute Ratios	Fine	60%
	(% of Normal)	Small	80%
		Large	120%
		Very Large	150%
		Extra Large	200%
		Super/Subscript	83%
7	Banner		No
8	Form Number		0

FOOTERS

For all pages, these should be 0.5 inch above the bottom of the page. Note the following examples. For odd-numbered pages:

1/95	Stationary Internal Combustion Sources	3.1-1
(<u>not</u> 01/95) [or use date given]	***[Chapter title, initial caps only]***	***[Section Number w/page number]***

For even-numbered pages, nearly the same information is used, but order reverses:

3.1-2	EMISSION FACTORS	1/95
[Section number w/page number]	***[Volume title, all caps]***	***[date]***

TEXT, HEADINGS, & SUBHEADINGS

All text should be Times New Roman 11 pt. Always use **super- and subscripts that are 9 pt.** (83% in text and tables). Headings to introduce a chapter should be 15 pt. & all caps. The main heading of a section should be formatted as a 1st-order heading (i. e., initial caps and bold) regardless of the number of digits (some sections will begin with a 3- or 4-digit heading number). Number all section headings through the 3rd level. Mark all heading for the table of contents, but just headings (i. e., no superscript numbers). Do not, under any circumstances, use the paragraph numbering or outline features. Note the following specifics:

- Spacing between section number and heading should always be 2 spaces; it may not align with ¶ indent because number of digits (width) of section numbers vary

- Amount of ¶ indents should always be 0.5 inch. Always use indents (F7); do not use tabs even for lists that use number or bullets (reset amount of indent if necessary)

- Do not use hard returns within text paragraphs or lists that begin with numbers or bullets

- No right text margin justification

- Style of 3rd-, 4th-, 5th-, or higher-order headings may vary depending on what heading level a section begins with and whether the subsection is numbered. Always flush to left margin (not indented); use hyphen with 1 space before and a hard return after; see the following examples (*note*: [] = required space, imbedded WordPerfect command, or note to reader):

  Subheading Title[]-[*Hard return*]
  After only a 0.5-inch ¶ indent and no intervening line of space, text follows. . . [*unnumbered heading*] OR

  2.1.3.3[][]Acid Gases[]-[*Hard return*]
  After only a 0.5-inch ¶ indent and no intervening line of space, text follows,
  "The chief acid gases. . . [*numbered heading*]

- It is imperative to use required spaces in text as follows: Appendix[]A, Table[]#, and #[]unit; do not allow such items to split at the end of text lines

- Capitalize terms such as the following (and above) as specific referrals: Section[]2.2, Chapter[]2

EXAMPLE OF AP-42 SECTION HEADING LEVELS

1.1 First Order Heading

1.1.1 Second Order Heading[1,2]

Text for this section should begin on this line.

1.1.1.1 Third Order Heading -
Text for this section should begin on this line.

Fourth Order Heading -
Text for this section should begin on this line.

PUNCTUATION/SPACING

- Punctuation should <u>always</u> be outside quotes unless it is a part of the quoted passage
- Use 2 spaces after a colon, ":", except in ratios: "10:1" or in periodical references: "*9*(7):643-67".
- <u>Always</u> use 1 space (required) in cases such as "e. g.," or "i. e.,"
- <u>Always</u> use 1 space between authors' initials in list of references
- <u>Always</u> use 1 space (required) in U. S.; use U. S. even as a noun (but do <u>not</u> change it if it is spelled out)
- Delete any space between # & "%": e. g., "77%", <u>not</u> "77 %"
- Do not use apostrophes with years, i. e., use "1970s", <u>not</u> "1970's"
- Dashes are always "en" dashes, with a required space to each side

LISTS WITHIN A TEXT PARAGRAPH

If numbered, use both parentheses: e.g., "(1)" <u>not</u> "1)". For unnumbered lists outside text, use NO bullets; instead use hyphens. From left margin, use the 0.5-inch ¶ indent, then a hyphen followed by another F4 indent set for 2 spaces, as shown in the following example:

- Text starts with capital letter and usually no end punctuation, but **this is case-specific**; if internal punctuation is used (i. e., a series of items with commas), each item might end with a semicolon ";". If this is done, the next to last item should end with "; and", and the final one should end with a period.

Also, a numbered list outside the text is fine, and the format should be similar with 1 or more levels to the list:

1. After the number (or letter) and a period, use a 2-space indent, then text starts with a capital letter, and end punctuation is case-specific if needed.

   a. Text again starts with a capital letter; use case-specific end punctuation if needed for clarity.

NUMBERS

- Always use numerals, e. g., 3 to 5 days, 4 plants, 5 percent (not five percent) except at the beginning of a sentence. Use % sign in tables and table footnotes (column heads and footnotes); but not in text

- In 4-digit numbers, comma use is optional except when used with numbers of 5 or more digits, e. g., 1000°F is OK, but also 1,000 to 10,000 lb

- Insert a zero before the decimal if none is used in a given number

- Be sure a space appears before the "E" in "1.10[]E-03" or "1.10[]E+03"

- Style for ranges (values & references):

    - Text and table guts: 1 - 2 (1 required space on each side of hyphen)

    - Text reference citations and table footnotes; use: 1-2 and 3,5 (*note:* no spaces, not "3, 5")

- SCC numbers: should be "solid", i. e., no spaces; insert hyphens per the formula 1-2-3-2 as follows: #-##-###-##

FIGURES

Figures should not have borders.

- For text references, always cite the word "Figure" and the full number for each. Text references should not cite a range (e. g., Figures 5.2-1 through 5.2-4)

- Caption font: Should match text font style (Times New Roman 11 pt.)

- Caption style: 1st word only initial cap (not all words), ends with a period, and centered relative to the figure. If SCCs appear in the figure, on the next line (no intervening line of space), center the following statement: "(Source Classification Codes in parentheses.)" If a figure must be presented in "landscape" orientation, the caption must be centered below the figure within (and parallel to) the right margin. Do not place "SCC" before the SCCs given throughout the figure

TABLES

- Landscaped tables are to be put into Table Boxes

- For text references: use "Tables 9.3.2-1 and 9.3.2-2", not "Tables 9.3.2-1 and -2". If a range of tables is mentioned, each full number should be cited (e. g., "Tables 5.2-2, 5.2-3, and 5.2-4"), but the word "Table" does not need to be repeated

- Font sizes: title, entries, and footnotes: should always be same size as text font (11 pt.). Table entries ("guts") ONLY may use 9-pt. font to avoid continuing table. Do not make title or footnotes the same size font as table if a 9-pt. font is used

- Title format, if too long to fit on 1 line: Avoid only 1 or 2 words on second line and split at a logical place, e. g., "EMISSION FACTORS FOR [hard return] ABRASIVE MANUFACTURING"

- If the table title subhead "EMISSION FACTOR RATING: [rating letter here]" is used and any exceptions are footnoted, add the following after the rating letter: "(except as noted)"

- Style if continued: use only header with table # and "(cont.)", no footers: do not repeat title: e. g., "Table 9.3.2-1 (cont.)." Note that no period follows the table number but use a period both after "cont." and following the closing parenthesis

- Boxes, "downlines": all tables should use only single-line boxes (not double) and no horizontal lines after column headings. Use vertical downlines from top to bottom only for major column subheads (not subcolumn headings)

- Column headings: placement & style: centered over column [except possibly first column may be flush left; this is case-specific)], "stacked" from the "bottom up" (i. e., the line between column headings and table guts). Use all initial caps for words, with one exception: EMISSION FACTOR RATING; this term should always be all caps within a table column heading or subheading or footnote, or as a subheading for table title. Capitalization of unit abbreviations must be case-specific

- Columns: Widths should be equalized as much as possible. *Use column command to decimal align and center numbers within the individual column except in cases where space problems may arise (i. e., to avoid continuing a table or using a smaller font). Always use tabs and adjust spacing if not standard; do not use spaces.

*In Table Edit:
2 Format
2 Column
3 Justify
5 Decimal Align

For Centering Columns w/decimals:
2 Format
2 Column
4 #Digits (Enter a number of decimal places to achieve a centered column of numbers with decimals.)

EXAMPLE TABLE WITH DECIMAL ALIGNED NUMBERS

VOC[a]			
	National Emissions	**Per Capita Emission Factors**	
Use	**tons/yr**	**lb/yr**	**lb/day**
Aerosol products	**37.6**	**3.5**	**9.6**
Household products	**2.01**	**1.9**	**5.2**
Toiletries	**14.5**	**1.4**	**3.8**
Rubbing compounds	**6.8**	**0.64**	**1.8**

VOC[a]			
	National Emissions	**Per Capita Emission Factors**	
Use	**tons/yr**	**lb/yr**	**lb/day**
Polishes and waxes	**5.3**	**0.49**	**1.3**

- When the only entry is a footnote, precede with an "em" dash (control V: 4,34)

- Left column terms: capitalize 1st word only (except possibly for specific terms, e. g., "Pre-Phase")

- Align text entries on the left and indent subsequent lines 2 spaces relative to first character. Entries in subsequent columns should align with last "spillover" line of table text entry (but not SCC number in parentheses)

- Footnotes:

  - Within a footnote, the term "EMISSION FACTOR RATING" must lead, and can be preceded only by a reference number.

  - Order: always left to right and top to bottom; correct as necessary; use ONLY superscript letters

  - Specific letters not to use or to double: i, l, & o; but aa, bb, etc., are ok if needed
  - Placement: no return or line of space between table bottom (except that resulting from use of superscript letters to avoid overstriking table box line)

  - Alignment: Should align with table width on the left and right and not extend beyond. Use an indent (with 1 space only) after superscript so subsequent lines align with first text character, not text flush to left margin; also a second column on same page is OK to avoid continuing table if not confusing

  - Use 1 space between superscript letter & text as noted above; use the advance down code (0.05) between the bottom line of table and the beginning of superscript letters

EXAMPLE TABLE REFLECTING POSITION OF SUPERSCRIPTED LETTERS

Particle Size[a] (m)	**Cumulative Mass % Stated Size**			**Cumulative Emission Factor[b] ([lb/ton] Coal, As Fired)**		
	Uncontrolled	**Multiple Cyclones**	**ESP**	**Uncontrolled**	**Multiple Cyclones**	**ESP**
15	**40**	**99**	**83**	**2.8A**	**1.38A**	**0.046**
15	**40**	**99**	**83**	**2.8A**	**1.38A**	**0.046**

[a] Expressed as aerodynamic equivalent diameter.

- ALL acronyms used in table but not defined previously in text should be defined at the end of footnote "a" (but not chemical terms/nomenclature; if any are used that were not previously introduced/identified in the text, it is OK because it is assumed all readers will recognize standard chemical terms)

EQUATIONS

Make sure first thing is "Func {" and do not use "vertical" (for Super and Subscripts) or "scalesym"

$$E = \frac{(6.234 x 10^{-4})\ P\ A\ t\ V_o\ D_o}{V_s\ T} + L_d\ D_d$$

```
FUNC {E ~=~ {(6.234`
x `10^{-4})~{P ~A ~
t~V_o~`D_o}} over
{V_s~T} ~+~
{L_d~D_d}}
```

Number equations if more than 1. In building an equation Also, placement of "where:" should be alone on a line below equation, usually flush to left margin (or possibly indented; these will be case-specific), with list of terms defined beginning on line below, aligned by "="

where:

E_v = emission factor for VOC, mass per vehicle (lb/vehicle) (exclusive of any add-on control devices)
A_v = area coated per vehicle (ft^2/vehicle)
c_1 = conversion factor: 1 ft/12,000 mil
T_f = thickness of the dry coating film (mil)

REFERENCES

- Use the endnote feature for numbering text references; do not use superscripts or footnotes
- List should start immediately following text (no white space) unless table(s) follow text (i. e., tables should not split up references). Also, style for text citations should be: "...blah.^{10}" not "...blah^{10}."
- The subheading for references should be "References For Section [insert section number]". Do not number this subheading

- Only in list of references, set a 0.5-inch tab from the left margin so all reference text aligns on the left regardless of the reference number digits

EXAMPLE:

1. *Second Review Of Standards Of Performance For Sewage Sludge Incinerators*, EPA-450/3-84-010, U. S. Environmental Protection Agency, Research Triangle Park, NC, March 1984.

