EMISSION FACTOR DOCUMENTATION FOR

AP-42 SECTION 1.7,

LIGNITE COMBUSTION

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1. INTRODUCTION

The document, "Compilation of Air Pollutant Emission Factors" (AP-42), has been published by the U.S. Environmental Protection Agency (EPA) since 1970. Supplements to AP-42 have been routinely published to add new emissions source categories and to update existing emission factors. An emission factor is an average value which relates the quantity (weight) of a pollutant emitted to a unit of activity of the source. The uses for the emission factors reported in AP-42 include:

- Estimates of area-wide emissions;
- Emission estimates for a specific facility; and
- Evaluation of emissions relative to ambient air quality.

The EPA routinely updates AP-42 in order to respond to new emission needs of State and local air pollution control programs, industry, and the Agency itself. Section 1.7 in AP-42, the subject of this Emission Factor Documentation (EFD) report, pertains to lignite combustion in stationary, external equipment.

The last comprehensive update of AP-42 Section 1.7 was in 1982, focusing on uncontrolled, baseline, emission factors for the criteria pollutants. The section was appended in 1986 with data on particle sizing distributions. The purpose of the present effort on AP-42 Section 1.7 is to update the data base for the earlier revisions and to extend the scope to other pollutant species and revised equipment classifications. Specifically, the scope of the current update includes the following activities:

- Updating of emission factors for criteria pollutants for baseline, uncontrolled operation using data generated since the 1982 revision;
- Inclusion of several non-criteria emission species for which data are available: organics speciation, air toxics, and greenhouse or

ozone depletion gases [such as nitrous oxide (N_2O), and carbon dioxide (CO_2)];

- Revise and expand emission source classifications to include fluidized bed combustion and to separate wall-fired boilers from tangentially-fired boilers; and

- Expand and update technical discussion and control efficiency data for boiler operation with nitrogen oxides (NO_x), carbon monoxide (CO), or particulate matter (PM) control.

The update began with a review of the existing version of Section 1.7 (last revised by Supplement A, published in October 1986). Spot checks were made on the quality of existing emission factors by selecting primary data references from the Section 1.7 Background File and recalculating emission factors.

An extensive literature review was undertaken to improve technology descriptions, update usage trends, and collect new test reports for criteria and non-criteria emissions. The new test reports were subjected to data quality review as outlined in the draft EPA document, "Technical Procedures For Developing AP-42 Emission Factors And Preparing AP-42 Sections" (March 6, 1992). The data points obtained from test reports receiving sufficiently high quality ratings were then combined with existing data, wherever possible, and used to produce new emission factors.

In this revision, several new emission factors for non-criteria pollutants have been added. These new emission factors pertain to speciated volatile organic compounds (VOCs), hazardous air pollutants (HAPs), N_2O, CO_2, and fugitive emissions. Additionally, in this revision, the information on control technologies for PM, sulfur oxides (SO_x), and NO_x emissions has been updated.

The purpose of this EFD is to provide background information and to document the procedures used for the revision, update, and development of emission factors for lignite combustion. Data from two state air pollution control agencies were used to add controlled emission factors for lignite-fired boilers. Emission factors were also developed for fluidized bed combustion as a new boiler configuration category.

Because of a lack of new baseline emissions data, the existing data contained in the Background File for the 1986 Section 1.7 were identified as the best baseline data available for this update. These data were reviewed and the low quality data were purged from the section. The remaining data of higher quality were used as the basis of the revised baseline criteria pollutant emission factors. In addition, data contained in the Background File that had not been included in the 1986 section were used to revise emission factors (since these data were of higher quality than any new data collected as a result of data search efforts in 1992). The baseline emission factors were recalculated using different calculation procedures than those used for the previous section. These revised calculation procedures allowed for more accurate comparison of emission test data. Using these same calculation procedures, the new controlled emissions data obtained from the North Dakota Department of Health and the Texas Air Control Board were used to generate controlled emission factors.

Including this Introduction (Chapter 1), this EFD contains five chapters. Chapter 2 provides an overall characterization of lignite combustion, a description of lignite usage in both the North Dakota and the Texas regions, and source/control descriptions. Chapter 3 gives a review of the emissions data collection and review procedures. The sources examined during the literature search are discussed. The data quality and emission factor rating procedures are also discussed in this section. Chapter 4 details the emission factor development procedures. It includes the review of specific data and details of emission factor compilations. Chapter 5 presents the revised AP-42 Section 1.7. Appendix A provides sample calculations for emission factor development. A marked-up copy of the 1986 Section 1.7, showing areas of revision, is included in Appendix B.

2. SOURCE DESCRIPTION

The two geographical areas of the United States with extensive lignite deposits are centered around the states of North Dakota and Texas. Lignite combustion occurs almost exclusively in these two regions. The typical uses of lignite combustion will be discussed for each of these regions. A process description for each lignite combustion source category is provided; the pollutants generated from lignite combustion are also discussed. Finally, the pollution controls used to abate emissions generated from lignite combustion are described.

2.1 CHARACTERIZATION OF LIGNITE APPLICATIONS[1-5]

Lignite is a relatively young coal with properties intermediate to those of bituminous coal and peat. The two geographical areas of the United States with extensive lignite deposits are centered around the states of North Dakota and Texas. Lignite in both areas has a high moisture content (30 to 40 weight percent) and a low wet-basis heating value [1400 to 1900 kcal/kg (2500 to 3400 Btu/lb)]. Consequently, lignite is burned only near where it is mined because effective transportation costs for low heating value fuels are prohibitive. A small amount is used for industrial and domestic combustion. Lignite is mainly used for steam/electric production in power plants. Lignite combustion was initially limited to small stokers, but the technology has advanced to the current practice of firing in large cyclone and pulverized coal boilers.

The major advantages of lignite are that, in these two localized areas, it is plentiful and low in sulfur content. The disadvantages are that more fuel and larger facilities are necessary to generate a unit of power than is the case with bituminous coal. There are several reasons for: (1) the higher moisture content means that more energy is lost in heating the moisture to combustion temperatures, which reduces boiler efficiency; (2) more energy is required to grind lignite to specified size limits, especially in pulverized coal-fired units; (3) greater tube spacing and additional soot blowing are required because of lignite's higher ash fouling tendencies; and (4) because of its lower heating value, more lignite must be handled to produce a given amount of power. Lignite usually is not cleaned or dried before combustion (except for some incidental drying in the crusher or pulverizer and during transfer to the burner). No major problems exist with the handling or combustion of lignite when its unique characteristics are taken into account.

2.1.1 North Dakota Region[5]

The North Dakota region has the largest lignite reserves in the world. The lignite deposits of this region are contained in North Dakota, South Dakota, Montana, and adjacent portions of Canada. The state of North Dakota has identified lignite resources of approximately 350 billion tons. Overall, the North Dakota region has identified lignite resources of 465 billion tons. Only a fraction of the identified resources are demonstrated as economically recoverable lignite reserves.

Most of the lignite-fired combustion sources in the region are located in the State of North Dakota. Minnesota and South Dakota also have large lignite-fired stations. As shown in Table 2-1 the state of North Dakota has 15 lignite-fired utility boilers.[6] The firing capacity of the newer boilers is generally much larger than that for the older units. Six of the newer boilers in the State have capacities greater than 400 MW (unless otherwise indicated, MW refers to megawatts of electrical output in this report). Many of the smaller stoker-fired utility boilers have been retired since the 1982 update of AP-42 Section 1.7. The largest spreader stoker in the State was converted to a circulating fluidized bed boiler in 1987.

The small lignite-fired stokers are used for on-site power generation, space heating, and process heat. The North Dakota Department of Health had 8 spreader stokers and 5 other stokers (underfeed and overfeed units) under permit in 1980 at commercial/institutional facilities.[7] The Department also had 5 spreader stokers under permit in 1980 for industrial facilities.[7] The number of small lignite-fired stoker units seems to be on the decline, however. There are probably less than 50 commercial/institutional and industrial lignite-fired boilers in the entire U.S.

2.1.2 <u>Gulf Region</u>[5]

The Gulf lignite region covers portions of five States including Alabama, Mississippi, eastern and southeastern Arkansas, northern Louisiana, and southeastern Texas. Figure 2-1 shows the lignite belt in these states. The Gulf region has 68 billion tons of identified lignite resources. Texas has approximately 52 billion tons of identified lignite resources. In Texas, the lignite belt runs parallel to the Gulf Coast approximately 150 miles inland from the coast. All of the major lignite-fired power plants in Texas are located on the lignite belt.

Table 2-2 is a partial listing of boilers located in the Gulf region. There are eight power generation facilities with lignite- fired utility boilers, including a facility in Louisiana. One older industrial lignite-fired boiler is operating in Texas. No small commercial or institutional boilers fired on lignite were identified in Texas during this update.

2.2 PROCESS DESCRIPTION[3]

In a pulverized fuel steam generator, the fuel is fed from the stock pile into bunkers adjacent to the steam boiler. From the bunkers, the fuel is metered into several pulverizers which grind it to approximately 200 mesh particle size. A stream of hot air from the air preheater begins the fuel-drying process and conveys the fuel pneumatically to the burner nozzle where it is injected into the burner zone of the boiler.

Three burner arrangements are used for firing pulverized lignite in existing steam generators:

- Tangential firing,
- Horizontally-opposed burners,
- Front wall burners.

These arrangements are shown schematically in Figure 2-2.

In the tangential method of firing pulverized coal into the burner zone, the pulverized coal is introduced from the corners of the boiler in vertical rows of burner nozzles. Such a firing mechanism produces a vortexing flame pattern which essentially uses the entire furnace enclosure as a burner.

Other manufacturers have developed both front-wall firing and horizontally-opposed firing boilers. In these firing mechanisms, the pulverized coal is introduced into the burner zone through a horizontal row of burners. For furnaces less than about 200 MW, the burners are usually located on only one wall (i.e., front wall firing). For larger boilers, the burners are located on the front and back walls firing directly opposed to each other (i.e., horizontally opposed burners). This type of firing mechanism produces a more intense combustion pattern than the tangential firing and has a slightly higher heat release rate in the burner zone itself.