SECTION 3: ELECTRONIC PUBLISHING REQUIREMENTS

In order to incorporate AP-42 sections and L&E documents to an electronic form, such as Adobe Acrobat, the document must be compatible with other electronic formats. The following are requirements for electronic publishing of these documents that should be adhered to.

FONTS

Change the Font to Times New Roman 11pt (Make absolutely sure that the Base also is Times New Roman 11pt and that the printer is defaulted to Times New Roman 11pt) and change the tabs to absolute tabs (1,.5 or whatever the tabs should be for special circumstances).

HEADINGS

Make sure each heading is as follows:

- [Center]SECTION 2.0[HRt]
  [Center]EMISSIONS FROM MANUFACTURING[HRt][HRt][HRt]
- 2.1[Tab]EMISSIONS SUMMARY[HRt][HRt]
- 2.1.1[Tab]<u>Motor Vehicle Emissions</u>[HRt][HRt]
- 2.1.1.1[Tab]Process Emissions--[HRt]

FIGURE QUALITY

Check each figure and make sure that it can be seen properly in WordPerfect. Mark table titles and figures for the List of Tables and List of Figures.

- Drawings are created in a drawing program with excellent export capabilities (that is, vectored graphics with editable text capability, such as with Corel Draw, WordPerfect Presentations, or the graphics software of WordPerfect for Windows. Note that other graphics software (e.g., Freelance for Windows) can be used but only if fixed font size is used to avoid the problem of text extending beyond space designed for it.).
- Arrow heads are sized: .008
- Lines are sized: .02
- Fonts: Times Roman, 9 pt within the graphic
- Save original drawing file
- Select all & export as .pcx (selected only):
  COLORS: black & white
  SIZE: 1 to 1
  RESOLUTION: 300 DPI
- Select all, group & export as .wpg (selected only):
  COLORS: 16 colors
  EXPORT TEXT AS: Curves

LANDSCAPE FIGURES/FIGURE TITLES

Figure Box Specifications:
Horizontal: Left

Size: 6" wide by 8.99" high
Rotate 90 degrees
Type in figure filename.

Below are requirements for captions when creating landscape figures.
Horizontal: Right
Size: 0.168" wide by 8.99" high
Rotate 90 degrees

Center and type in figure title.

Note: These numbers are chosen from "definition": Figure Screen.

FORMATTING

Make sure that the documents includes *only* True Type fonts (such as Times New Roman).

Make sure all disk files for each section, including appendices, are together in one zip file and that a systematic naming scheme is used.

SUBSCRIPTS AND SUPERSCRIPTS

Superscripts and subscripts should be set at 83% or 9pt font size.

EXAMPLE AP-42 SECTION

11.6 Portland Cement Manufacturing

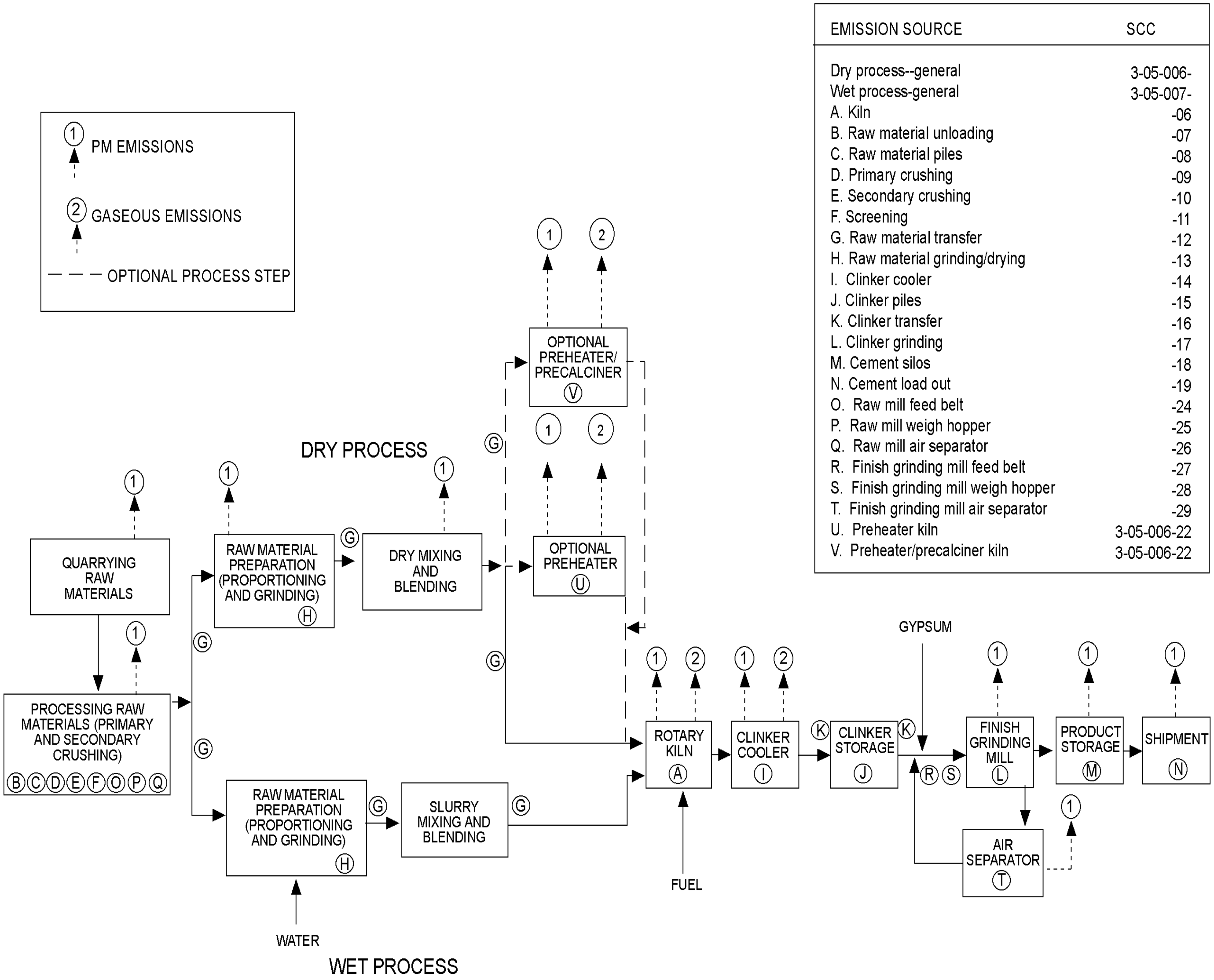
11.6.1 Process Description[1-7]

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 noncalcarious constituents are found naturally in the limestone. Occasionally, pockets of pyrite, which can significantly increase emissions of sulfur dioxide (SO_2), 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 (CO_2) 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



EMISSION SOURCE	SCC
Dry process--general	3-05-006-
Wet process-general	3-05-007-
A. Kiln	-06
B. Raw material unloading	-07
C. Raw material piles	-08
D. Primary crushing	-09
E. Secondary crushing	-10
F. Screening	-11
G. Raw material transfer	-12
H. Raw material grinding/drying	-13
I. Clinker cooler	-14
J. Clinker piles	-15
K. Clinker transfer	-16
L. Clinker grinding	-17
M. Cement silos	-18
N. Cement load out	-19
O. Raw mill feed belt	-24
P. Raw mill weigh hopper	-25
Q. Raw mill air separator	-26
R. Finish grinding mill feed belt	-27
S. Finish grinding mill weigh hopper	-28
T. Finish grinding mill air separator	-29
U. Preheater kiln	3-05-006-22
V. Preheater/precalciner kiln	3-05-006-22

Figure 11.6-1. Process flow diagram for portland cement manufacturing. (SCC = Source Classification Code.)

operations, to the extent that such replacement can be implemented without adversely 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 ($CaCO_3$) 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 (CO_2) 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[1,3-7]

Particulate matter (PM and PM-10), nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), and CO_2 are the primary emissions in the manufacture of portland cement. Small quantities of volatile organic compounds (VOC), ammonia (NH_3), 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 NO_x increases. The amount of NO_x generated from fuel increases with the quantity of nitrogen in the fuel. In the cement manufacturing process, NO_x 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 NO_x generated. For example, in the kiln, natural gas combustion with a high flame temperature and low fuel nitrogen generates a larger quantity of NO_x 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 NO_x 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 NO_x 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 SO_2 into the product, thereby mitigating the quantity of SO_2 emissions in the exhaust stream. Depending on the process and the source of the sulfur, SO_2 absorption ranges from about 70 percent to more than 95 percent.

The CO_2 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 CO_2. Substantial quantities of CO_2 also are generated through calcining of limestone or other calcareous material. This calcining process thermally decomposes $CaCO_3$ to CaO and CO_2. Typically, portland cement contains the equivalent of about 63.5 percent CaO. Consequently, about 1.135 units of $CaCO_3$ are required to produce 1 unit of cement, and the amount of CO_2 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 CO_2 emissions from the pyroprocess depend on energy consumption and generally fall in the range of 0.85 to 1.35 Mg of CO_2 per Mg of clinker.

In addition to CO_2 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/m^3) (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 $m^3/min/m^2$ (1.5:1 $acfm/ft^2$) and ESP with a net surface collection area of 1,140 to 1,620 $m^2/1{,}000\ m^3$ (350 to 500 $ft^2/1{,}000\ ft^3$). These systems are reported to achieve outlet PM loadings of 45 mg/m^3 (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 SO_2 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 SO_2 control. Fabric filters on cement kilns are also reported to absorb SO_2. Generally, substantial control is not achieved. An absorbing reagent (e. g., CaO) must be present in the filter cake for SO_2 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 11.6-1 (Metric Units). EMISSION FACTORS FOR PORTLAND CEMENT MANUFACTURING KILNS AND CLINKER COOLERS[a]

Process	Filterable[b]				Condensable[c]			
	PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING	Inorganic	EMISSION FACTOR RATING	Organic	EMISSION FACTOR RATING
Wet process kiln (SCC 3-05-007-06)	65[d]	D	16[e]	D	ND		ND	
Wet process kiln with ESP (SCC 3-05-007-06)	0.38[f]	C	0.33[g]	D	0.076[h]	D	ND	
Wet process kiln with fabric filter (SCC 3-05-007-06)	0.23[j]	E	ND		0.10[j]	E	ND	
Wet process kiln with cooling tower, multiclone, and ESP (SCC 3-05-007-06)	0.10[k]	E	ND		0.14[k]	E	ND	
Dry process kiln with ESP (SCC 3-05-006-06)	0.50[m]	D	ND		0.19[m]	D	ND	
Dry process kiln with fabric filter (SCC 3-05-006-06)	0.10[n]	D	0.084[p]	D	0.45[n]	D	ND	
Preheater kiln (SCC 3-05-006-22)	130[q]	D	ND		ND		ND	
Preheater kiln with ESP (SCC 3-05-006-22)	0.13[r]	D	ND		ND		ND	
Preheater kiln with fabric filter (SCC 3-05-006-22)	0.13[s]	C	ND		0.017[t]	D	ND	
Preheater/precalciner kiln with ESP (SCC 3-05-006-23)	0.024[u]	D	ND		ND		ND	
Preheater/precalciner process kiln with fabric filter (SCC 3-05-006-23)	0.10[v]	D	ND		ND		ND	
Preheater/precalciner process kiln with PM controls (SCC 3-05-006-23)	ND		ND		0.078[w]	D	ND	

Table 11.6-1 (cont.).