In all of these methods for firing pulverized fuel, the ash is removed from the furnace both as fly ash and bottom ash. The bottom of the furnace is often characterized as either wet or dry, depending on whether the ash is removed as a liquid slag or as a solid. Pulverized coal units have been designed for both wet and dry bottoms, but the current practice is to design only dry bottom furnaces. The wet bottom furnace requires higher temperatures [usually > 1,430 ^{o}C (> 2,600 $^{\circ}$F)] in order to melt the ash before it is removed from the furnace. This is important to NO_x control since higher temperatures result in higher NO_x emissions from thermal fixation (see Section 2.3.2 for discussion of thermal NO_x formation).

2.2.1 Cyclone Firing

The cyclone burner is a slag-lined high-temperature vortex burner. The coal is fed from the storage area to a crusher that crushes the coal (or lignite) into particles of approximately 6 mm (0.25 inch) in diameter or less. Crushed lignite is partially dried in the crusher and is then fired in a tangential or vortex pattern into the cyclone burner. The burner itself is shown schematically in Figure 2-3. The temperature within the burner is hot enough to melt the ash to form a slag. Centrifugal force from the vortex flow forces the melted slag to the outside of the burner where it coats the burner walls with a thin layer of slag. As the solid lignite particles are fed into the burner, they are forced to the outside of the burner and are imbedded in the slag layer. The solid lignite particles are trapped there until complete burnout is attained.

The ash from the burner is continuously removed through a slag tap which is flush with the furnace floor. Such a system ensures that the burner has a sufficient thickness of slag coating on the burner walls at all times.

One of the disadvantages of cyclone-firing is that in order to maintain the ash in a slagging (liquid) state, the burner temperature must be maintained at a relatively high level. This higher temperature promotes NO_x fixation. Unfortunately, this cannot be offset via the reduction of available oxygen without employing an auxiliary fuel to maintain stability. Tests on cyclone burners firing lignite alone have shown that the burner cannot be satisfactorily operated at substoichiometric air conditions because of flame stability problems (i.e., the fire goes out at air addition rates less than the theoretical requirements).

2.2.2 Stoker Firing

In a stoker-firing furnace, shown schematically in Figure 2-4, the lignite is spread across a grate to form a bed which burns until the lignite is completely burned out. In such a mechanism, the lignite is broken up into approximately 5-cm (2-inch) pieces and is fed into the furnace by one of several feed mechanisms: underfeed, overfeed, or spreading. The type of feed mechanism used has little effect on NO_x emissions.

The physical size of stoker-fired boilers is limited because of the structural requirements and difficulties in obtaining uniform fuel and air distribution to the grate. Most manufacturers of stoker-fired equipment limit their design to 30 MW.

In most stoker units, the grate on which the lignite is burned gradually moves from one end of the furnace to the other. The lignite is spread on the grate in such a fashion that at the end of the grate only ash remains (i.e., all of the lignite has been burned to the final ash product). When the ash reaches the end of the grate, it falls into an ash collection hopper and is removed from the furnace.

Stoker-fired furnaces are dry-bottom furnaces and, as such, generally have lower heat release rates and lower temperature profiles than the corresponding pulverized lignite or cyclone-fired units. Hence, stoker-fired units typically have lower NO_x emission rates than other lignite-burning equipment used for generating steam.

2.2.3 Fluidized Bed Combustion

There are two major categories of fluidized bed combustors (FBCs): (1) atmospheric FBCs, operating at or near ambient pressures, and (2) pressurized FBCs, operating at from 4 to 30 atmospheres (60 to 450 psig). Pressurized FBC systems are not considered a demonstrated technology for lignite combustion.

Figures 2-5 and 2-6 show the two principal types of atmospheric FBC boilers, bubbling bed and circulating bed. The fundamental distinguishing feature between these types is the fluidization velocity. In the bubbling bed design, the fluidization velocity is relatively low, ranging between 16 and 39 meters/sec (5 and 12 ft/sec), in order to minimize solids carryover or elutriation from the combustor. Circulating FBCs, however, employ fluidization velocities as high as 9 meters/sec (30 ft/sec) to promote the carryover or circulation of the solids. High temperature cyclones are used in circulating FBCs and in some bubbling FBCs to capture the unburned solid fuel and bed material for return to the primary combustion chamber for more efficient fuel utilization.

Fluidized bed combustion is a boiler design which can lower sulfur dioxide (SO_2) and NO_x emissions without the use of post-combustion or add-on controls. A calcium-based limestone or dolomitic sorbent is often used for the bed material to capture SO_2 evolved during combustion. Captured SO_2 is retained as a solid sulfate and is either purged from the bed or removed from the flue gas stream by the particulate control device. Emissions of thermal NO_x are reduced because FBCs are able to operate at lower combustion temperatures compared to the more conventional designs, thus reducing the fixation of atmospheric nitrogen.

2.3 EMISSIONS

The emissions generated from lignite combustion include the criteria pollutants PM, NO_x, SO_x, total organic compounds (TOC), and CO. The non-criteria pollutants generated from lignite combustion include CO_2, N_2O, trace elements, fugitive emissions, and PM with an aerodynamic diameter of less than 10 microns (PM-10).

2.3.1 Particulate Emissions

Particulate emissions may be categorized as either filterable or condensible. Filterable emissions are generally considered to be the particles that are trapped by the glass fiber filter in the front half of an EPA Method 5 or EPA Method 17 sampling train. Particles less than 0.3 microns and vapor-phase elements pass through the filter. Condensible particulate matter (CPM) is material that is emitted in the vapor state which later condenses to form homogeneous and/or heterogeneous aerosol particles. The CPM emitted from lignite-fired boilers is primarily inorganic in nature. The PM-10 is a portion of total PM and is of concern since particles smaller than 10 microns can easily enter the lungs.

Particulate emissions from lignite combustion are directly related to the ash content of the lignite and firing configuration of the boiler. Cyclone furnaces emit less PM because, in a wet bottom boiler, more of the incoming ash is retained in the slag. Pulverized lignite units generate more fine PM because of the size of the fuel that is fired.

2.3.2 NO_x Emissions

The NO_x formed in combustion processes are due either to thermal fixation of atmospheric nitrogen in the combustion air ("thermal NO_x") or to the conversion of chemically-bound nitrogen in the fuel ("fuel NO_x"). Although five oxides of nitrogen exist, the term NO_x is customarily used to include the composite of nitric oxide (NO), and nitrogen dioxide (NO_2). Nitrous oxide is of increasing interest as an upper atmosphere gas, but is not included in NOx. Test data have shown that for most stationary combustion systems, over 90 percent of the emitted NO_x is typically in the form of NO.

Thermal NO_x formation rates in flames are exponentially dependent on temperature; they are proportional to the molecular nitrogen (N_2) concentration in the flame, the square root of the molecular oxygen (O_2) concentration in the flame, and the residence time.[20] This is corroborated by experimental data which shows thermal NOx formation is most strongly dependant on three factors: (1) peak temperature, (2) O_2 concentration or stoichiometric ratio, and (3) time of exposure at peak temperature. The emission trends due to changes in these factors are fairly consistent for all types of boilers: an increase in flame temperature, O_2 availability, and/or residence time at high temperatures leads to an increase in NO_x production (under oxidizing conditions), regardless of the boiler type.

Fuel nitrogen conversion is the most important NO_x-forming mechanism in lignite lignite-fired boilers. It can account for approximately 80 percent of the total NO_x emissions in lignite firing. The percent conversion of fuel nitrogen to NO_x, however, varies greatly with the local stoichiometric ratio and the air/fuel mixing in the near-burner flame zone.

A number of variables influence how much NO_x is formed by these two mechanisms. One important variable is the firing configuration. The NO_x emissions from tangentially (or corner)-fired boilers are, on average, less than those of wall-fired and cyclone units. Also important are the firing practices employed during boiler operation. Low excess air (LEA) firing, staged combustion (SC), low NO_x burners (LNBs), or some combination thereof may result in NO_x reductions of 10 to 60 percent. Load reduction can likewise decrease NO_x production.

The N_2O emissions for most coal-fired boilers are only a small fraction of the NO_x levels. During this AP-42 Section 1.7 update, no N_2O data for direct lignite-firing were located, with the exception of FBC units.

2.3.3 SO_x Emissions[2]

The SO_x emissions from lignite combustion depend on the sulfur content of the lignite and the lignite composition (viz., sulfur content, heating value, and alkali concentration). The conversion of lignite sulfur to SO_x is generally inversely proportional to the concentration of alkali constituents in the lignite. The sodium oxide content is believed to have the greatest effect on sulfur conversion because the natural sodium content in ash acts as a built-in sorbent for SO_x removal.

2.3.4 Carbon Monoxide Emissions[16-19]

The CO emission rate from combustion sources depends on the oxidation efficiency of the fuel. By controlling the combustion process carefully, CO emissions can be minimized. Thus, if a unit is operated improperly or not maintained, the resulting concentrations of CO (as well as organic compounds) may increase by several orders of magnitude. Smaller boilers, heaters, and furnaces tend to emit more of these pollutants than do larger combustors. This is because smaller units usually have a higher ratio of heat transfer surface area to flame volume, leading to reduced flame temperature and combustion intensity and, therefore, lower combustion efficiency than large combustors. Larger combustors also have more complex combustion control systems to trim oxygen to a level which gives low CO and high combustion efficiency.

The presence of CO in the exhaust gases of combustion systems results principally from incomplete fuel combustion. Several conditions can lead to incomplete combustion. These include:

- Insufficient O_2 availability;
- Extremely high levels of excess air (which leads to quenching);

- Poor fuel/air mixing;
- Cold-wall flame quenching;
- Reduced combustion temperature;
- Decreased combustion gas residence time; and
- Load reduction (i.e., reduced combustion intensity).