Process	Filterable[b]				Condensable[c]			
	PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING	Inorganic	EMISSION FACTOR RATING	Organic	EMISSION FACTOR RATING
Clinker cooler with ESP (SCC 3-05-006-14)	0.048[x]	D	ND		0.0038[x]	D	ND	
Clinker cooker with fabric filter (SCC 3-05-006-14)	0.068[y]	D	ND		0.0084[z]	D	ND	
Clinker cooler with gravel bed filter (SCC 3-05-006-14)	0.11[aa]	D	0.084[bb]	D	0.0045[cc]	D	ND	

[a] 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.
[b] Filterable PM is that collected on or before the filter of an EPA Method 5 (or equivalent) sampling train.
[c] Condensable PM is that collected in the impinger portion of a PM sampling train.
[d] References 20,26.
[e] References 3,20,26.
[f] References 8-9,18,20,25-26,32,34-36,41-44,60,64.
[g] References 3,8-9,18,20,25-26,32,34-36,41-44,60,64.
[h] References 8-9,20,64.
[j] Reference 14.
[k] Reference 21.
[m] References 19,21.
[n] Reference 23.
[p] References 3,23.
[q] Reference 17.
[r] Reference 31.
[s] References 17,47-50,61.
[t] Reference 51.
[u] Reference 37.
[v] References 30,33,51,56-59,63
[w] References 30,33,37,51,59.
[x] Reference 8.
[y] References 9,12,27,30,33.
[z] References 9,12,30.
[aa] References 22,29,31
[bb] References 3,22,29,31
[cc] References 22,29

Table 11.6-2 (English Units). EMISSION FACTORS FOR PORTLAND CEMENT MANUFACTURING KILNS AND CLINKER COOLERS[a]

Process	Filterable[b]				Condensable[c]			
	PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING	Inorganic	EMISSION FACTOR RATING	Organic	EMISSION FACTOR RATING
Wet process kiln (SCC 3-05-007-06)	130[d]	D	31[e]	D	ND		ND	
Wet process kiln with ESP (SCC 3-05-007-06)	0.77[f]	C	0.65[g]	D	0.15[h]	D	ND	
Wet process kiln with fabric filter (SCC 3-05-007-06)	0.46[j]	E	ND		0.20[j]	E	ND	
Wet process kiln with cooling tower, multiclone, and ESP (SCC 3-05-007-06)	0.20[k]	E	ND		0.29[k]	E	ND	
Dry process kiln with ESP (SCC 3-05-006-06)	1.0[m]	D	ND		0.38[m]	D	ND	
Dry process kiln with fabric filter (SCC 3-05-006-06)	0.20[n]	D	0.17[p]	D	0.89[n]	D	ND	
Preheater kiln (SCC 3-05-006-22)	250[q]	D	ND		ND		ND	
Preheater kiln with ESP (SCC 3-05-006-22)	0.26[r]	D	ND		ND		ND	
Preheater kiln with fabric filter (SCC 3-05-006-22)	0.25[s]	C	ND		0.033[t]	D	ND	
Preheater/precalciner kiln with ESP (SCC 3-05-006-23)	0.048[u]	D	ND		ND		ND	
Preheater/precalciner process kiln with fabric filter (SCC 3-05-006-23)	0.21[v]	D	ND		ND		ND	
Preheater/precalciner process kiln with PM controls (SCC 3-05-006-23)	ND		ND		0.16[w]	D	ND	

Table 11.6-2 (cont.).

	Filterable[b]				Condensable[c]			
Process	PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING	Inorganic	EMISSION FACTOR RATING	Organic	EMISSION FACTOR RATING
Clinker cooler with ESP (SCC 3-05-006-14)	0.096[x]	D	ND		0.0075[x]	D	ND	
Clinker cooker with fabric filter (SCC 3-05-006-14)	0.13[y]	D	ND		0.017[z]	D	ND	
Clinker cooler with gravel bed filter (SCC 3-05-006-14)	0.21[aa]	D	0.16[bb]	D	0.0090[cc]	D	ND	

[a] 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.

[b] Filterable PM is that collected on or before the filter of an EPA Method 5 (or equivalent) sampling train.

[c] Condensable PM is that collected in the impinger portion of a PM sampling train.

[d] References 20,26.

[e] References 3,20,26.

[f] References 8-9,18,20,25-26,32,34-36,41-44,60,64.

[g] References 3,8-9,18,20,25-26,32,34-36,41-44,60,64.

[h] References 8-9,20,64.

[j] Reference 14.

[k] Reference 21.

[m] References 19,21.

[n] Reference 23.

[p] References 3,23.

[q] Reference 17.

[r] Reference 31.

[s] References 17,47-50,61.

[t] Reference 51.

[u] Reference 37.

[v] References 30,33,51,56-59,63

[w] References 30,33,37,51,59.

[x] Reference 8.

[y] References 9,12,27,30,33.

[z] References 9,12,30.

[aa] References 22,29,31

[bb] References 3,22,29,31

[cc] References 22,29

Table 11.6-3 (Metric Units). EMISSION FACTORS FOR PORTLAND CEMENT MANUFACTURING RAW MATERIAL AND PRODUCT PROCESSING AND HANDLING[a]

	Filterable[b]			
Process	PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING
Raw mill with fabric filter (SCC 3-05-006-13)	0.0062[c]	D	ND	
Raw mill feed belt with fabric filter (SCC 3-05-006-24)	0.0016[d]	E	ND	
Raw mill weigh hopper with fabric filter (SCC 3-05-006-25)	0.010[e]	E	ND	
Raw mill air separator with fabric filter (SCC 3-05-006-26)	0.016[e]	E	ND	
Finish grinding mill with fabric filter (SCC 3-05-006-17, 3-05-007-17)	0.0042[f]	D	ND	
Finish grinding mill feed belt with fabric filter (SCC 3-05-006-27, 3-05-007-27)	0.0012[d]	E	ND	
Finish grinding mill weigh hopper with fabric filter (SCC 3-05-006-28, 3-05-007-28)	0.0047[e]	E	ND	
Finish grinding mill air separator with fabric filter (SCC 3-05-006-29, 3-05-007-29)	0.014[g]	D	ND	
Primary limestone crushing with fabric filter (SCC 3-05-006-09)[h]	0.00050	E	ND	
Primary limestone screening with fabric filter (SCC 3-05-006-11)[h]	0.00011	E	ND	
Limestone transfer with fabric filter (SCC 3-05-006-12)[h]	1.5×10^{-5}	E	ND	
Secondary limestone screening and crushing with fabric filter (SCC 3-05-006-10 + -11, 3-05-007-10 + -11)[h]	0.00016	E	ND	

[a] Factors represent uncontrolled emissions, unless otherwise noted. Factors are kg/Mg of material process, unless noted. SCC = Source Classification Code. ND = no data.

4[b] Filterable PM is that collected on or before the filter of an EPA Method 5 (or equivalent) sampling train.

[c] References 15,56-57.

[d] Reference 57.

[e] Reference 15.

[f] References 10,12,15,56-57.

[g] References 10,15.

[h] 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[a]

Process	Filterable[b]			
	PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING
Raw mill with fabric filter (SCC 3-05-006-13)	0.012[c]	D	ND	
Raw mill feed belt with fabric filter (SCC 3-05-006-24)	0.0031[d]	E	ND	
Raw mill weigh hopper with fabric filter (SCC 3-05-006-25)	0.019[e]	E	ND	
Raw mill air separator with fabric filter (SCC 3-05-006-26)	0.032[e]	E	ND	
Finish grinding mill with fabric filter (SCC 3-05-006-17, 3-05-007-17)	0.0080[f]	E	ND	
Finish grinding mill feed belt with fabric filter (SCC 3-05-006-27, 3-05-007-27)	0.0024[d]	E	ND	
Finish grinding mill weigh hopper with fabric filter (SCC 3-05-006-28, 3-05-007-28)	0.0094[e]	E	ND	
Finish grinding mill air separator with fabric filter (SCC 3-05-006-29, 3-05-007-29)	0.028[g]	D	ND	
Primary limestone crushing with fabric filter (SCC 3-05-006-09)[h]	0.0010	E	ND	
Primary limestone screening with fabric filter (SCC 3-05-006-11)[h]	0.00022	E	ND	
Limestone transfer with fabric filter (SCC 3-05-006-12)[h]	2.9×10^{-5}	E	ND	
Secondary limestone screening and crushing with fabric filter (SCC 3-05-006-10 + -11, 3-05-007-10 + -11)[h]	0.00031	E	ND	

[a] Factors represent uncontrolled emissions, unless otherwise noted. Factors are lb/ton of material processed, unless noted. SCC = Source Classification Code. ND = no data.

[b] Filterable PM is that collected on or before the filter of an EPA Method 5 (or equivalent) sampling train.

[c] References 15,56-57.

[d] Reference 57.

[e] Reference 15.

[f] References 10,12,15,56-57.

[g] References 10,15.

[h] 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[a]

Particle Size, µm	Cumulative Mass Percent Equal To Or Less Than Stated Size			
	Uncontrolled		Controlled	
	Wet process (SCC 3-05-007-06)	Dry process (SCC 3-05-006-06)	Wet process With ESP (SCC 3-05-007-06)	Dry process With FF (SCC 3-05-006-06)
2.5	7	18	64	45
5.0	20	ND	83	77
10.0	24	42	85	84
15.0	35	44	91	89
20.0	57	ND	98	100

[a] Reference 3. SCC = Source Classification Code. ND = no data.

Table 11.6-6. SUMMARY OF AVERAGE PARTICLE SIZE DISTRIBUTION FOR PORTLAND CEMENT CLINKER COOLERS[a]

Particle Size, µm	Cumulative Mass Percent Equal To Or Less Than Stated Size	
	Uncontrolled (SCC 3-05-006-14, 3-05-007-14)	With Gravel Bed Filter (SCC 3-05-006-14, 3-05-007-14)
2.5	0.54	40
5.0	1.5	64
10.0	8.6	76
15.0	21	84
20.0	34	89

[a] Reference 3. SCC = Source Classification Code.

Table 11.6-7 (Metric Units). EMISSION FACTORS FOR PORTLAND CEMENT MANUFACTURING[a]

Process	SO_2[b]	EMISSION FACTOR RATING	NO_x	EMISSION FACTOR RATING	CO	EMISSION FACTOR RATING	CO_2[c]	EMISSION FACTOR RATING	TOC	EMISSION FACTOR RATING
Wet process kiln (SCC 3-05-007-06)	4.1[d]	C	3.7[e]	D	0.060[f]	D	1,100[g]	D	0.014[f]	D
Long dry process kiln (SCC 3-05-006-06)	4.9[h]	D	3.0[j]	D	0.11[k]	E	900[m]	D	0.014[n]	E
Preheater process kiln (SCC 3-05-006-22)	0.27[p]	D	2.4[q]	D	0.49[r]	D	900[s]	C	0.090[t]	D
Preheater/precalciner kiln (SCC 3-05-006-23)	0.54[u]	D	2.1[v]	D	1.8[w]	D	900[x]	E	0.059[y]	D
Preheater/precalciner kiln with spray tower (SCC 3-05-006-23)	0.50[z]	E	ND		ND		ND		ND	

[a] Factors represent uncontrolled emissions unless otherwise noted. Factors are kg/Mg of clinker produced, unless noted. SCC = Source Classification Code. ND = no data.

[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.

[j] References 11,38-40,65.

[k] References 39,65.

[m] References 11,21,23,65.

[n] References 40,65. TOC as measured by Method 25A or equivalent.

[p] References 47-50.

[q] References 48-50.

[r] Reference 49.

[s] References 24,31,47-50,61.

Table 11.6-7 (cont.).

[t] Reference 49; total organic compounds as measured by Method 25A or equivalent.
[u] References 28,30,33,37,53,56-59.
[v] References 28,30,33,37,45,56-59.
[w] References 28,30,37,56-58,63.
[x] References 24,31,47-50,61. Based on test data for preheater kilns; should be considered an upper limit.
[y] References 30,33,56,63; total organic compounds as measured using Method 25A or equivalent.
[z] Reference 54.

Table 11.6-8 (English Units). EMISSION FACTORS FOR PORTLAND CEMENT MANUFACTURING[a]

Process	SO_2[b]	EMISSION FACTOR RATING	NO_x	EMISSION FACTOR RATING	CO	EMISSION FACTOR RATING	CO_2[c]	EMISSION FACTOR RATING	TOC	EMISSION FACTOR RATING
Wet process kiln (SCC 3-05-007-06)	8.2[d]	C	7.4[e]	D	0.12[f]	D	2,100[g]	D	0.028[f]	D
Long dry process kiln (SCC 3-05-006-06)	10[h]	D	6.0[j]	D	0.21[k]	E	1,800[m]	D	0.028[n]	E
Preheater process kiln (SCC 3-05-006-22)	0.55[p]	D	4.8[q]	D	0.98[r]	D	1,800[s]	C	0.18[t]	D
Preheater/precalciner kiln (SCC 3-05-006-23)	1.1[u]	D	4.2[v]	D	3.7[w]	D	1,800[x]	E	0.12[y]	D
Preheater/precalciner kiln with spray tower (SCC 3-05-006-23)	1.0[z]	E	ND		ND		ND		ND	

[a] Factors represent uncontrolled emissions unless otherwise noted. Factors are lb/ton of clinker produced, unless noted. SCC = Source Classification Code. ND = no data.