Since various combustion modifications for NO_x reduction can produce one or more of the above conditions, the possibility of increased CO emissions is a concern for environmental, energy efficiency, and operational reasons.

2.3.5 Total Organic Compounds

Small amounts of TOCs are emitted from lignite combustion. These TOCs include VOCs, semi-volatile organic compounds, and condensible organic compounds. Emissions of VOCs are primarily characterized by the criteria pollutant class of unburned vapor-phase hydrocarbons. Unburned hydrocarbon emissions can include essentially all vapor phase organic compounds emitted from a combustion source. These are primarily emissions of aliphatic, oxygenated, and low molecular weight aromatic compounds which exist in the vapor phase at flue gas temperatures. These emissions include all alkanes, alkenes, aldehydes, carboxylic acids, and substituted benzenes (e.g., benzene, toluene, xylene, ethyl benzene, etc.).[30,31]

The remaining organic emissions are composed largely of compounds emitted from combustion sources in a condensed phase. These compounds can almost exclusively be classed into a group known as polycyclic organic matter (POM), and a subset of compounds called polynuclear aromatic hydrocarbons (PNA or PAH). There are also the PAH-nitrogen analogs. Information available in the literature on POM compounds generally pertains to these PAH groups. Because of the dominance of PAH information (as opposed to other POM categories) in the literature, many reference sources have inaccurately used the terms POM and PAH interchangeably.

Formaldehyde is formed and emitted during combustion of hydrocarbon-based fuels including lignite. Formaldehyde is present in the vapor phase of the flue gas. Since formaldehyde is subject to oxidation and decomposition at the high temperatures encountered during combustion, large units with efficient combustion resulting from closely regulated air-fuel ratios, uniformly high combustion chamber temperatures, and relatively long retention times generally have lower formaldehyde emission rates than do small, less efficient combustion units.

2.3.6 Trace Element Emissions

Trace elements are also emitted from the combustion of lignite. For this update of AP-42, trace metals included in the list of 189 hazardous air pollutants under Title III of the 1990 Clean Air Act Amendments (CAAA-90) are considered.[36] The quantity of trace metals emitted depends on combustion temperature, fuel feed mechanism and the composition of the fuel. The temperature determines the degree of volatilization of specific compounds contained in the fuel. The fuel feed mechanism affects the partitioning of emissions into bottom ash and fly ash.

The quantity of any given metal emitted, in general, depends on:

- Its concentration in the fuel;
- The combustion conditions;
- The type of particulate control device used, and its collection efficiency as a function of particle size; and
- The physical and chemical properties of the element itself.

It has become widely recognized that some trace metals concentrate in certain waste particle streams from a combustor (bottom ash, collector ash, flue gas particulate), while others do not.[37] Various classification schemes to describe this partitioning have been developed.[38-40] The classification scheme used by Baig, et al. is as follows:[35]

- Class 1: Elements which are approximately equally distributed between fly ash and bottom ash, or show little or no small particle enrichment;
- Class 2: Elements which are enriched in fly ash relative to bottom ash, or show increasing enrichment with decreasing particle size;
- Class 3: Elements which are intermediate between Class 1 and 2;
- Class 4: Volatile elements which are emitted in the gas phase.

By understanding trace metal partitioning and concentration in fine particulate, it is possible to postulate the effects of combustion controls on incremental trace metal emissions.[37] For example, several NOx controls for boilers reduce peak flame temperatures [e.g., staged combustion, flue gas recirculation (FGR), reduced air preheat, and load reduction]. If combustion temperatures are reduced, fewer Class 2 metals will initially volatilize, and fewer will be available for subsequent condensation and enrichment on fine particulate matter. Therefore, for combustors with particulate controls, lowered volatile metal emissions should result due to improved particulate removal. Flue gas emissions of Class 1 metals (the non-segregating trace metals) should remain relatively unchanged.

Lowered local O_2 concentrations are also expected to affect segregating metal emissions from boilers with particle controls. Lowered O_2 availability decreases the possibility of volatile metal oxidation to less volatile oxides. Under these conditions, Class 2 metals should remain in the vapor phase into the cooler sections of the boiler. More redistribution to small particles should occur and emissions should increase. Again, Class 1 metals should not be significantly affected.

Other combustion NO_x controls which decrease local O_2 concentrations (staged combustion and low NOx burners) may also reduce peak flame temperatures. Under these conditions, the effect of reduced combustion temperature is expected to be stronger than that of lowered O_2 concentrations.

2.4 CONTROL TECHNOLOGIES

This section discusses the different emission controls used on lignite-fired boilers. The PM, NO_x and SO_x controls will be discussed in this section.

2.4.1 Particulate

The primary PM control systems for large industrial and utility boilers are electrostatic precipitators (ESPs) and fabric filters (or baghouses). Multiple cyclones and scrubbers are used for PM control mainly on small industrial stokers, either alone or in series with an ESP or baghouse. Filterable particulate emissions can be efficiently controlled by all four of these methods. Cyclones, ESPs, and fabric filters have little effect on measured CPM because they are generally operated at temperatures above the upper limit of the front-half of EPA Method 5 [i.e., 135 °C (275 °F)]. Thus, most CPM would remain vaporized and pass through the control device. Wet scrubbers, however, reduce the gas stream temperature; as a result, they could theoretically remove some of the CPM.

The operating parameters that influence ESP performance include:[19]

- Fly ash mass loading,
- Particle size distribution,
- Fly ash electrical resistivity, and
- Precipitator voltage and current.

The larger ESPs built since the mid 1970s can achieve control efficiencies of 99.5 or better percent for total PM.[11]

The PM removal efficiency of fabric filters is dependent on a variety of particle and operational characteristics.[20-21] Particle characteristics that effect the collection efficiency include particle size distribution and particle cohesion characteristics. Operational parameters that effect fabric filter collection efficiency include:

- Air-to-cloth ratio,
- Operating pressure loss,
- Cleaning sequence,
- Interval between cleaning,
- Cleaning method, and
- Cleaning intensity.

In addition, fabric properties that affect the particle collection efficiency and size distribution include:

- Structure of fabric,
- Fiber composition, and
- Bag properties.

Baghouses are typically categorized by one of three cleaning methods: (1) mechanical or shake/deflate cleaned baghouses, (2) reverse gas cleaned baghouses, and (3) pulsed-jet cleaned baghouses. Baghouses can achieve collection efficiencies of 99.7 percent or better for total particulate matter.[12]

2.4.2 NO_x Control

Combustion modifications, such as LEA-firing, flue gas recirculation (FGR), SC, and reduced load operation, are primarily used to control NO_x emissions in large coal-fired facilities.

The formation of thermal NO_x occurs in part through the Zeldovich mechanism:

(2-1) $N_2 + O \leftrightarrow NO + N$

(2-2) $N + O_2 \leftrightarrow NO + O$

(2-3) $N + OH \leftrightarrow NO + H$

Reaction (2-1) is the rate-determining step due to its large activation energy.[13] Kinetically, thermal NO_x formation is related to N_2 concentration, combustion temperature, and O_2 concentration by the following equation:[13]

(2-4) $[NO] = k_1 \exp(-k_2/T) [N_2] [O_2]^{1/2} t$

where:

[ ] = mole fraction

T = temperature (°K)

t = residence time

k_1, k_2 = reaction rate coefficient constants

From these considerations, it can be seen that thermal NO_x formation can be controlled by four approaches: (1) reduction of peak temperature of reaction, (2) reduction of N_2 concentration, (3) reduction of O_2 level, and (4) reduction of the residence time of exposure at peak temperature. Combustion modification techniques to control thermal NO_x in boilers have focused on reducing the O_2 level, peak temperature, and time of exposure at peak temperature in the primary flame zones of the furnaces. Equation 2-4 also shows that thermal NO_x formation depends exponentially on temperature, parabolically on O_2 concentration, and linearly on residence time. Therefore, initial efforts to control NO_x emissions have often focused on methods to reduce peak flame temperatures.

In coal-fired boilers, the control of fuel NO_x is also very important in achieving the desired degree of NO_x reduction, since fuel NO_x can account for 80 percent of the total NO_x formed.[14-16] Fuel nitrogen conversion to NO_x is highly dependent on the fuel-to- air ratio in the combustion zone and, in contrast to thermal NO_x formation, is relatively insensitive to small changes in combustion zone temperature.[17] In general, increased mixing of fuel and air increases nitrogen conversion which, in turn, increases fuel NO_x. Thus, to reduce fuel NO_x formation, the most common combustion modification technique is to suppress combustion air levels below the theoretical amount required for complete combustion. The lack of oxygen creates reducing conditions that, given sufficient time at high temperatures, cause volatile fuel nitrogen to convert to N_2 rather than NO.

In the formation of both thermal and fuel NO_x, all of the above reactions and conversions do not take place at the same time, temperature, or rate. The actual mechanisms for NO_x formation in a specific situation are dependent on the quantity of fuel-bound nitrogen and the temperature and stoichiometry of the flame zone. Although the NO_x-formation mechanisms are different, both thermal and fuel NO_x are promoted by rapid mixing of fuel and combustion air. Thus, primary combustion modification controls for both thermal and fuel NO_x typically rely on the following control approaches:

- Decrease residence time at high temperatures (under oxidizing conditions):
  - Decrease adiabatic flame temperature through dilution,
  - Decrease combustion intensity,
  - Increase flame cooling,
  - Decrease primary flame zone residence time;
- Decrease primary flame-zone O_2 level:
  - Decrease overall O_2 level,
  - Control (delayed) mixing of fuel and air,
  - Use of fuel-rich primary flame zone.

The most prevalent NO_x control for lignite-fired boilers is overfire air using dedicated air ports, or by taking a top row of burners out of service and adjusting air flow to the furnace. Control of NO_x via LEA combustion can significantly increase the ash fouling potential in the boiler.[18] Creating overfire air conditions in one tangentially-fired unit by removing the top three burners from service and adjusting the dampers did not increase the ash fouling potential.[18]

No post-combustion, ammonia-based NO_x controls have been used with lignite combustors due to the lack of regulatory requirements.

2.4.3 SO_x Control

Several techniques are used to reduce SO_x from lignite combustion. Flue gases can be treated through wet, semi-dry, or dry desulfurization processes of either the throwaway type (in which all waste streams are discarded) or the recovery (regenerable) type (in which the SO_x absorbent is regenerated and reused). To date, wet systems are the most commonly applied. Wet systems generally use alkali slurries as the SO_x absorbent medium and can be designed to remove in excess of 90 percent of the incoming SO_x. Lime/limestone scrubbers, sodium scrubbers, spray drying, and dual alkali scrubbing are among the commercially proven flue gas desulfurization techniques. Limestone may also be injected directly into the furnace section of boilers to capture SO_2 shortly after formation. Effectiveness of these devices depends not only on the control device design but also on operating variables, such as liquid-to-gas ratio and sorbent reactivity.

Sodium scrubbing processes generally employ a wet scrubbing solution of sodium hydroxide (NaOH) or sodium carbonate (Na_2CO_3) to absorb SO_2 from the flue gas. The operation of the scrubber is characterized by a low liquid-to-gas ratio (1.3 to 3.4 l/m^3 [10 to 25 gal/ft^3]) and a sodium alkali sorbent which has a high reactivity relative to lime or limestone sorbents. The scrubbing liquid is a solution rather than a slurry because of the high solubility of sodium salts.

The double or dual alkali system uses a clear sodium alkali solution for SO_2 removal followed by a regeneration step using lime or limestone to recover the sodium alkali and produce a calcium sulfite and sulfate sludge. The SO_2 is removed from the flue gas as in sodium scrubbing. Most of the scrubber effluent is recycled back to the scrubber, but a slipstream is withdrawn and reacts with lime or limestone in a regeneration reactor. The regeneration reactor effluent is sent to a thickener where the solids are concentrated. The overflow is sent back to the system while the underflow is further concentrated in a vacuum filter (or other device) to about 50 percent solids content. The solids are washed to recover soluble sodium compounds which are returned to the scrubber.

The lime and limestone process uses a slurry of calcium oxide (CaO) or limestone ($CaCO_3$) to absorb SO_2 in a wet scrubber. The process produces a calcium sulfite and calcium sulfate mixture. Calcium sulfite and calcium sulfate crystals precipitate in a hold tank. The hold tank effluent is recycled to the scrubber to absorb additional SO_2. A slip stream from the hold tank is sent to a solid-liquid separator to remove precipitated solids. The waste solids, typically 35 to 70 weight percent solids, are generally disposed of by ponding or landfill.

Spray drying is a dry scrubbing approach to flue gas desulfurization. A solution or slurry of alkaline material is sprayed into a reaction vessel as a fine mist and contacted with the flue gas for a relatively long period of time (5 to 10 seconds). The SO_2 reacts with the alkali solution or slurry to form liquid-phase salts. The slurry is dried by the latent heat of the flue gas to about one percent free moisture. The dried alkali continues to react with SO_2 in the flue gas to form sulfite and sulfate salts. The spray dryer solids are entrained in the flue gas and carried out of the dryer to a particulate control device such as an ESP or baghouse. Systems using a baghouse for PM removal report additional SO_2 sorption occurring across the baghouse. Gas exit temperatures are typically in the 65 to 93 °C (150 to 200 °F) range which provides a safe margin against water condensation.

Limestone may also be injected into the furnace, typically in an FBC, to react with SO_2 and form calcium sulfate. An FBC is comprised of a bed of inert material that is suspended or "fluidized" by a stream of air. Lignite is injected into this bed and burned. Limestone is also injected into this bed where it is calcined to lime and reacts with SO_2 to form calcium sulfate. Bed temperatures are typically maintained between 760 and 870 °C (1,400 and 1,600 °F). Particulate matter emitted from the boiler is generally captured in a cyclone and recirculated or sent to disposal. Additional PM control equipment, such as an ESP or baghouse, is used after the cyclone to further reduce particulate emissions.

TABLE 2-1. LIGNITE-FIRED BOILERS IN THE NORTH DAKOTA REGION[a]

Company	Plant	Firing configuration	Capacity, MW	Year in service[b]
Basin Electric Power Coop.	Antelope Valley Station Unit #1	Pulverized Coal Tangential	440	1984
Basin Electric Power Coop.	Antelope Valley Station Unit #2	Pulverized Coal Tangential	440	1986
Basin Electric Power Coop.	Leland Olds #1	Pulverized Coal Horizontally Opposed	216	1966
Basin Electric Power Coop.	Leland Olds #2	Cyclone	440	1975
Basin Electric Power Coop.	W.J. Neal #1	Pulverized Coal Front Wall	25	1953
Basin Electric Power Coop.	W.J. Neal #2	Pulverized Coal Front Wall	25	1953
Montana Dakota Utilities	Coyote	Cyclone	440	1981
Montana Dakota Utilities	Heskett #1	Spreader Stoker	25	1963
Montana Dakota Utilities	Heskett #2	Fluidized Bed	66	1987
Minnkota Power Coop.	Milton R. Young #1	Cyclone	240	1970
Minnkota Power Coop.	Milton R. Young #2	Cyclone	440	1976
United Power Association	Coal Creek #1	Pulverized Coal Tangential	500	1978
United Power Association	Coal Creek #2	Pulverized Coal Tangential	500	1979
United Power Association	Stanton #1	Pulverized Coal Front Wall	130	1966
United Power Association	Stanton #2	Pulverized Coal Tangential	60	After 1978
Otter Tail Power Company	Big Stone (South Dakota)	Cyclone	440	1975
Otter Tail Power Company	Hoot Lake (Minnesota)	Pulverized Coal Tangential	59	1959

[a]References 2-3, 6.
[b]The year in sevice is an estimate.

TABLE 2-2. LIGNITE-FIRED BOILERS IN THE GULF REGION[a]

Company	Plant	Firing configuration	Capacity, MW	Year in service[b]
Texas Utilities	Martin Lake #1,#2,#3,#4	Pulverized Coal Tangential	750	1977, 1978 1979, 1980
Texas Utilities	Monticello #1,#2,#3,#4	Pulverized Coal Horizontally Opposed	750	1975, 1976 1979
Texas Utilities	Big Brown #1, #2	Pulverized Coal Tangential	590	Late 60's
Southwestern Electric Power Co.	H.W. Pirkey #1	Pulverized Coal Horizontally Opposed	720	1984
Southwestern Electric Power Co.	Dolet Hills (Louisiana)	Pulverized Coal	720	1986
Houston Lighting & Power	Limestone #1, #2	Pulverized Coal Tangential	800	1986, 1987
South Texas Electric Coop.	San Miguel #1	Pulverized Coal Horizontally Opposed	400	1979
Texas New Mexico Power Co.	Calvert #1, #2	Circulating Fluidized Bed	150	1990, 1991
Alcoa	Sandow 1, 2, & 3	Wet Bottom Tangential, Dried Lignite	100	1953

[a]References 3, 9.
[b]The year in service is an estimate.

Figure 2-1. Lignite-bearing strata of the Gulf Coast Region.[8]

Figure 2-2. Burner arrangements for pulverized fuel-firing in a utility boiler (viewed from above).[3]

Figure 2-3. Schematic of cyclone-firing of lignite in a utiity boiler.[3]

Figure 2-4. Schematic of stoker-firing in a boiler.[3]

Figure 2-5. Bubbling FBC schematic.[10]

Figure 2-6. Circulating FBC schematic.[10]

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3. GENERAL EMISSIONS DATA REVIEW AND ANALYSIS PROCEDURES

This section summarizes the procedures for the literature search and the criteria for evaluating the data which were identified. The results of the search and conclusions regarding the usefulness of the data obtained for developing emission factors are also presented. The data and emission factor rating and review criteria are also contained in this chapter.

3.1 CRITERIA POLLUTANTS

3.1.1 Literature Search

An extensive literature search was conducted to identify sources of criteria and non-criteria emissions data for lignite combustion. The following sources were searched for emissions data:

- Existing AP-42 Background files,
- Files maintained by the EPA's Emission Standards Division and Emission Factor and Methodologies Section,
- PM-10 background documents,
- New Source Performance Standards Background Information Documents,
- National Technical Information Service (NTIS) holdings,
- Various EPA emissions assessment documents for coal combustion,
- Contractor in-house files,
- U.S. Department of Energy (DOE) Clean Coal Project Documents,
- NO_x, SO_x, and Particulate Control Symposia,
- Lignite and Low Rank Coal Symposia,

- Proceedings of the American Power Conference,
- Information from boiler manufacturers,
- Proceedings of the International Conference on Fluidized Bed Combustion,
- Electric Power Research Institute (EPRI) reports and communications.

The main conclusion from the literature search was that the data base on lignite emissions and control is relatively sparse compared to higher rank coals or oil. Some articles on lignite combustion were found in the Proceedings of the American Power Conference, Proceedings of the International Conference on Fluidized Bed Combustion, Lignite Symposia, and the Low Rank Coal Symposia. Most of the articles did not contain emissions data but some of these articles supplied specific plant operational and design data. The lignite symposia, and the conferences on fluidized bed combustion did contain emissions data for a pilot-scale fluidized bed unit which were not used since emissions data for the full-scale units were available. The Reference 1 article was useful for characterizing emissions control techniques. However, the emissions data in the article were not used because a large amount of primary data were available for the specific plant tested. The article offered data and discussion on the effect of NO_x control on slagging in a boiler firing North Dakota lignites. Another useful report was a DOE study (Reference 2). This report offers a large amount of lignite proximate/ultimate analysis data and discusses the lignite resources in the U.S.