[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.

[j] References 11,38-40,65.

[k] References 39,65.

[m] References 11,21,23,65.

[n] References 40,65. TOC as measured by Method 25A or equivalent.

[p] References 47-50.

[q] References 48-50.

[r] Reference 49.

[s] References 24,31,47-50,61.

[t] Reference 49; total organic compounds as measured by Method 25A or equivalent.

Table 11.6-8 (cont.).

[u] References 28,30,33,37,53,56-59.
[v] References 28,30,33,37,45, and 56 to 59.
[w] References 28,30,37,56-58,63.
[x] References 24,31,47-50,61. Based on test data for preheater kilns; should be considered an upper limit.
[y] References 30,33,56,63; total organic compounds as measured using Method 25A or equivalent.
[z] Reference 54.

Table 11.6-9 (Metric And English Units). SUMMARY OF NONCRITERIA POLLUTANT EMISSION FACTORS FOR PORTLAND CEMENT KILNS[a]

(SCC 3-05-006-06, 3-05-007-06, 3-05-006-22, 3-05-006-23)

Pollutant Name	Type Of Control	Average Emission Factor		EMISSION FACTOR RATING	References
		kg/Mg	lb/ton		
Inorganic Pollutants					
Silver (Ag)	FF	3.1×10^{-7}	6.1×10^{-7}	D	63
Aluminum (Al)	ESP	0.0065	0.013	E	65
Arsenic (As)	ESP	6.5×10^{-6}	1.3×10^{-5}	E	65
Arsenic (As)	FF	6.0×10^{-6}	1.2×10^{-5}	D	63
Barium (Ba)	ESP	0.00018	0.00035	D	64
Barium (Ba)	FF	0.00023	0.00046	D	63
Beryllium (Be)	FF	3.3×10^{-7}	6.6×10^{-7}	D	63
Calcium (Ca)	ESP	0.12	0.24	E	65
Cadmium (Cd)	ESP	4.2×10^{-6}	8.3×10^{-6}	D	64
Cadmium (Cd)	FF	1.1×10^{-6}	2.2×10^{-6}	D	63
Chloride (Cl)	ESP	0.34	0.68	E	25,42-44
Chloride (Cl)	FF	0.0011	0.0021	D	63
Chromium (Cr)	ESP	3.9×10^{-6}	7.7×10^{-6}	E	64
Chromium (Cr)	FF	7.0×10^{-5}	0.00014	D	63
Copper (Cu)	FF	0.0026	0.0053	E	62
Fluoride (F)	ESP	0.00045	0.00090	E	43
Iron (Fe)	ESP	0.0085	0.017	E	65
Hydrogen chloride (HCl)	ESP	0.025	0.049	E	41,65
Hydrogen chloride (HCl)	FF	0.073	0.14	D	59,63
Mercury (Hg)	ESP	0.00011	0.00022	D	64
Mercury (Hg)	FF	1.2×10^{-5}	2.4×10^{-5}	D	11,63
Potassium (K)	ESP	0.0090	0.018	D	25,42-43
Manganese (Mn)	ESP	0.00043	0.00086	E	65
Ammonia (NH_3)	FF	0.0051	0.010	E	59
Ammonium (NH_4)	ESP	0.054	0.11	D	25,42-44
Nitrate (NO_3)	ESP	0.0023	0.0046	E	43
Sodium (Na)	ESP	0.020	0.038	D	25,42-44
Lead (Pb)	ESP	0.00036	0.00071	D	64
Lead (Pb)	FF	3.8×10^{-5}	7.5×10^{-5}	D	63
Sulfur trioxide (SO_3)	ESP	0.042	0.086	E	25
Sulfur trioxide (SO_3)	FF	0.0073	0.014	D	24,30,50
Sulfate (SO_4)	ESP	0.10	0.20	D	25,42-44
Sulfate (SO_4)	FF	0.0036	0.0072	D	30,33,52

Table 11.6-9 (cont.).

Pollutant Name		Type Of Control	Average Emission Factor		EMISSION FACTOR RATING	References
			kg/Mg	lb/ton		
	Selenium (Se)	ESP	7.5x10^{-5}	0.00015	E	65
	Selenium (Se)	FF	0.00010	0.00020	E	62
	Thallium (Th)	FF	2.7x10^{-6}	5.4x10^{-6}	D	63
	Titanium (Ti)	ESP	0.00019	0.00037	E	65
	Zinc (Zn)	ESP	0.00027	0.00054	D	64
	Zinc (Zn)	FF	0.00017	0.00034	D	63
Organic Pollutants						
CASRN[b]	Name					
35822-46-9	1,2,3,4,6,7,8 HpCDD	FF	1.1x10^{-10}	2.2x10^{-10}	E	62
	C3 benzenes	ESP	1.3x10^{-6}	2.6x10^{-6}	E	65
	C4 benzenes	ESP	3.0x10^{-6}	6.0x10^{-6}	E	65
	C6 benzenes	ESP	4.6x10^{-7}	9.2x10^{-7}	E	65
208-96-8	acenaphthylene	FF	5.9x10^{-5}	0.00012	E	62
67-64-1	acetone	ESP	0.00019	0.00037	D	64
100-52-7	benzaldehyde	ESP	1.2x10^{-5}	2.4x10^{-5}	E	65
71-43-2	benzene	ESP	0.0016	0.0031	D	64
71-43-2	benzene	FF	0.0080	0.016	E	62
	benzo(a)anthracene	FF	2.1x10^{-8}	4.3x10^{-8}	E	62
50-32-8	benzo(a)pyrene	FF	6.5x10^{-8}	1.3x10^{-7}	E	62
205-99-2	benzo(b)fluoranthene	FF	2.8x10^{-7}	5.6x10^{-7}	E	62
191-24-2	benzo(g,h,i)perylene	FF	3.9x10^{-8}	7.8x10^{-8}	E	62
207-08-9	benzo(k)fluoranthene	FF	7.7x10^{-8}	1.5x10^{-7}	E	62
65-85-0	benzoic acid	ESP	0.0018	0.0035	D	64
95-52-4	biphenyl	ESP	3.1x10^{-6}	6.1x10^{-6}	E	65
117-81-7	bis(2-ethylhexyl)phthalate	ESP	4.8x10^{-5}	9.5x10^{-5}	D	64
74-83-9	bromomethane	ESP	2.2x10^{-5}	4.3x10^{-5}	E	64
75-15-0	carbon disulfide	ESP	5.5x10^{-5}	0.00011	D	64
108-90-7	chlorobenzene	ESP	8.0x10^{-6}	1.6x10^{-5}	D	64
74-87-3	chloromethane	ESP	0.00019	0.00038	E	64
218-01-9	chrysene	FF	8.1x10^{-8}	1.6x10^{-7}	E	62
84-74-2	di-n-butylphthalate	ESP	2.1x10^{-5}	4.1x10^{-5}	D	64
53-70-3	dibenz(a,h)anthracene	FF	3.1x10^{-7}	6.3x10^{-7}	E	62
101-41-4	ethylbenzene	ESP	9.5x10^{-6}	1.9x10^{-5}	D	64
206-44-0	fluoranthene	FF	4.4x10^{-6}	8.8x10^{-6}	E	62
86-73-7	fluorene	FF	9.4x10^{-6}	1.9x10^{-5}	E	62
50-00-0	formaldehyde	FF	0.00023	0.00046	E	62

Table 11.6-9 (cont.).

Pollutant		Type Of Control	Average Emission Factor		EMISSION FACTOR RATING	References
CASRN[b]	Name		kg/Mg	lb/ton		
	freon 113	ESP	2.5×10^{-5}	5.0×10^{-5}	E	65
193-39-5	indeno(1,2,3-cd)pyrene	FF	4.3×10^{-8}	8.7×10^{-8}	E	62
78-93-3	methyl ethyl ketone	ESP	1.5×10^{-5}	3.0×10^{-5}	E	64-65
75-09-2	methylene chloride	ESP	0.00025	0.00049	E	65
	methylnaphthalene	ESP	2.1×10^{-6}	4.2×10^{-6}	E	65
91-20-3	naphthalene	FF	0.00085	0.0017	E	62
91-20-3	naphthalene	ESP	0.00011	0.00022	D	64
85-01-8	phenanthrene	FF	0.00020	0.00039	E	62
108-95-2	phenol	ESP	5.5×10^{-5}	0.00011	D	64
129-00-0	pyrene	FF	2.2×10^{-6}	4.4×10^{-6}	E	62
100-42-5	styrene	ESP	7.5×10^{-7}	1.5×10^{-6}	E	65
108-88-3	toluene	ESP	0.00010	0.00019	D	64
	total HpCDD	FF	2.0×10^{-10}	3.9×10^{-10}	E	62
3268-87-9	total OCDD	FF	1.0×10^{-9}	2.0×10^{-9}	E	62
	total PCDD	FF	1.4×10^{-9}	2.7×10^{-9}	E	62
132-64-9	total PCDF	FF	1.4×10^{-10}	2.9×10^{-10}	E	62
132-64-9	total TCDF	FF	1.4×10^{-10}	2.9×10^{-10}	E	62
1330-20-7	xylenes	ESP	6.5×10^{-5}	0.00013	D	64

[a] Factors are kg/Mg and lb/ton of clinker produced. SCC = Source Classification Code. ESP = electrostatic precipitator. FF = fabric filter.

[b] Chemical Abstract Service Registry Number (organic compounds only).

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APPENDIX B
PUBLIC PARTICIPATION PROCEDURES

PUBLIC PARTICIPATION PROCEDURES
for
EPA'S EMISSIONS ESTIMATION GUIDANCE MATERIALS

Introduction and Purpose

The purpose of this report is to document and publicize the public participation procedures which the U.S. Environmental Protection Agency (EPA) will follow for the submittal, evaluation, and revision or addition of air pollutant emission factors and other emission estimation techniques. The procedures provide the public with the opportunity to participate in the establishment of emission factors and techniques both by the submittal of new material and by the evaluation of that material via a public review process. These procedures are required by Section 130 of the Clean Air Act of 1990. Revisions or additions submitted and evaluated per these procedures and subsequently accepted by EPA will be incorporated into EPA's publication "Compilation of Air Pollutant Emission Factors", Volume I, Stationary Sources, or Volume II, Mobile Sources (AP-42), and its' associated databases.

Background

EPA has compiled results from various emissions testing programs for over 25 years in AP-42. The results are most often presented as the mass of emissions expected per unit of process throughput. These quotients are generally referred to as emission factors, and they are often useful for estimating emissions from processes similar to those tested. Such estimates are most appropriately used to develop the area-wide emission inventories used for air quality modeling and control strategy development. In addition to AP-42, EPA has distributed a number of guidance documents, memoranda and computer databases containing emission factors, some of which do not appear in AP-42. Examples of these materials are "Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone" (EPA-450/4-91-016), "Locating and Estimating Air Emissions from Sources of Styrene" (EPA-454/R-93-011), the Factor Information Retrieval database system (FIRE), the Volatile Organic Compound (VOC)/Particulate Matter (PM) Speciation Data System (Speciate), the MOBILE5 model, and various memoranda on estimating emissions from particular area source categories issued by the Emissions Inventory Branch.

For several years EPA has solicited comments on draft sections of AP-42 and other emissions estimation guidance from trade associations, environmental organizations, State and local air pollution agencies, and individual industry experts. EPA has also worked cooperatively with several trade associations to gather data in support of emission factor development. Both of these types of interactions are expected to continue in the future using the procedures described herein. These procedures extend the opportunity to participate in the development and evaluation of the EPA's emission factor guidance materials to any member of the public.