The information contained in the AP-42 Background File was reviewed. From this, it was concluded that the most promising source of new emissions data for lignite combustion would be the air pollution control agencies in the EPA Regions where lignite combustion is prevalent. The North Dakota Department of Health and the Texas Air Control Board were both contacted as a result.

The North Dakota Department of Health had supplied emissions data for the previous updates, and agreed to supply emissions data for this update. The Department has collected a large amount of data since the last complete update of Section 1.7 in 1982. The continuous emission monitoring (CEM) equipment at each of the seven largest lignite-fired utility boilers in North Dakota are re-certified by the Department every three years using relative accuracy testing. The older utility boilers are only required to monitor opacity, and consequently fewer emissions data are available for these plants. The smaller stoker units generally have only PM emissions data available.

The Texas Air Control Board (TACB) also agreed to supply emission data for this update of Section 1.7. The TACB has a main office in Austin and 12 regional offices. Following the lignite belt and using a map identifying TACB regions, the two regions with the majority of lignite combustors were determined to be Regions 3 and 12. The emissions data available from the TACB are NSPS performance testing and CEM recertification testing.

The regional offices were expected to have a considerable amount of emissions data available for each lignite-fired power plant. Due to the time constraints of this update, however, and the limited staff resources available at both of these air pollution agencies, only a limited amount of the emissions data available could be obtained. In future, the best way to obtain the data would be to go directly to the North Dakota Department of Health offices and the main and regional offices of the TACB to search and find the available emissions data.

3.1.2 Literature Evaluation[3]

To establish a final group of references for use in the updated section, the following general criteria were used:

- Emissions data must be from a well documented reference;
- The referenced study must contain results based on more than one test run; and
- The report must contain sufficient data to evaluate the testing procedures and source operating conditions.

By employing these criteria in a thorough review of the reports, documents, and information, a final set of reference materials was compiled. The data contained in this final set of references were then subjected to a thorough quality and quantity evaluation to determine their suitability for use in emission factor calculations. Checklists were employed to standardize and document this evaluation. The completed checklists were placed in the background files for this update to Section 1.7. Data with the following characteristics were always excluded from further consideration:

1. Test series averages reported in units that cannot be converted to the selected reporting units;

2. Test series representing incompatible test methods (i.e., comparison of EPA Method 5 front-half with EPA Method 5 front- and back-half);

3. Test series of controlled emissions for which the control device is not specified;

4. The series in which the source process is not clearly identified and described; and

5. Test series in which it is not clear whether the emissions were measured before or after the control device.

Data sets that were not excluded were assigned a quality rating. The rating system used was that specified in Reference 3. The data were rated as follows:

A - Multiple tests performed on the same source using sound methodology and reported in enough detail for adequate validation. These tests are not necessarily EPA reference method tests, although such reference methods are preferred and certainly to be used as a guide.

B - Tests that were performed by a generally sound methodology but lack enough detail for adequate validation.

C - Tests that were based on an untested or new methodology or that lacked a significant amount of background data.

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

The following criteria were used to evaluate source test reports for sound methodology and adequate detail:

1. <u>Source operation</u>. The manner in which the source was operated is well documented in the report. The source was operating within typical parameters during the test.

2. <u>Sampling procedures</u>. The sampling procedures conformed to generally acceptable methodology. If actual procedures deviated from accepted methods, the deviations are well documented. When this occurred, an evaluation was made of the extent that such alternative procedures could influence the test results.

3. Sampling and process data. Adequate sampling and process data are documented in the report. Many variations can occur unnoticed and without warning during testing. Such variations can induce wide deviations in sampling results. If a large spread between test results cannot be explained by information contained in the test report, the data were suspect and given a lower rating.

4. Analysis and calculations. The test reports contain original raw data sheets. The nomenclature and equations used were compared to those (if any) specified by EPA to establish equivalency. The depth of review of the calculations was dictated by the reviewer's confidence in the ability and conscientiousness of the tester, which in turn was based on factors such as consistency of results and completeness of other areas of the test report.

3.1.3 Emission Factor Quality Rating

In each AP-42 section, tables of emission factors are presented for each pollutant emitted from each of the emission points associated with the source. The reliability or quality of each of these emission factors is indicated in the tables by an overall Emission Factor Quality Rating ranging from A (excellent) to E (poor). These ratings incorporate the results of the above quality and quantity evaluations on the data sets used to calculate the final emission factors. The overall Emission Factor Quality Ratings are described as follows:

A - Excellent: Developed only from A-rated test data taken from many randomly chosen facilities in the industry population. The source category is specific enough so that variability within the source category population may be minimized.

B - Above average: Developed only from A-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 industries. As in the A-rating, the source category is specific enough so that variability within the source category population may be minimized.

C - Average: Developed only from A- and B-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 in the A-rating, the source category is specific enough so that variability within the source category population may be minimized.

D - Below average: The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there is 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 category population. Limitations on the use of the emission factor are noted in the emissions factor table.

E - Poor: The emission factor was developed from C- and D-rated test data, and there is 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. Limitations on the use of these factors are noted where applicable.

The use of these criteria is somewhat subjective and depends to an extent on the individual reviewer. Details of the rating of each candidate emission factor are provided in Chapter 4 of this report.

3.2 SPECIATED VOCs

3.2.1 Literature Search

An extensive literature search was conducted during this revision to identify sources of speciated VOC emissions data associated with lignite-fired boilers. Some specific areas searched include Tennessee Valley Authority (TVA), EPRI/PISCES, EPA/Air and Waste Management Association (A&WMA) Air Toxic Symposiums, and Toxic Air Pollutants: State and Local Regulatory Strategies 1989.

3.2.2 Literature Evaluation

Until recently, little concern existed for VOC speciation on stationary external sources. Therefore, available data for VOC speciation were inadequate to develop emission factors. Some qualitative information is available in the EPA Office of Air Quality Planning and Standards (OAQPS) databases. The primary databases are the VOC/PM Speciation Data System (SPECIATE) and the Crosswalk/Air Toxic Emission Factor Database (XATEF), and their associated references. Some VOC speciation data were also identified in the general HAPs data search.

3.3 Hazardous Air Pollutants

3.3.1 Literature Search

When possible, primary references were obtained in order to calculate or verify emission factors presented. Many of the data evaluated were not of suitable quality for developing emission factors and were, therefore, eliminated for use in this update.

A literature search was conducted using the Dialog Information Retrieval Service. This is a broad-based data retrieval system that has access to over 400 data bases. Specifically for the air toxics search, six data bases were queried by key words relating to the processes and chemicals of concern. The data bases accessed include: NTIS, COMPENDEX PLUS, POLLUTION ABSTRACT, CONFERENCE PAPERS, ENERGY SCIENCE & TECHNOLOGY, and EPRI. The list of literature generated from the search was evaluated for applicability and the relevant documents were obtained.

Searches of the EPA's HAPs data bases were also performed. These data bases include XATEF, SPECIATE, and the Air Chief CD ROM which contains additional data. The computer searches were performed by source classification code (SCC) for all boiler sizes and types that are fired on coal. The reference numbers were recorded for each of the "hits" and these references were obtained for review.

Several industry and non-agency sources were also contacted in order to obtain source test data for development of emission factors. Since few data were available for lignite directly, data for coal combustion in general were compiled to obtain data for related conditions.

3.3.2 Literature Evaluation for HAPs

The references obtained from the literature search were evaluated for their applicability for generating emission factors. Table 3-1 summarizes the data sources and indicates which sources were used in generating the emission factors. The table contains a reference number which corresponds to the list of references provided at the end of this section. The references are evaluated and discussed in greater detail in Chapter 4, Section 4.3.1. The criteria used to perform this evaluation are discussed in detail in Section 3.1.2.

3.3.3 Data and Emission Factor Quality Rating Criteria

Emissions data used to calculate emission factors are obtained from many sources such as published technical papers and reports, documented emissions test results, and regulatory agencies such as local air quality management districts. The quality of these data must be evaluated to determine how well the calculated emission factors represent the emissions of an entire source category. Data sources may vary from single source test runs to ranges of minimum and maximum values for a particular source. Some data must be eliminated all together due to their format or lack of documentation. Factors such as the precision and accuracy of the sampling and analytical methods and the operating and design specifications of the unit being tested are key in the evaluation of data viability.

The EPA has prepared a document that specifies technical procedures for the development of AP-42 emission factors and the preparation of supporting documentation.[3] See Section 3.1.2 for the description of the evaluation and rating criteria.

The first step in evaluating a data report is to determine whether the source is a primary or secondary source. A primary source is that which reports the actual source test results while a secondary source is one that references a data report. Many of the sources referenced by XATEF, SPECIATE, and the CD ROM are secondary or tertiary sources. Preferably, only primary sources were used in the development of emission factors. When there was not time in this work effort to obtain or evaluate the primary sources, data were taken from a secondary reference if it appeared that an adequate evaluation of the data was performed.

The primary source reports are evaluated to determine if sufficient information is included on the device of interest and on any abatement equipment associated with the device. General design parameters such as boiler size, firing configuration, fuel type, operating parameters during the test, (e.g. load), are all required in order to evaluate the quality of the data. Information on the type and number of samples, sampling and analytical methods used, sampling locations, quality control samples and procedures, modifications to methods, fuel composition and feed rates are also needed. Sufficient documentation to determine how the data were reduced and how emissions estimates were made are required. This documentation should include sample calculations, assumptions, and correction factors. Equivalent information for the abatement device(s) must also be included.

When primary data could not be obtained in the time frame of this update, secondary sources were evaluated to determine the representativeness of the emission factors for a source category. A judgement on the quality of the author's analysis of the primary data was made in this case, which automatically warrants a lower quality rating for the emission factor. The secondary sources provide at least an order of magnitude estimate of emissions and possibly better; however, this cannot be evaluated without reviewing the primary data.

3.4 N_2O

3.4.1 Literature Search

An extensive literature search was conducted to identify sources of N_2O emissions data associated with lignite-fired boilers. Some specific areas of search included University of North Dakota, Air and Energy Engineering Research Laboratory (AEERL), Combustion and Flame, Journal of Geophysical Research, International Conferences of Fluidized Bed Combustion, and A&WMA.

3.4.2 Literature Evaluation

Because of the limited test reports for lignite, data from tests of other coal types were also used. Because the data and emission factor quality rating criteria have been available only since 1988, data with quality problems (e.g., lack of complete documentation), were used in order to get, at a minimum, a semi-quantitative estimate.

Data obtained through the literature search, except that derived from on-line N_2O analysis with gas chromatography/electron capture detection (GC/ECD), were rated C or poorer, because the data were based on untested or new methodology that lacked sufficient background data. A problem had been identified in using grab sampling techniques for measuring N_2O emissions. Storing combustion products in grab samples containing SO_2, NO_x and water for periods as short as 1 hour had led to formation of several hundred parts per million of N_2O where none originally existed. Improved methodologies for N_2O sampling and analysis and their relative effects on data quality ratings are as follows:

1. On-line N_2O analysis with GC/ECD (preferred method), and
2. Grab samples:
   a. Removing H_2O - drying the sample reduces the most important reactant, but may not entirely eliminate N_2O formation,
   b. Removing SO_2 - scrubbing the sample through NaOH solution, or
   c. A combination of the two (second preference).

The N_2O data for fluidized bed combustors were developed from test reports using lignite and the data were assigned a quality rating of D. Because the data were not recorded with an on-line N_2O analysis GC/ECD and the facilities tested do not represent a cross section of the industry; as a result, the emission factor received an E rating.

3.5 FUGITIVE EMISSIONS

A literature search was conducted on fugitive emissions for coal-fired sources in general. A literature evaluation and data rating was not conducted for lignite storage and handling operations, because those fugitive emissions for lignite-fired boilers are covered in sub-sections of Chapter 11. The fly ash handling operations in most modern utility and industrial combustion sources consist of pneumatic systems or enclosed and hooded systems which are vented through small fabric filters or other dust control devices. The fugitive PM emissions from these systems are therefore minimal. Fugitive PM emissions can sometimes occur during transfer operations from silos to trucks or rail cars. The PM emission factors corresponding to these operations can be developed using the procedures in Chapter 11.

3.6 PARTICLE SIZE DISTRIBUTION

3.6.1 Literature Search[3]

The literature search emphasized filling the perceived gaps in the previous updates. Updates to AP-42 are supposed to report PM-10 emissions as the sum of the in-stack filterable particulate and the organic and inorganic CPM. Upon review of the previous AP-42 update of particulate sizing emission data, the largest gap appeared to be the lack of CPM data.

The Background Files for AP-42 Section 1.7 were reviewed. A Dialog search was conducted, focussing on reports issued since 1980. Based on the results of the Dialog search, NTIS documents, EPA reports, and conference proceedings were ordered and journal articles were collected. Conference symposia that were searched included the Eighth and Ninth Particulate Control Symposia and the Air and Waste Management Association Conferences for 1988 through 1991.

The following PM-10 "gap filling" documents were examined:

Reference 9: The factors applicable to sections 1.1, 1.3, and 1.7 all came from AP-42.

Reference 10: Not applicable to stationary source combustion.

Reference 11: Lists the average collection efficiencies of various particulate control devices for different size fractions. This was the source of the overall collection efficiency estimates for the 1986 PM-10 update of AP-42 Chapter 1.

The following regional EPA offices and State and regional air pollution control boards were contacted:

- EPA Region 2,
- EPA Region 3,
- EPA Region 4,
- EPA Region 5,
- California Air Resources Board: Stationary Sources Division, Monitoring and Laboratory Division, and the Compliance Division;
- Illinois Air Pollution Control;
- New York Air Pollution Control;
- New Jersey Air Pollution Control;
- Bay Area Air Quality Management District (CA);
- Kern County Air Pollution Control District (CA);
- Stanislaus County Air Pollution Control District (CA); and
- San Joaquin County Air Pollution Control District (CA).

The primary source of the particulate size distribution data for the previous AP-42 update was the Fine Particulate Emissions Information System (FPEIS). The FPEIS was not updated since the printouts obtained during the previous AP-42 update. The printouts used for the previous update were available in the Background Files.

The EPA OAQPS Emissions Monitoring Branch was contacted for test data from method development studies for EPA Method 202.

Contacts were also made with EPRI, Wheelabrator Air Pollution Control, Southern Research Institute, and Entropy Environmental.

3.6.2 Literature Evaluation

The previous AP-42 update was reviewed and evaluated.[12] The size distribution data was evaluated by spot-checking the tabulated results against the original FPEIS printouts. If during the literature search, an original test report was uncovered that corresponded to a particular FPEIS printout, the data were compared. The objective of the review was to ensure that the data collected in the 1986 update were ranked and used appropriately. The previous update was also evaluated with respect to the development of emission factors from the particle size distribution data.

The original FPEIS printouts were also examined. There were two objectives in the reevaluation of the FPEIS printouts:

- To ensure that only filterable PM was included in the cumulative percent mass results, and

- To search for impinger results to provide CPM emission data.

New literature was evaluated based on the use of appropriate sampling methods and documentation of sufficient process information.

3.6.3 Data Quality Ranking

Data were reviewed and ranked as described in Section 3.1.2 and the data evaluation criteria presented for the previous update. Data quality was assessed based on the particle sizing and/or PM-10 measurement method used and the availability of sampling and process data.

For particulate sizing and filterable PM-10 data the following criteria were used:

- Particle sizing tests performed by cascade impactors or PM-10 measurements performed via EPA Method 201 or EPA Method 201A. The test information must provide enough detail for adequate validation and the isokinetics must fall between 90 and 110 percent.

- Particle sizing tests performed via source assessment sampling system (SASS) trains if the sampling flow-rate isokinetic value was reported and sufficient operating data were used. Cascade impactor data or EPA Method 201 or EPA Method 201A data were not used if isokinetics were not reported or if isokinetics were not within the 90 to 110 percent range.

- SASS train data if the isokinetics were not reported or if the isokinetics did not fall within the 90 to 110 percent range.

- Test results based on a generally unaccepted particulate sizing method, such as polarized light microscopy.

Although cascade impactors are generally considered the best available method for measuring particulate size distributions, errors in segregating specific sizes of combustion particles arise from the following:

- Particle bounce and re-entrainment,
- Diffusive deposition of fine particles,
- Deposition of condensible/adsorbable gases, and
- Losses to the impactor walls.

The effects of such errors are described in the literature.[13]

The ranking of CPM data was based primarily on the methodology. Most CPM source tests have been conducted using the back-half of an EPA Method 5, EPA Method 17, or South Coast Methods 5.2 or South Coast Method 5.3 trains. However, these test methods do not require an N_2 purge of the impingers. Without the N_2 purge, dissolved SO_2 remains in the impingers and is included in the inorganic CPM results. This type of CPM data is considered very low-quality.[14] In contrast, EPA Method 202 includes a one-hour N_2 purge of the impingers immediately after sampling to remove dissolved SO_2. Therefore, EPA Method 202 CPM data should be ranked higher than EPA Method 5 or EPA Method 17 CPM data, even though EPA Method 202 is a relatively new method. The following ratings were selected for CPM data:

A - CPM tests performed via EPA Method 202. The test information must provide enough detail for adequate validation and the isokinetics must fall between 90 and 110 percent.

B - CPM tests performed via EPA Method 202 but isokinetics not reported or isokinetics not within the 90 to 110 percent range. CPM tests performed via EPA Method 5 or EPA Method 17 or another acceptable EPA method that does not include an impinger N_2 purge, if the isokinetics were within the 90 to 110 percent range.

C - CPM tests performed via EPA Method 5 or EPA Method 17 or another acceptable EPA Method that does not include an impinger N_2 purge, if the isokinetics were not reported or not within the 90 to 110 percent range.

D - Test results based on a generally unaccepted CPM method.

TABLE 3-1. EVALUATION OF REFERENCES

Reference	Evaluation summary	Parameter of interest
4	Not a primary reference; however, emission factors provided for emission estimates.	POM
5	Not a primary reference; however, data are of sufficient quality for estimates.	Copper
6	Not a primary reference; however, data of sufficient quality for estimates.	Metals
7	Source test data of sufficient quality for calculate emission factors and enrichment ratios.	PAH, metals, radionuclides
8	Emission factors of sufficient quality to perform emission estimates.	Manganese

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12. "Compilation of Air Pollutant Emission Factors", AP-42, Section 1.7, Supplement A, U.S. Environmental Protection Agency, Research Triangle Park, NC, October 1986.

13. Ondov, John M., "Cascade Impactors in the Chemical and Physical Characterization of Coal-Combustion Aerosol Particles", Chapter 25 of Fossil Fuels Utilization: Environmental Concerns, 1986.

14. Telephone conversation between S. Hughes, Acurex Environmental, and Ron Myers, U.S. Environmental Protection Agency, March 24, 1992.

4. EMISSION FACTOR DEVELOPMENT

This chapter describes how the revised AP-42 Section 1.7 was developed from data in the 1986 section, and new data obtained from the literature search.[17] The data are reviewed and assigned a data quality ranking according to the procedures outlined in Chapter 3. All of the data incorporated into the revised section are compiled into summary tables which show the primary data used to develop the emission factors.

4.1 CRITERIA POLLUTANTS

New emissions data for lignite combustors were collected during this update for NO_x and SO_2. Emissions data for CO and organic compounds were very limited and highly dependant on source design and operating conditions. The sources of criteria emissions data were assigned a data quality rating. In addition to the rating rationale, a brief discussion is provided below for each developed emission factor of the methods used to collect the data, the level of documentation provided, the data consistency, and the number of runs per test.

4.1.1 Review of Previous Data

The emissions data that are the basis of the 1986 Section 1.7 emission factors were reviewed and assigned a quality rating to determine the data that should be included in the revised section. Major references containing emissions data for more than one firing configuration are discussed in the following paragraphs.