The Clean Air Act Amendments of 1990 renewed and strengthened national efforts to reduce air pollution. In particular, Title I of the Amendments addressed the continuing problem of high ambient ozone levels in many areas of the U.S., resulting in their designation as "ozone non-attainment areas". The Amendments require comprehensive emission inventories and control strategies to reduce ambient ozone concentrations. Much of the emission inventory data on which control strategies are developed are based on emission factors. Therefore, it is critical that these factors be accurate and current. The 1990 Amendments recognized this and made provisions to ensure that timely and accurate data are used.

Section 804 of the 1990 Amendments addressed the revision process for emission factors by adding Section 130 to Part A of Title I of the Act. Section 130 states:

> "Within 6 months after enactment of the Clean Air Act Amendments of 1990, and at least every 3 years thereafter, the Administrator shall review and, if necessary, revise, the methods (emission factors) used for the purposes of this Act to estimate the quantity of emissions of carbon monoxide, volatile organic compounds, and oxides of nitrogen from sources of such air pollutants (including area and mobile sources).
>
> "In addition, the Administrator shall establish emission factors for sources for which no such methods have previously been established by the Administrator. The Administrator shall permit any person to demonstrate improved emissions estimating techniques, and following approval of such techniques, the Administrator shall authorize the use of such techniques. Any such technique may be approved only after appropriate public participation. Until the Administrator has completed the revision required by this section, nothing in this section shall be construed to affect the validity of emission factors established by the Administrator before the date of the enactment of the Clean Air Act Amendments of 1990."

As seen, the 1990 Amendments reinforced the role of public participation in the emission factor development process. Anyone in the public is allowed to submit data to establish new emission factors, revise existing emission factors, or demonstrate improved emissions estimating techniques. (For purposes of this discussion, EPA is considering emission factors, emissions estimating techniques, and methods of estimating as interchangeable terms.) The EPA is to evaluate these data and, if found acceptable, approve their use. Any approvals of new or revised emission factors, whether originating from EPA or the public, can occur only after the public has had sufficient opportunity to review and comment.

Scope and Limitations

These procedures allow anyone to submit for review emission estimating techniques for any air pollutants emitted by any stationary point or area source or mobile source, regardless of whether or not the source is currently addressed by either Volume of AP-42. The procedures can be used to request revisions to existing factors or to establish emission factors for sources not yet addressed by EPA. Information may be submitted at any time and may address any aspect of AP-42 or any other EPA emissions estimating materials.

Although Section 130 requires these procedures to be established only for carbon monoxide (CO), oxides of nitrogen (NO_x), and volatile organic compounds (VOC), EPA intends to follow the same general procedures to address any criteria, toxic, or other air pollutant, although not necessarily under the same priority.

These procedures are **not** a means for individual facilities to obtain EPA approval of a site-specific emission factor or to determine the appropriateness of applying a published EPA factor to a specific facility. EPA does not approve site-specific factors or judge the appropriateness of its factors for specific facilities. The responsibility for such decisions continues to be that of the State or local regulating authority, as well as the facility operators themselves.

EPA's published emission factors are intended to provide an affordable method of estimating emissions where no better data are available. They are best used to characterize the total emissions loading of a large geographic area containing many individual facilities. Therefore, these factors attempt to represent a typical or average facility or process in a given industry. EPA recognizes that other methods of obtaining emissions estimates may be more accurate than industry-average emission factors, and encourages the use of better methods whenever the source and/or the State or local regulating authority is able to support those methods. Methods which may provide more accurate estimates when properly applied include continuous emissions monitors

(CEMs), source testing, material balances, and engineering calculations. (See Introduction to AP-42 for further details.)

Procedures for Submittal and Evaluation of Techniques

1. A request for revision or addition of an emissions estimating technique or any other aspect of AP-42 or other emissions estimation guidance should be submitted in writing to EPA at the following address:

   Leader, Emission Factor and Inventories Group
   MD-14
   USEPA
   Research Triangle Park, NC 27711

   The section Initial EPA Review for Completeness and Applicability contains a list of the items that must be addressed by a request in order for it to be considered complete and widely applicable. The section EPA Review for Technical Acceptability contains the criteria that EPA will use to evaluate whether the request is technically acceptable. The requestor should be familiar with the material in both of these sections and should ensure that their request addresses all items.

2. EPA will perform a first-step review of the request for completeness and applicability using the criteria given in the section Initial EPA Review for Completeness and Applicability. The requestor should be familiar with the items listed in that section and should ensure that their request addresses all required items. The emission source for which information is submitted should be non-unique and the emission estimation technique should be widely applicable to similar sources in order to be considered further by EPA. EPA will inform the requestor of its evaluation of completeness and applicability within 30 days of receipt of the request.* If the request is deemed complete and applicable, EPA will place a notice to the public describing the requested revision(s) on the Clearinghouse for Inventories and Emission Factors (CHIEF) area of the Office of Air Quality Planning and Standards' (OAQPS) Technology Transfer Network (TTN) bulletin board system. This notice will identify the existing public review group members to receive EPA's initial recommendation, and it will solicit additional members. (See Procedures for Participating as a Public Reviewer). If deemed incomplete or not widely applicable by EPA, the requestor may amend and resubmit the request.

3. After finding the request complete and applicable, EPA will begin an internal review for technical acceptability. Appendix B describes the criteria that EPA will use to evaluate the proposed revisions for acceptability. Requestors should be familiar with the criteria in EPA Review for Technical Acceptability and should evaluate their own request before submittal to ensure that all criteria are adequately addressed. EPA may have to prioritize requests for technical review if a large number are received at one time. Priority will be established based upon the guidelines given in the section Factors for Prioritizing Technical Reviews.

4. EPA will issue its initial recommendation to accept or reject the submitted revisions within 90 days of beginning the technical review.*   This initial recommendation will be described in a second notice to the public on the CHIEF bulletin board. The request (including items 1 through 12 of the section Initial EPA Review for Completeness and Applicability) and the initial recommendation will be sent to the public review group, including anyone who has been added to the group during the 90-day technical review period. (See Procedures for Participating as a Public Reviewer). Detailed test reports (item 13 of the section Initial EPA Review for Completeness and Applicability) will not ordinarily be sent to the public review group. They will be sent to individual reviewers upon request, and thus, they must be non-

confidential.

5. Members of the public review group will submit their individual review comments to EPA within 90 days of receipt of the review package. Public reviewers should review the material for the same attributes addressed by EPA (see EPA Review for Technical Acceptability).

6. EPA will consider the review comments and issue a final decision via a third notice on the CHIEF bulletin board within 30 days.[*] The final decision notice will summarize the comments and describe any changes made to the initial recommendation. EPA's acceptance or rejection of any or all public reviewer's comments are final. Any changes or additions to the estimation guidance are considered "authorized" as of the date of the final notice. These changes will be reflected in the next possible update to AP-42, FIRE, guidance documents or memos.

* Deadlines for review may be extended based upon the volume and complexity of the material and other considerations. All time frames given in terms of Calendar Days, not Business or Working Days.

Procedures for Participating as a Public Reviewer

In addition to the opportunity to submit information on new or revised estimation techniques, the public may also participate by reviewing EPA's initial recommendations of whether to add or revise techniques through a public review process. Individuals may request to be on the public review group for one or more sections. Such requests should be made to EPA in writing at the address given above in item 1 of Procedures for Submitting and Evaluating Techniques. These requests may also be made via the CHIEF area of the OAQPS TTN bulletin board system. The request must identify the specific sections of AP-42 that the person is interested in reviewing.

EPA has established a list of contacts for each AP-42 section from previous and ongoing efforts to revise AP-42. This list is currently used as the starting point for developing a list of interested reviewers for draft sections. A draft section is typically sent for review to about a dozen individuals representing trade associations, environmental groups, State and local air agencies, and individual companies. EPA will use this established list as the initial public review group for complete requests submitted per these procedures. This initial public review group list will be publicized on the CHIEF area of the TTN bulletin board system as part of the notice that a request has been deemed complete and applicable. (See item #3 above.) Individuals requesting membership before the date of the initial recommendation will be sent the public review package and will be added to that section's public review group list for any future updates.

Reviewers can have their names removed from the list by contacting EPA in writing or via the CHIEF area of the TTN at the address given above in item 1 of Procedures for Submitting and Evaluating Techniques. Reviewers may also be removed from the list by EPA if they do not respond to a public review package. A "no comment" response will be sufficient to show continuing interest in order to keep the reviewer on the review list for future revisions. EPA invites and encourages any member of the public to participate in the development of improved emissions estimation techniques according to these procedures.

Initial EPA Review for Completeness and Applicability

EPA encourages the submission of any data (including industry/process descriptions, diagrams, etc.) that a submitter believes may be useful in the Agency's ongoing effort to review and revise the emission factor information presented in AP-42. Each submittal will be carefully evaluated according to the criteria and will be adopted for publication where appropriate.

In evaluating proposed emission estimation techniques from the public, EPA will conduct a two-step internal review prior to an external public review. The first step of the internal review is to ensure that all of the necessary information to conduct an evaluation has been submitted, and that the proposed technique is widely applicable to similar sources. The second step is the actual evaluation of the technique for technical acceptability. The result of the second step of the internal EPA review is an "Initial Recommendation" to accept or reject the proposed revisions. The Initial Recommendation and supporting materials are then reviewed by a public review group before a final decision is made.

This section describes the minimum information that must be submitted for EPA to perform the first step of internal review for completeness and applicability. EPA will not begin the second step of internal review for technical acceptability until the material has passed the first step review. The criteria EPA will use for the second step technical evaluation are given in the section EPA Review for Technical Acceptability. Listed below are the items that EPA will review for the first step completeness and applicability review. The submitter should insure that their proposal adequately addresses all of the following items in order to receive further consideration.

1. Submitter's Name, Mailing Address, and Phone

2. Contact Name, Address, and Phone (if different from Submitter)

3. AP-42 section, guidance document, or database affected

4. Description of emission source affected
   (Include SCC codes if available and process flow chart if applicable)

5. Estimated number of facilities affected

6. Estimated total emissions affected

7. Description of proposed change or addition. Identify whether an estimation technique, process description, both, or other change or addition is being proposed. Also identify which of the following cases the request addresses:

   a. A change to an existing estimation technique or factor without alteration of the source description. (e.g., "The NOx emission factor for Wall-fired Utility boilers burning subbituminous coal should be changed from 21 to 17 based on new source tests".)
   b. An estimation technique or factor for one or more new source descriptions resulting from a finer division of an existing source description to distinguish alternative processes. (e.g., "The NOx emission factor for Wall-fired Utility boilers burning subbituminous coal should be subdivided to distinguish single-wall fired from double wall-fired boilers, based on an analysis of existing source tests which shows a significant difference in emission rates between the two.")
   c. An estimation technique or factors for a finer level of resolution of an existing source description and its technique or factor. (e.g., "The VOC emission factor for a complete fabric printing operation should be subdivided into individual processes so that emissions from dryers can be estimated and controlled separately.")
   d. An estimation technique for a source not currently addressed by EPA.

8. New or marked-up text of the proposed revision to AP-42, guidance document, or database citation, which clearly shows where the existing text is affected.

9. Brief description of the type and source of data or analyses supporting the request. Material balances and other analyses will be considered. If revision to an existing factor is proposed, the description should include the data supporting the current factor as well as any new data being submitted. If submittal is for Case a (see item 7 above), describe why the current factor is inadequate and why the submitted data should be considered superior to data supporting current factor. If submittal is for Cases b or c, describe why the more detailed source description is required, and why emissions are different. In all cases, describe the extent of the data available or the analyses done to develop the factor or estimation technique.

10. Estimate of the range or uncertainty of the estimation technique.

11. Describe what effect(s) the proposed change might have on your facility (e.g., it will affect the fee the company pays, it will affect the regulation applicable to the source, etc.).

12. Any significant issues associated with the request (e.g., no standard test method exists, test method used is different from that used for the existing factor, definition of pollutant is unclear).

13. All data and analyses necessary to support the request, including test reports, material balance logs, data evaluations, etc.