In developing the 1986 AP-42 Section 1.7, Reference 2 was used extensively. This reference was the basis of the SO_x emission factors for all of the firing configurations. It presents a summary of SO_x emissions from 28 days of testing at a pulverized lignite-fired tangentially-fired unit; 8 days of testing at a pulverized coal (PC) horizontally-opposed unit firing lignite; 3 days of testing at a lignite PC front-fired unit; 5 days of testing at a cyclone-fired unit, and 2 days of testing at a spreader stoker. The sampling method used to collect the SO_x data was the controlled condensation method of Lisle and Sensenbaugh in which the flue gas is drawn through a condenser at 60 to 90 °C (140 to 194 °F) [where the sulfur trioxide (SO_3) is selectively condensed and collected] and then passes through an impinger containing a 3 percent hydrogen peroxide (H_2O_2) solution. The analytical method employed was a titration using a standard NaOH solution. This reference also contains some NO_x emissions data for all of the plants tested. The method used to collect the NO_x data was EPA Method 7. The calculation procedure is discussed; it was not equivalent to current EPA procedures, but was valid. This reference was assigned a data rating of B. Even though the data date to 1973, these tests represent a large number of source test runs executed over a long time period by valid methods. These data are true baseline data because most of the sampling occurred at the exit of the boilers, rather than at the stack or after PM controls.

A second key reference for the 1986 Section 1.7 update was Reference 5. This reference is the basis of many of the previous emission factors. Individual source test reports from Reference 5 will be discussed individually for the purpose of data review.

Reference 8 is NSPS support testing for NO_x at the Texas Utilities (TU) Big Brown Power Station in Fairfield, Texas. The background file for the unrevised section attached to the Big Brown source test report contains two other source test reports also performed in support of the NSPS testing. The other two reports are for a PC unit (Leland Olds) and a cyclone fired unit (Milton R. Young I) in North Dakota. These three source test reports are the primary documents used in support of the NSPS. The NO_x emissions data from the two reports for Milton R. Young and Leland Olds appear unchanged in Reference 3, the NSPS standards support document. The NO_x emissions data for Big Brown Station in the lignite NSPS support document include fuel data and different process operation data than appear in the primary test report. The author of the NSPS support document apparently obtained additional process and fuel data from the plant for the NSPS support document. Therefore, the emissions and process data in the NSPS support document for Big Brown are used in this update rather than the primary report.

4.1.2 Pulverized Coal Dry Bottom Emission Factors

The PC emission factors contained in the 1986 AP-42 Section 1.7 update for PM, SO_x, and NO_x are based on data from five sources: from Reference 5, Reference 18, Reference 6, Reference 2, and the results of the NSPS standards support source testing conducted at the Leland Olds and Big Brown power plants contained in Reference 3.

The Stanton source test report has uncontrolled and controlled emissions data for PM, SO_x, and NO_x.[18] The source test methods are specified for each pollutant (e.g., the particulate data was collected according to ASTM Power Test Code 27-1957). The source testing was conducted using sound methodologies, but the number of source test runs was inadequate. The boiler had divided flue gas ducting and only one run was conducted for each pollutant on each duct. The uncontrolled PM data were taken on two different days. No fuel ash or sulfur contents were given in the report, and the emission factors generated from these data are based on assumed sulfur and ash percentages. This report was assigned a data rating of D.

Reference 6 focuses on ash fouling rates when burning low- and high-sodium lignite. The article presents PM and SO_x emissions data from a tangentially-fired boiler. The particulate data was collected according to ASTM Power Test Code 27-1957. Two methods were used to collect the SO_x data: the selective condensation method of Lisle and Sensenbaugh, and the absorption method by Berk and Burdick. Agreement is reported as being good between the two methods. The author of this article is the primary author of Reference 2; the SO_x emissions data in this article are likely also contained in Reference 2. Since Reference 2 contains a large amount of SO_x data for this specific plant, the data from this article was not rated or treated as additional data. The coal composition and boiler operating conditions during testing are presented. The main problem with this source is that there is no documentation on how many source test runs were incorporated in the final results. The particulate testing results are presented as a percentage of incoming ash emitted in the flue gas. The particulate data in this article were given a D rating.

The NSPS standards support testing conducted at Leland Olds, a horizontally opposed-fired boiler, and at Big Brown I & II, twin tangentially-fired boilers, yielded a significant amount of baseline NO_x emissions data. Eight days of source testing were conducted at the twin units of Big Brown station, and three days of testing were conducted at Leland Olds. The results and original source test reports are contained in References 3 and 8, respectively. Simultaneous sampling for NO_x was conducted at both plants using EPA Method 7 and continuous emission monitors (CEM). The CEM data from both reports showed inconsistencies due to recurring problems with the CEM equipment. The CEM results for the Leland Olds plant had no information regarding the calibration procedures carried out during testing. The Big Brown source test report did contain actual copies of the strip charts with pre-test and post-test calibration results. The first five days of CEM data in the Big Brown report were voided by the source test contractor because of gas conditioning problems. The last three days of CEM data were considered valid by the contractor with calibration drifts for the three days reported as 5, 4, and 2 percent. The current EPA method specifies that the calibration drift be within 3 percent of the span. The CEM emissions data from the NSPS support testing were not assigned a data quality rating because sufficient EPA Method 7 data were available. The NO_x emission results for Big Brown Units I & II were based on 28 baseline EPA Method 7 runs. The NO_x emissions results for the Leland Olds Unit I were based on 31 baseline EPA Method 7 runs. No raw data sheets are presented in either of these reports. The EPA Method 7 NO_x emissions data were assigned a data quality rating of B.

An additional source of criteria emissions data for the Leland Olds Unit I was Reference 7. The emissions data were not included in the prior update.[17] This report contains a data summary for one day of baseline CEM data for Leland Olds for NO_x and CO. The detailed description of sampling equipment and methods are contained in another report which was not reviewed. The report does not specifically cite EPA CEM methods, but does discuss calibration procedures carried out during the test program. It was assumed that this test program used EPA CEM methods since it was conducted for the Agency. These data were assigned a data rating of B.

4.1.3 Cyclone Emission Factors

The cyclone fired-boiler emission factors contained in the previous update for PM, NO_x, and SO_x were based on emissions data from five sources: Reference 12, Reference 2, two source test reports from Reference 5, and results of the NSPS support testing from Reference 8.

The main source of baseline particulate emissions data for cyclone furnaces for the prior update was Reference 12. This contains the results of nine source tests on three cyclone-fired plants. The PM emission rate in lb/hr, the coal feed rate in tons/hr, and the ash content of the coal were provided. This source was assigned a B data rating.

The most comprehensive source of baseline NO_x emissions data was the NSPS standards support testing contained in Reference 8. This report contains simultaneous source testing for NO_x using EPA Method 7 and CEM taken over four days. The CEM results for this plant had no information regarding the calibration procedures carried out during testing. The CEM data were not given a data quality rating. The first two days of baseline EPA Method 7 NO_x data were given a data quality rating of B. The last two days of EPA Method 7 NO_x data cover only one of two boiler exhaust ducts and, therefore, were excluded from consideration.

An additional source of PM emissions data used in the previous Section 1.7 was a source test report from Reference 5 for Milton R. Young Unit I. This 1971 report presents the results from two test runs taken after the dust collector. One test run was called "preliminary" by the contractor and was conducted on one of the two divided flue gas ducts. The other run was conducted on both flue gas ducts. No specific method was specified in the report. Some of the raw data sheets are missing and the calculation procedures used were not equivalent to current EPA methods. These data were assigned a D rating.

Another source of NO_x and SO_x emissions data used in the previous Section 1.7 was a source test report from Reference 5 for Milton R. Young unit I. This 1971 source test report presents NO_x and SO_x emissions data taken using CEM. The report does not specify the CEM method. The report also discusses a problem with moisture in the flue gas affecting the SO_x CEM results. These data were given a C rating.

4.1.4 Spreader Stoker and Other Stoker Emission Factors

The spreader stoker emission factors contained in the 1986 AP-42 Section 1.7

update for PM, NO_x, and SO_x emissions are based on Reference 2 and four source test reports from Reference 5. The process data were often not reported in these references. A rough table of plants and the control device information for each plant was obtained from the Background File. This was the only source of control and process data available for this update effort. This information is essential for the data in the current update to meet the exclusion criteria.[19]

Two of the source test reports cited in Reference 5 are of low quality for developing emission factors. The first of these reports, Reference 20, has emissions data for PM, NO_x, and SO_x. The source test methods are specified as ASTM 27-1957 for PM testing, the Shell Development method for SO_x, and Saltzman Reagent for NO_x emissions testing. The main problem is that only one run was conducted at the inlet and outlet of the control device for PM. One run for NO_x and SO_x was conducted at the outlet of the control device. This source was assigned a D rating. The second report, Reference 21, contains controlled PM emissions data for three boilers. The method used for collecting the data was specified as ASTM 27-1957, but only one run was conducted for each plant. This source was assigned a D rating.

Reference 22 contains controlled PM emissions data for two spreader stoker boilers and uncontrolled PM data for two other overfeed stokers. The method used to collect the particulate data is specified as the latest National Air Pollution Control Agency and Public Health Bulletins as well as ASTM Power Test Code 27. The sampling train used to collect this data was equivalent to a current EPA Method 5 train. The calculation procedure is well documented but the equations are not completely equivalent to current EPA Method 5 calculational procedures. The results are based on three test runs. The main problem with this data is the lack of information regarding the control device. Reference 5 was the only source of information for the control device. Therefore, these data were assigned a C data rating.

The Reference 23 report contains SO_x and PM data for the F.P. Wood Plant. The particulate data is invalid because of strong cyclonic flow conditions at the sampling point. The SO_x data were taken at a different location and were not as sensitive to flow conditions. These SO_x data are also contained in Reference 2; no additional detail is contained in this report. Therefore these data will not be rated as an additional source.