14. If test data are submitted:
    a. Is the point tested clearly identified?
    b. Were process parameters monitored and recorded?
    c. Were process parameters within normal ranges?
    d. Are upsets and deviations described and explained?
    e. Are the test methods and procedures described?
    f. Are the methods compatible with approved EPA methods?
    g. Is there enough detail for EPA to validate the procedures?
    h. Are deviations from the normal procedures identified?
    i. Are original raw data and field data sheets included?
    j. Are QA/QC procedures described?

EPA Review for Technical Acceptability

The second step of the review begins once all of the information has been received from the submitter. The submitter is encouraged to review the following information carefully in order to understand the manner in which submitted information will be evaluated and the criteria used by EPA to determine whether changes to the AP-42 are warranted. The submitter should also be familiar with the guidelines issued by EPA for preparation and quality rating of emission factors ("Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections", EPA-454/B-93-050, and any subsequent revisions).

It might be useful to first outline the type of test data that is not considered acceptable in making revisions to AP-42 emission factors. This will help the submitter avoid proposing unacceptable emission estimation techniques. The following data generally are excluded from consideration:

1. Test data or averages reported in units that cannot be converted to appropriate reporting units.

2. Test series for which the test method is not described or is incompatible with existing EPA

approved methods.

3. Test series on controlled emissions for which the control device is not specified or is insufficiently described.

4. Test series in which it is not stated whether the measured emissions were controlled or uncontrolled.

5. Test series in which the process is not clearly identified and described.

6. Test data for which the QA/QC procedures are not clearly defined and documented.

Parties with data to submit should screen the data to ensure that they satisfy these basic requirements.

EPA's guidelines are intended to ensure consistency in the reporting of emission factors for AP-42. However, the background information and data for each source category will vary with respect to volume and soundness. For this reason, the Agency exercises a certain degree of flexibility in evaluating the submitted emissions data. In the case of existing factors based on limited data, a small amount of new data may be sufficient to prompt a revision to the emission factors. Where extensive data were available to support the factors initially, more new data would likely be needed to support a change in the factors.

Each source test that passes preliminary EPA approval is assigned a rating. A rating system is needed because some data might be used when little other information is available, but would be excluded if sufficient high-quality data were already available. The current version of "Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections" should be consulted for the details of the source test rating criteria.

The emission factors presented in AP-42 generally represent single-value statistical averages determined by engineering judgement to be representative of the available data for a specific source category operation. These results are reduced to a single value representing any of various statistical parameters, including arithmetic mean and median. In the ideal case, a large number of A-rated source tests representing a cross-section of the industry would be reduced to a single value which serves as the emission factor. However, if the number of A-rated tests is so limited that the inclusion of lower-rated tests would improve the robustness of the emission factor, then the lower-rated test data are included in the compilation of the average value, which would then receive an appropriately lower emission factor quality rating.

Normally, emission factors are grouped in tables representing source operations or related groups of operations within a source category. The reliability of these factors is indicated by an overall rating factor ranging from A (excellent) to E (poor). These ratings take into account the type and amount of data from which the factors were calculated. As in the case of the source test ratings, the current version of "Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections" should be consulted for the details of the emission factor rating process.

Factors for Prioritizing Technical Reviews

In the event that EPA does not have adequate resources to evaluate all submitted materials, the following criteria will be used to determine the priority for material to be reviewed.

1. Estimating techniques for sources for which EPA does not currently have a technique will receive top priority, unless the estimated magnitude of emissions for the source category is judged

insignificant by EPA.

2. Estimating techniques for significant sources which currently have D, E, or Unrated emission factors will receive next priority.

3. Estimating techniques for sources with an existing emission factor which has not been revised to represent newer process technology or test methods will receive third priority.

4. Sources categories for which the total national impact is greater will receive higher priority than lesser impact categories. Consideration of national impact will take into account the magnitude of emissions nationwide, the concentration of emission sources, and the toxicity of the pollutants to be estimated. A large difference between two requests in total impacts may be sufficient to overcome the priorities established by items 1, 2, and 3, above.

5. Source categories which are being or will shortly be considered by EPA for regulation will receive lower priority, to avoid duplication of the detailed review to be done as part of the regulatory process.

Internal Procedures

1. The EFIG Group Leader receives the request, logs it in, and assigns a lead reviewer. The lead reviewer will usually be the person responsible for the affected chapter or section of AP-42.

COMPLETE BY DAY 5

2. The lead reviewer checks the submitted material for completeness. If the request is complete the lead reviewer will place the first notice ("Complete request for Section X.XX has been received") on the CHIEF Bulletin Board and will assemble an internal technical review panel. The first notice should also identify the members of the existing public review group and solicit additional members. If the request is incomplete the lead reviewer will inform the submitter of such. The lead reviewer should place the first notice on the bulletin board OR notify the submitter that the request is incomplete or not applicable OR notify the submitter that an extension of the first step review time is necessary within 30 days of EPA's receipt of the request.

COMPLETE BY DAY 35

3. The internal technical review panel should be assembled as soon as possible, since the 90-day clock for their review begins with the placing of the first notice on CHIEF. The panel should consist of the lead reviewer and the EFIG Group Leader, as a minimum. A representative of ESD should be added if a MACT source category may be affected. A representative of IGES should be added if the request concerns an area source estimation method or otherwise significantly impacts inventory totals. A representative of EMB should be added if the submittal includes any significant stack testing issues. Representatives of AQMD or any other relevant groups may be added as deemed necessary by the lead reviewer.

   The lead reviewer is responsible for making the initial recommendation of whether to accept or reject the submitted material, after considering input from all technical review panel members. This determination should be shared with the panel members at least a week before the recommendation is to be placed on the bulletin board, to allow for resolution of any objections from panel members. The lead reviewer should place the Initial Recommendation (second notice), whether yea or nay, on the CHIEF Bulletin Board within

90 days of the date of the Completeness determination (first notice).

COMPLETE BY DAY 125

4. The lead reviewer will add anyone to the public review group who has submitted such a request by the date of the Initial Recommendation, and will mail copies of the review package to the group immediately after the second notice is placed.

COMPLETE BY DAY 126

5. The lead reviewer should receive comments from the external public review group within 90 days of mailing the review packages out. This should allow for at least 75 days of review after allowing for transit and distribution times.

COMPLETE BY DAY 216

6. The lead reviewer should summarize the public review group's comments and place the Final Decision (third notice) on the bulletin board within 30 days. The lead reviewer will also ensure that AP-42, FIRE, or other affected materials are appropriately revised. The lead reviewer will also ensure that public group reviewers who did not respond to the mailing are removed from the public group reviewer list for that AP-42 section.

COMPLETE BY DAY 246

Note: All time frames given in terms of Calendar Days, not Business or Working Days.

APPENDIX C

F FACTOR METHOD

Summary of F-Factor Methods for Determining Emissions from Combustion Sources

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July, 1976

*Taken from Source Evaluation Society Newsletter, Vol. l, No. 4, November 1976

SUMMARY OF F FACTOR METHODS FOR DETERMINING EMISSIONS FROM COMBUSTION SOURCES

R. T. Shigehara, R. M. Neulicht, W. S. Smith, and J. W. Peeler

INTRODUCTION

The Federal Standards of Performance for New Stationary Sources, regulating particulate matter, sulfur dioxide, and nitrogen oxide emissions from fossil fuel-fired steam generating units, are expressed in terms of pollutant mass per unit of heat input. Many State regulations for combustion equipment are expressed in the same form. To arrive at this emission rate, the original method required the determination of the pollutant concentration, effluent volumetric flow rate. and heat input rate. In the October 6, 1975, Federal Register[2], an "F factor" technique, which required only the determination of the fuel type, pollutant concentration and the oxygen (O_2) concentration, was promulgated as a procedure to replace the original method. At the same time. an F Factor approach, based on either O_2 or carbon dioxide (CO_2) measurements, was promulgated for use in reducing the pollutant concentration data obtained under the continuous monitoring requirements to the desired units. Recently, wet F Factors[3], which allow the use of wet basis measurements of the same parameters, and F Factors for wood and refuse have been calculated.

The purpose of this paper is to summarize the various methods and to present the calculated F Factor values for the different types of fuels. The various uses of F Factors and errors involved in certain applications and conditions are also discussed.

SUMMARY OF METHODS

The first method, referred to simply as the F Factor Method, is based on two principles:

1. The ratio of the quantity of dry effluent gas generated by combustion to the gross calorific value of the fuel is a constant within any given fuel category. This ratio is normally called the dry F Factor; however, for purposes of-this paper, it will be called the F_d Factor.

2. An excess air correction factor may be expressed in terms of the dry oxygen content of the effluent stream. The use of this method requires dry basis measurements of the pollutant concentration (C_d) and percent oxygen ($\%O_{2d}$). The emission rate (E) is calculated by the equation:

$$E = C_d F_d \left[\frac{20.9}{20.9 - \%O_{2d}} \right] \tag{1}$$

If the moisture content of the flue gas (B_{ws}) is determined, a natural derivative of Equation 1, which would allow direct wet basis measurements of pollutant and oxygen concentrations, i.e. C_w

and $\%O_{2w}$, respectively, is as follows;

$$E = C_w F_d \left[\frac{20.9}{20.9(1 - B_{ws}) - \%O_{2w}} \right] \tag{2}$$

This equation has been approved in principle by the Environmental Protection Agency and may be used if it is demonstrated that B_{ws} can be accurately determined and that any absolute error in B_{ws} will not cause an error of more than ± 1.5 percent in the term:

$$\frac{20.9}{20.9(1 - B_{ws}) - \%O_{2w}}$$

The second technique, called the F_w Factor Method, is based on the same two principles as the F_d Factor Method, except that the two quantities, the effluent gas and the oxygen concentration, are determined on a wet basis. The ratio of the quantity of wet effluent gas generated by combustion to the gross calorific value of the fuel is called the wet F Factor or the F_w Factor. The use of this technique, however, requires in addition to the wet pollutant concentration (C_w) and oxygen ($\%O_{2w}$) the determination of the fractional moisture content of the air (B_{wa}) supplied for combustion. (Guidelines for this determination will be discussed later.) The equation for calculating the emission rate is:

$$E = C_w F_w \left[\frac{20.9}{20.9(1 - B_{wa}) - \%O_{2w}} \right] \tag{3}$$

This equation is a simplification of the theoretically derived equation.[3] Under typical conditions, a positive bias of no more than 0.25 percent is introduced.

The third procedure, the F_c Factor Method, is based on principles related to but slightly different than those for the F_d Factor and F_w Factor Methods:

1. For any given fuel category, a constant ratio exists between the volume of carbon dioxide produced by combustion and the heat content of the fuel. This ratio is called the F_c Factor.

2. The ratio of the theoretical carbon dioxide produced during combustion and the measured carbon dioxide provides an exact basis for dilution correction.

This method requires measurement of the pollutant concentration and percent carbon dioxide

($\%C0_2$) in the effluent stream. Measurements may be made on a wet or dry basis. Using the subscripts, "d" and "w", to denote dry and wet basis measurements, respectively, the equations for calculating E are:

$$E = C_d F_c \left(\frac{100}{\%CO_{2d}} \right) = C_w F_c \left(\frac{100}{\%CO_{2w}} \right) \tag{4}$$

DETERMINATION OF F FACTORS

Values of F_d in dscf/10^6 Btu, F_w in wscf/10^6 Btu, and F_c in scf/10^6 Btu, may be determined on an individual case-by-case basis using the ultimate analysis and gross calorific value of the fuel The equations are:

$$F_d = \frac{10^6(3.64\%H + 1.53\%C + 0.57\%S + 0.14\%N - 0.46\%O)}{GVC} \tag{5}$$

$$F_w = \frac{10^6(5.57\%H + 1.53\%C + 0.57\%S + 0.14\%N - 0.46\%O + 0.21\%H_2O*)}{GVC} \tag{6}$$

$$F_c = \frac{10^6(0.321\%C)}{GVC} \tag{7}$$

where = H, C, S, N, O, and H_2O are the concentrations by weight (expressed in percent) of hydrogen, carbon, sulfur, nitrogen, oxygen, and water from the ultimate analysis. (*Note: The $\%H_2O$ term may be omitted if %H and %O include the unavailable hydrogen and oxygen in the form of H_20.) GCV is the gross calorific value in Btu/lb of the fuel and must always be the value consistent with or corresponding to the ultimate analysis.

For determining F_w, the ultimate analysis and GCV_w must be on an "as received" or "as fired" basis, i.e., it must include the free water. Often in practice, the ultimate analysis and/or gross calorific value of a particular fuel are not known. For most commonly used fuels, tabulated average F Factors may be used instead of the individually determined values. These average values of F_d, F_w, and F_c, calculated from data obtained from the literature[2-14] are given in Table I. F Factors for wood and bark are also listed in Table I, and factors for various types of refuse are listed in Table II

ULTIMATE CARBON DIOXIDE

The ratio of F_c to F_d times 100 yields the ultimate percent CO_2 or the maximum CO_2 concentration that the dry flue gas is able to attain. By dividing this number into 20.9, a ratio called the F_o Factor is obtained. F_o values calculated from the ultimate analyses of the various fuels are given in Tables I and II.

F_o values can also be calculated from CO_2 and O_2 data obtained in the field by using the following equation.

$$F_o = \frac{20.9 - \%O_{2d}}{\%CO_{2d}} \qquad (8)$$

These calculated F_o values can be used to check Orsat data or other analyses of CO_2 and O_2 that have been adjusted to a dry basis. The process simply involves comparing F_o values calculated from Equation 8 with the values listed in Table I or II. Further details of this validation procedure are outlined in Reference 15.

ERRORS AND APPLICATION

The derivations of Equations l through 4 are discussed in References 3, 4, and 5. The following discussion gives further explanation of the F Factors and describes some of the problems and errors that arise in applying the F Factor Methods. Several uses for F Factors in addition to calculating emission rates are outlined.

Deviation in F Factors

The F Factors were calculated from data obtained from the literature. In the October 6, 1975, Federal Register[2] the values of F_d and F_c were calculated by summing all data points and dividing by the total number of samples. Then the deviations from the extreme values (highest and lowest) were determined. The higher of the two values, termed "maximum percent deviation from the average F Factors," are listed in parenthesis in Table I. These deviations are probably due to differences in the composition of the fuel, and may also include variations due to the analytical methods and analysts (laboratories). The standard deviations of the samples were not calculated since much of the data were already averages of several samples and there may have been more samples from one locale or of one kind than another.

After publication of the F_d and F_c Factors, it was determined that the midpoint value would be a better value than the average for small samples and for data taken from the literature. Therefore, the F_w Factors and the values for wood and refuse are midpoint values rather than arithmetic averages. The associated deviations are termed, "maximum percent deviation from the midpoint F Factor."

F_w Factors for refuse, wood, and wood bark were not calculated because of the high variability of free moisture contents. For example, the moisture in bark may vary from 20 percent (air dried) to 75 percent (hydraulic debarking).[6] Free moisture content variations of ± 15 percent introduce about 5 percent variations. However, for lignite, the moisture contents vary only from about 33 to 45 percent. This range causes a deviation of 3.8 percent from the midpoint F_w Factor, which enabled an F_w Factor to be established.

Incomplete Combustion

The assumption of complete combustion is made in the derivation of all F Factor Methods. If products of incomplete combustion, such as carbon monoxide, are present in the effluent stream, the volume of effluent gas and carbon dioxide per pound of fuel burned will differ from the values used in calculating the F Factors. However, adjustments to the measured CO_2 or O_2 concentration can be made, which would minimize the magnitude of the error when applying Equations 1-5. These adjustments are given by the following equations:

$$(\%CO_2)_{adj} = \%CO_2 + \%CO \tag{9}$$

$$(\%O_2)_{adj} = \%O_2 - 0.5\ \%CO \tag{10}$$

By making these adjustments, the error amounts to minus one-half the concentration of CO present. Thus, if 1 percent CO (an extreme case) is present, an error of minus 0.5 percent is introduced. Without adjusting the CO_2 or O_2 concentration, a combustion source having 11 percent CO_2, 1 percent CO, and 6 percent O_2 will result in about plus 9 percent error for the F_c Factor Method and about plus 3 percent for the F_d Factor and F_w Factor Methods.

Similarly, unburned combustible matter in the ash will cause the volume of effluent gas and carbon dioxide per unit of heat input to differ from the calculated F Factor values. This is true, however, only if the heat input is thought of in terms of the coal input rate times the calorific value. If the heat input rate is considered as only that calorific value which is derived from the combusted matter, the F Factor Methods are only slightly affected. In other words, if any portion of the fuel goes through the combustion process unburned, the F Factor Methods will not include as heat input the calorific value associated with the uncombusted matter, and a slight positive bias will be introduced.

The positive bias is due to the combustion process, which is said to consist first of evaporating the free moisture, then the burning of the volatile matter, and last the burning of the fixed carbon, with the ash remaining. The volatile matter includes hydrogen, which results in a lower F Factor than the calculated values. Since a higher proportion of fixed carbon than volatile matter generally remains in the ash, the F_c Factor Method is affected more than the F_d Factor and F_w Factor Methods. For example, assume that 100 lb of a coal which 55.8% C, 5.7% H, 1.1%N, 3.2% S, 21.5% O, and 12.6% ash (percent by weight, as received basis), is burned and 5 lb fixed carbon remains in the ash. About plus 2.3 percent error is incurred with the F_c Factor and less than 1 percent with the F_d Factor and F_w Factor Methods.

Effect of Wet Scrubbers

When wet scrubbers are used, a portion of the carbon dioxide may be absorbed by the scrubbing solution. Therefore, the F_c Factor Method will yield an emission rate higher than the

actual rate. If a gas stream having 14% CO_2 before the scrubber loses 10 percent of the CO_2, or 1.4% CO_2, the error is about plus 13 percent.

The F_d Factor Method is also affected by the loss of CO_2 in the scrubber, but to a lesser degree than the F_c Factor Method. If the gas stream has 6% O_2 and 1.4% CO_2 is lost in the scrubber, the error will be about plus 2 percent.

The F_w Factor Method is not applicable after wet scrubbers since the scrubber generally adds moisture to the flue gas, thereby "diluting" the gas stream. The pollutant concentration will be lowered by the same proportion of moisture added and the O_2 concentration will be lower than actual, which would tend to yield lower than true numbers.

When the scrubbing solution is lime or limestone, the F_c Factor Method may be used after wet scrubbers. It is generally assumed that due to the optimum operating conditions, the amount of CO_2 absorption is minimized and, therefore, the application of the F_c Factor Method will not yield appreciable errors. However, with limestone scrubbers, there is a possibility of CO_2 being added to the gas stream due to the reaction of SO_2 with the limestone. Therefore, the F_c Factors must be increased by 1 percent.

Determination of Ambient Air Moisture

Guidelines have been developed for the determination of B_{wa}, the moisture fraction in ambient air, in Equation 3, which will soon be published in the Federal Register. The guidelines are presented below.

Approval may be given for determination of B_{wa} by on-site instrumental measurement provided that the absolute accuracy of the measurement technique can be demonstrated to be within ± 0.7 percent water vapor. In lieu of actual measurement, B_{wa} may be estimated as follows:

1. B_{wa}= 0.027. This factor may be used as a constant value at any location.

2. B_{wa}= highest monthly average of B_{wa} that occurred within a calendar year at the nearest Weather Service Station, calculated using data for the past 3 years. This factor may be used on an annual basis at any facility.

3. B_{wa}= highest daily average of B_{wa} that occurred within a calendar month at the nearest Weather Service Station, calculated for each month for the past 3 years used as an estimating factor for the respective calendar month.

(Note that the following estimating factors are selected to assure that any negative error introduced in the emissions by the estimating term:

$$\frac{20.9}{20.9(1-B_{wa})-\%O_{2ws}}$$

will not be larger than -1.5 percent.

However, positive errors, or over-estimation of emissions, of as much as 5 percent may be introduced depending upon the geographic location of the facility and the associated range of ambient moisture.)

Sampling Location and Sampling Points

Ambient air leakage into an exhaust system may cause variations across the duct or stack in the relative concentrations of CO_2 and O_2. For this reason, the Federal regulation[2] specify that CO_2 or O_2 be measured simultaneously and approximately at the same point as the gaseous pollutants measurements.

For particulate emission performance tests, which require traversing, it is specified that the O_2 samples be obtained simultaneously by traversing the duct at the same sampling location used for each run of the Method 5. This requirement may be satisfied by attaching a stainless steel tube to the particulate sampling probe and, using a small diaphragm pump, obtaining an integrated gas sample over the duration of the run (of Reference 1). The sample should be analyzed using an Orsat apparatus.

As an alternative to traversing the same sampling points of Method 5, a minimum of 12 oxygen sampling points may be used for each run. This would require a separate integrated gas sampling train traversing the duct work simultaneously with the particulate run.

Other Applications

In addition to calculating emission rates, F Factors have several other uses. If Q_{sd}, the dry effluent volumetric flow rate, or Q_{sw}, the wet effluent volumetric flow rate, and Q_H, the heat input rate, are measured, a value of F_d, F_w, or F_c may be calculated. These equations are given below:

$$F_{d(calc)}=\frac{Q_{sd}}{Q_H}\quad\frac{20.9-\%O_2}{20.9} \qquad (11)$$

$$F_{w(calc)}=\frac{Q_{sw}}{Q_H}\quad\frac{20.9(1-B_{wa})-\%O_{2w}}{20.9} \qquad (12)$$

$$F_{c(calc)}=\frac{Q_{sd}}{Q_H}\quad\frac{\%CO_{2d}}{100}=\frac{Q_{sw}}{Q_H}\quad\frac{\%CO_{2w}}{100} \qquad (13)$$

The calculated values may then be compared to tabulated values of the F Factors to facilitate a material balance check.

If desired, Q_H can be calculated by using the Equations 11 through 13. In the past, it has been observed that the measurement of Q_S has been significantly greater than the stoichiometric calculations rates. The discrepancy is usually due to errors in determining Q_s. Due to aerodynamic interferences and improper alignment of the pilot tubes, higher than real readings have been obtained. Therefore, errors in measuring Q_S are positive, which leads to higher than true firing rates.

If an ultimate analysis and calorific determination of a particular fuel are made and the F Factor value is calculated, the accuracy of the results may be checked by comparison with the tabulated F Factors.

SUMMARY

The various F Factor Methods have been summarized and calculated F Factors for fossil fuels, wood, wood bark, and refuse material have been presented. In addition, some of the problems and errors that arise in applying the F Factor Method for calculating power plant emission rates were discussed and other uses of the F Factors were outlined.

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TABLE I. F FACTORS FOR VARIOUS FUELS [2-14, a, b, c]

Fuel Type	F_d dscf/10^6 Btu	F_w wscf/10^6 Btu	F_c scf/10^6 Btu	F_o
Coal				
Anthracite	10140 (2.0)	10580 (1.5)*	1980 (4.1)	1.070 (2.9)
Bituminous	9820 (3.1)	10680 (2.7)	1810 (5.9)	1.140 (4.5)
Lignite	9900 (2.2)	12000 (3.8)	1920 (4.6)	1.076(2.8)
Oil	9220(3.0)	10360 (3.5)	1430 (5.1)	1.346(4.1)
Gas				
Natural	8740 (2.2)	10650 (0.8)	1040 (3.9)	1.749 (2.9)
Propane	8740 (2.2)	10240 (0.4)	1200 (1.0)*	1.510 (1.2)*
Butane	8740 (2.2)	10430(0.7)	1260 (1.0)	1.479 (0.9)
Wood	9280 (1.9)*	-------------	1840 (5.0)	1.05 (3.4)
Wood Work	9640 (4.1)	------------	1860 (3.6)	1.056 (3.9)

[a] Numbers in parenthesis are maximum deviations (%) from either the midpoint or average F Factors.

[b] Note: To convert to metric system, multiply the above values by 1.123 x 10^{-4} to obtain scm/10^6 cal.

[c] All numbers below the asterisk (*) in each column are midpoint values. All others are averages.

TABLE II. MIDPOINT F FACTORS FOR REFUSE[2-14,a,b]

	F_d dscf/I0^6 Btu	F_c wscf/10^6 Btu	F_o
Paper and Wood Wastes[c]	9260 (3.6)	1870 (3.3)	1.046 (4.6)
Lawn and Garden Wastes[d]	9590 (5.0)	1840 (3.0)	1.088 (2.4)
Plastics			
Polyethylene	9173	1380	1.394
Polystyrene	9860	1700	1.213
Polyurethane	10010	1810	1.157
Polyvinyl chloride	9120	1480	1.286
Garbage[e]	9640 (4.0)	1790 (7.9)	1.110 (5.6)
Miscellaneous			
Citrus rinds and seeds	9370	1920	1.020
Meet scraps, cooked	9210	1540	1.252
Fried fats	8939	1430	1.310
Leather shoe	9530	1720	1.156
Heel and sole composition	9480	1550	1.279
Vacuum cleaner catch	9490	1700	1.170
Textiles	9354	1840	1.060
Waxed milkcartons	9413	1620	1.040

[a] Numbers in parentheses are maximum deviations (%) from the midpoint F Factors.

[b] To convert to metric system, multiply the above values by 1.123×10^{-4} to obtain scm/10^6 cal.

[c] Includes newspapers, brown paper, corrugated boxes, magazines, junk mail, wood, green logs, rotten timber

[d] Includes evergreen shrub cuttings, flowing garden plants, leaves, grass.

[e] Includes vegetable food wastes, garbage (not described).

APPENDIX D
HAZARDOUS AIR POLLUTANTS

CAA LIST OF 188 COMPOUNDS

Compound	**CAS #**
Acetaldehyde	75-07-0
Acetamide	60-35-5
Acetonitrile	75-05-8
Acetophenone	98-86-2
2-Acetylaminofluorene	53-96-3
Acrolein	107-02-8
Acrylamide	79-06-1
Acrylic acid	79-10-7
Acrylonitrile	107-13-1
Allyl chloride	107-05-1
4-Aminobiphenyl	92-67-1
Aniline	62-53-3
o-Anisidine	90-04-0
Asbestos	1332-21-4
Benzene	71-43-2
Benzidine	92-87-5
Benzotrichloride	98-07-7
Benzyl chloride	100-44-7
Biphenyl	92-52-4
Bis(2-ethylhexyl)phthalate	117-81-7
Bis(chloromethyl)ether	542-88-1
Bromoform	75-25-2
1,3-Butadiene	106-99-0
Calcium cyanamide	156-62-7
Captan	133-06-2
Carbaryl	63-25-2
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Carbonyl sulfide	463-58-1
Catechol	120-80-9
Chloramben	133-90-4
Chlordane	57-74-9
Chlorine	7782-50-5
Chloroacetic acid	79-11-8
2-Chloroacetophenone	532-27-4
Chlorobenzene	108-90-7
Chlorobenzilate	510-15-6
Chloroform	67-66-3
Chloromethyl methyl ether	107-30-2
Chloroprene	126-99-8
Cresols (mixed isomers)	1319-77-3

Compound	**CAS #**
m-Cresol	108-39-4
o-Cresol	95-48-7
p-Cresol	106-44-5
Cumene	98-82-8
2,4-D	94-75-7
DDE	3547-04-4
Diazomethane	334-88-3
Dibenzofuran	132-64-9
1,2-Dibromo-3-chloropropane	96-12-8
Dibutyl phthalate	84-74-2
1,4-Dichlorobenzene	106-46-7
3,3'-Dichlorobenzidine	91-94-1
Dichloroethyl ether (Bis(2-chloroethyl)ether)	111-44-4
1,3-Dichloropropene (1,3-Dichloropropylene)	542-75-6
Dichlorvos	62-73-7
Diethanolamine	111-42-2
N,N-Diethyl aniline (N,N-Dimethylaniline)	121-69-7
Diethyl sulfate	64-67-5
3,3-Dimethoxybenzidine	119-90-4
4-Dimethylaminoazobenzene	60-11-7
3,3-Dimethylbenzidine	119-93-7
Dimethylcarbamyl chloride	79-44-7
Dimethyl formamide	68-12-2
1,1-Dimethyl hydrazine	57-14-7
Dimethyl phthalate	131-11-3
Dimethyl sulfate	77-78-1
4,6-Dinitro-o-cresol	534-52-1
2,4-Dinitrophenol	51-28-5
2,4-Dinitrotoluene	121-14-2
1,4-Dioxane (1,4-Diethyleneoxide)	123-91-1
1,2-Diphenylhydrazine	122-66-7
Epichlorohydrin (1-Chloro-2,3-epoxypropane)	106-89-8
1,2-Epoxybutane (1,2-Butylene oxide)	106-88-7
Ethyl acrylate	140-88-5
Ethylbenzene	100-41-4
Ethyl carbamate (Urethane)	51-79-6
Ethyl chloride (Chloroethane)	75-00-3
Ethylene dibromide (1,2-Dibromoethane)	106-93-4
Ethylene dichloride (1,2-Dichloroethane)	107-06-2
Ethylene glycol	107-21-1
Ethyleneimine (Aziridine)	151-56-4
Ethylene oxide	75-21-8
Ethylene thiourea	96-45-7

Compound	**CAS #**
Ethylidene dichloride (1,1-Dichloroethane)	75-34-3
Formaldehyde	50-00-0
Heptachlor	76-44-8
Hexachlorobenzene	118-74-1
Hexachloro-1,3-butadiene	87-68-3
Hexachlorocyclopentadiene	77-47-4
Hexachloroethane	67-72-1
Hexamethylene-1,6-diisocyanate	822-06-0
Hexamethylphosphoramide	680-31-9
Hexane	110-54-3
Hydrazine	302-01-2
Hydrochloric acid	7647-01-0
Hydrogen fluoride	7664-39-3
Hydroquinone	123-31-9
Isophorone	78-59-1
Lindane	58-89-9
Maleic anhydride	108-31-6
Methanol	67-56-1
Methoxychlor	72-43-5
Methyl bromide (Bromomethane)	74-83-9
Methyl chloride (Chloromethane)	74-87-3
Methyl chloroform (1,1,1-Trichloroethane)	71-55-6
Methyl ethyl ketone	78-93-3
Methyl hydrazine	60-34-4
Methyl iodide (Iodomethane)	74-88-4
Methyl isobutyl ketone (Hexone)	108-10-1
Methyl isocyanate	624-83-9
Methyl methacrylate	80-62-6
Methyl tert-butyl ether	1634-04-4
4,4-Methylenebis(2-chloro)aniline	101-14-4
Methylene chloride (Dichloromethane)	75-09-2
Methylene diphenyl diisocyanate (MDI)	101-68-8
4,4'-Methylenedianiline	101-77-9
Naphthalene	91-20-3
Nitrobenzene	98-95-3
4-Nitrobiphenyl	92-93-3
4-Nitrophenol	100-02-7
2-Nitropropane	79-46-9
N-Nitrosodimethylamine	62-75-9
N-Nitrosomorpholine	59-89-2
N-Nitroso-N-methylurea	684-93-5
Parathion	56-38-2
Pentachloronitrobenzene (Quintozene)	82-68-8

Compound	**CAS #**
Pentachlorophenol	87-86-5
Phenol	108-95-2
p-Phenylenediamine	106-50-3
Phosgene	75-44-5
Phosphine	7803-51-2
Phosphorous	7723-14-0
Phthalic anhydride	85-44-9
PCBs	1336-36-3
1,3- Propane sultone	1120-71-4
beta-Propiolactone	57-57-8
Propionaldehyde	123-38-6
Propoxur (Baygon)	114-26-1
Propylene dichloride (1,2 Dichloropropane)	78-87-5
Propylene oxide	75-56-9
Propylenimine (2-Methyl aziridine)	75-55-8
Quinoline	91-22-5
Quinone	106-51-4
Styrene	100-42-5
Styrene oxide	96-09-3
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6
1,1,2,2-Tetrachloroethane	79-34-5
Tetrachloroethylene (Perchloroethylene)	127-18-4
Titanium tetrachloride	7550-45-0
Toluene	108-88-3
2,4-Toluene diamine	95-80-7
Toluene-2,4-diisocyanate	584-84-9
o-Toluidene	95-53-4
Toxaphene	8001-35-2
1,2,4-Trichlorobenzene	120-82-1
1,1,2-Trichloroethane	79-00-5
Trichloroethylene	79-01-6
2,4,5-Trichlorophenol	95-95-4
2,4,6-Trichlorophenol	88-06-2
Triethylamine	121-44-8
Trifluralin	1582-09-8
2,2,4-Trimethylpentane	540-84-1
Vinyl acetate	108-05-4
Vinyl bromide	593-60-2
Vinyl chloride	75-01-4
Vinylidene chloride (1,1-Dichloroethylene)	75-35-4
Xylene (mixed isomers)	1330-20-7
m-Xylene	108-38-3
o-Xylene	95-47-6

Compound	CAS #
p-Xylene	106-42-3
Antimony compounds	
Antimony	7440-36-0
Arsenic compounds (inorganic including arsine)	
Arsenic	7440-38-2
Arsine	
Beryllium Compounds	
Beryllium	7440-41-7
Cadmium Compounds	
Cadmium	7440-43-9
Chromium compounds	
Chromium	7440-47-3
Cobalt compounds	
Cobalt	7440-48-4
Coke oven emissions	
Cyanide compounds	
(XCN where X=H or any other group where a formal dissociation may occur)	
Hydrogen cyanide	74-90-8
Glycol ethers	
(include mono- and di- ethers of ethylene glycol, diethylene glycol, and triethylene glycol R-(OCH2CH2)n-OR' where n = 1, 2, or 3 R = alkyl or aryl groups R' = R, H, or groups which, when removed, yield glycol ethers with the structure: R-(OCH2CH)n-OH Polymers are excluded from the glycol category	
Lead compounds	
Lead	7439-92-1

Compound	**CAS #**
Manganese compounds	
Manganese	7439-96-5
Mercury compounds	
Mercury	7439-97-6
Mineral fibers (includes glass microfibers, glass wool fibers, rock wool fibers and slag wool fibers, each characterized as "respirable" (fiber diameter < 3.5 micrometers) and possessing an aspect ratio (fiber length divided by fiber diameter) > 3)	
Nickel compounds	
Nickel	7440-02-0
POM (includes organic compounds with more than one benzene ring, and which have a boiling point greater than or equal to 100° C)	
Radionuclides (a type of atom which spontaneously undergoes radioactive decay)	
Selenium compounds	
Selenium	7782-49-2

APPENDIX E

ACRONYMS

ACRONYMS

ACT	Alternative Control Techniques
AMS	Area and Mobile Source
AP-42	*Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources*
APPCD	Air Pollution Prevention and Control Division
BBS	Bulletin Board System
BDL	Below Method Detection Limit
BIDS	Background Information Documents
BTU	British Thermal Unit
CAA	Clean Air Act of 1990
CEMS	Continuous Emission Monitoring System
CHIEF	Clearinghouse for Inventories and Emission Factors
CO	Carbon Monoxide
CTC	Control Technology Center
CTG	Control Techniques Guidelines
EFIG	Emission Factors and Inventory Group
EMTIC	Emission Measurement Technical Information Center
ESD	Emission Standard Division
FIRE	Factor Information Retrieval System
HAPs	Hazardous Air Pollutants
L&E	*Locating and Estimating Air Toxic Emissions from Source Category of Substance*
MACT	Maximum Achievable Control Technology
MDL	Method Detection Limits
NATICH	National Air Toxics Information Clearinghouse
NESHAP	National Emisison Standard for Hazardous Air Pollutant
NO_x	Nitrogen Oxide
NSPS	New Source Performance Standard
NTIS	National Technical Information Service
OAQPS	Office of Air Quality Planning and Standards
OSHA	Occupational Safety and Health Administration
PB	Lead
PM	Particulate Matter
PM	Particulate Matter
RREL	Risk Reduction Engineering Laboratory
SCC	Source Classification Codes
SO_2	Sulfur Dioxide
SOP	Standard Operating Procedure
STIRS	Source Test Information Retrieval System
TOC	Total Organic Compounds
TRI	Toxic Release Inventory
TSAR	Test Method Storage and Retrieval
VOC	Volatile Organic Compounds