A significant amount of baseline emissions data for spreader stokers and other stokers were contained in the Section 1.7 Background File. Reference 14 is a trip report describing a visit to the North Dakota Department of Health. The letter has an attachment describing source test results and process and fuel data for plants in the Department of Health's permit files. The North Dakota Department of Health provided copies of the summary pages of these reports in a letter for the 1973 update of this section. The process and fuel data contained in both letters combined with the summary pages of the source test reports were reviewed. Source test results which did not include critical fuel, process, or control data were excluded. Although poorly documented, the remaining data were collected during triplicate testing conducted at the inlet and outlet of the control device. The method used to collect this particulate data is equivalent to the EPA Method 5. The two letters and attachments described above are considered a single reference (i.e., the stoker data package).[14] The stoker data package was assigned a data rating of C.

4.1.5 Review of New Baseline and Controlled Data

This portion of the chapter reviews and assigns a data rating to new data obtained from the literature search that were used to derive new emission factors. The literature search discussed in Chapter 3 revealed that only a small amount of published emissions data for lignite combustion was available. The literature search, therefore, focused on obtaining data from the air pollution control agencies which regulate most of the lignite-fired boilers in the U.S.

The North Dakota Department of Health and the TACB both provided source test data for this update effort. Both of these agencies have a significant amount of source test data available for lignite combustion. The data obtained represents only a portion of the data held by these agencies, however.

Almost all of the new data obtained during the current effort is controlled data. This is mainly due to the promulgation of two series of NSPS (i.e., Subpart D and Subpart Da) which regulate emissions from new boilers; TACB and North Dakota

Department of Health air pollution regulations/permits also limit emissions from existing sources.

4.1.6 North Dakota Department of Health Data[15]

The North Dakota Department of Health supplied source test results for nine lignite-fired utility boilers. Seven of the utility boilers are required to recertify their CEM equipment every three years. The majority of the data package received from the Department is relative accuracy testing to certify the plant CEM equipment. The department also supplied particulate source test summaries for eight of the nine boilers. All of the emissions data in the data package were collected in accordance with EPA methods. The particulate results are all based on three sampling runs, and the CEM results are based on nine or ten 5-minute averages. The emissions data in the package were all collected downstream of particulate controls. Process information on each boiler and associated controls were obtained from copies of the permits for the units. Coal composition data were supplied for each source test and plant. Some of the coal composition data applied to the week of testing and some were specific to each run. All of the boilers tested were operated above 70 percent of design capacity.

All of the major firing configurations are described in the data package. Five of the boilers are tangentially-fired lignite PC units. Two of the plants are cyclone-fired units. One of the plants is a spreader stoker, and one of the units is a fluidized bed boiler. The fluidized bed boiler is a retrofitted spreader stoker unit.

The data package also contains a personal communication which discusses the conversion of the spreader stoker to the fluidized bed boiler.[14] An attachment to this letter contains emission calculations for the old spreader stoker and the new fluidized bed boiler. Average lb/million Btu (lb/MMBtu) emission rates and coal compositions are supplied for both units. The spreader stoker NO_x data were used to generate lb/ton emission factors. The other emissions data were used as a reference for comparison to other source test data.

The entire North Dakota Department of Health data package was assigned a B rating. The source testing was performed using sound methods and the reports were reviewed by the EPA. If the complete documentation can be obtained for this data during future updates this data could receive an A data quality rating.

4.1.7 Texas Air Control Board[16]

The TACB has 12 regional offices in the State. The majority of lignite-fired boilers are located in Regions 3 and 12 of the State. Emissions data were obtained for three boilers in Region 3. Three complete source test reports were obtained for two twin 800 MW tangentially-fired boilers. The text and summary portions only of two source test reports were obtained for a circulating fluidized bed boiler located in Region 3.

Emissions data were obtained for four lignite-fired boilers in Region 12. Two complete source test reports were obtained for two twin 750 MW tangentially-fired boilers. Two complete source test reports were also obtained for a 720 MW and 750 MW horizontally opposed-fired boiler.

Process, control, and coal data used for calculation of emission factors were obtained from copies of portions of the permit files for each of the non-FBC boilers. The copies of the permit files were obtained from the main office of the TACB. All of the source test reports contained coal analyses for the boilers during testing. The process operating conditions were also contained in the source test reports. All source tests contained in the package were conducted while the boiler was operating near full load.

The majority of the Texas emissions data were NSPS compliance testing, and all of the testing was conducted in accordance with the procedures contained in the Appendix to the Code of Federal Regulations (CFR), Title 40, Chapter I, Part 60. The complete source test reports contain extensive documentation on calculation and calibration procedures. The emission rates were calculated using the F-factor calculation procedure specified by Reference Method 19 of 40 CFR Part 60 Appendix A.

All of the complete source test reports obtained from the TACB were assigned a data quality rating of A. The portions of source test reports obtained for the FBC were assigned a data quality rating of B due to a lack of adequate information detail regarding sampling and analytical methods.

4.1.8 Compilation of Baseline Emission Factors

The only new baseline, uncontrolled, data obtained were the fluidized bed emissions data, a stoker NO_x data point, and a cyclone NO_x data point. The new data for PC units are presented in the compilation of controlled emission factors because the designs of the current PC units pursuant to the NSPS are so different from the old units, and because all of the data were obtained after controls. The uncontrolled emission factors for the fluidized bed source category were not developed in the same sense as for the other categories. Fluidized bed design might be considered a combustion modification from the standpoint of NO_x emissions; however, these data were classified as baseline since no additional add-on NO_x controls were in place. The SO_x emission factor for this source category is a controlled factor reflecting the absorption of SO_x by the bed material. No baseline particulate emissions data were available for this source category.

As previously discussed, the majority of new data available for lignite combustion is controlled emissions data. The baseline emission factors for the revised section are based on the same data as the prior update section. The actual values of the emission factors have changed because different calculation procedures were used to generate emission factors from the previous source test data, and data of extremely poor quality were excluded from the revised Section 1.7.

The SO_x emission factor will still be based on the sulfur content and the sodium content of the lignite fired for all firing configurations. The values have changed slightly due to the elimination of duplicate data points and poor-quality data points. The primary reference for the SO_x emission factor is Reference 2. The data that the SO_x emission factor is based on are presented in Table 4.1. Most of the SO_x emissions data available cannot be used to generate emission factors because no ash analysis was available for the lignite fired during testing.

The only true NO_x baseline emissions data are the original data in the 1986 update; all subsequent data identified in the literature search were for post-NSPS units controlled for NO_x. Most of the NO_x data are based on sampling downstream of particulate controls. The particulate device normally does not affect NO_x emissions.

Many of the baseline particulate emission factors contained in the 1986 AP-42 update section were derived from controlled data. The control efficiencies used to back-calculate uncontrolled emissions were often based on poor source test data, design efficiencies, or values in the now-defunct National Emissions Data Base.

The data available for CO and VOC emissions from lignite-fired boilers are extremely limited. The Orsat data for CO was not used to generate emission factors.

The revised emission factors were developed by taking source test results in units of lbs of pollutant/MMBtu and multiplying by the Btu/ton gross wet heating value of the coal. Emissions data in parts per million by volume were converted to units of lb pollutant/MMBtu using an F-factor as specified by Reference Method 19 of 40 CFR Part 60 Appendix A. The PM emission factor for lignite PC boilers is based on a single data point from Reference 5 where the lb/hr particulate emission rate was divided by the coal burning rate of wet ton/hr. Baseline emission factors are summarized in Tables 4-1 through 4-9.

4.1.9 Compilation of Controlled Emission Factors

Most of the new data obtained from the literature search are for source testing conducted at the stack after pollution control systems. The plants constructed after the Subpart D NSPS were implemented were designed with controls integrated with the boiler to form a complete system. All of the plants built prior to the NSPS had some add-on PM control. The term baseline emissions is becoming an ambiguous concept. This is especially true for NO_x controls which are a function of boiler design and operation. The post-NSPS PC units are very different than the PC coal units built prior to 1971. The emissions data obtained for post-NSPS PC units are presented in this section. Volatile organic compound and CO emissions data are still considered essentially uncontrolled. The emissions of these compounds are related to the boiler design, however. Therefore, they were not combined with the baseline data for boilers designed prior to the NSPS implementation. The available NO_x control data for a specific boiler were often difficult to obtain for the current update. For example, most of the post-NSPS boilers were designed with overfire air ports for NO_x control, but many plants do not need to use overfire air to meet the first round of NSPS emission standards. Some older, wall-fired plants may take a top row of burners out of service to provide a form of overfire air. Most of the process and control information for this update was obtained from permit files; as a result, the information regarding NO_x controls was often sparse. It was assumed that all of the tangential boilers fired on lignite built after the NSPS were equipped with overfire air ports.

In general, the calculation procedure started with source test results in units of lbs of pollutant/MMBtu and multiplied by the Btu/ton gross wet heating value of the coal. Emissions data in parts per million by volume were converted to units of lb pollutant/MMBtu using the F-factors specified by Reference Method 19 of 40 CFR Part 60 Appendix A. Controlled emission factors are summarized in Tables 4-10 through 4-14.

4.2 Nitrous Oxide

The literature search for N_2O emissions from lignite firing revealed only data specific to lignite combustion in fluidized bed units. A survey of 42 documents revealed two documents which were used to develop the N_2O emission factor for these units:

<u>Reference 26</u>

This reference contained data from N_2O emissions of fluidized bed combustors. The data is in graphical form and presented in units of milligram per megajoule. The conversion from milligram per megajoule to ppm is one milligram per megajoule equals 1.7 ppm. The test was preformed on a circulating fluidized bed boiler controlled by recirculation of flue gases. The reference case is defined by a bed temperature of 850 °C (1600 °F), a primary air stoichiometry of 0.75 and excess air ratio of 1.2. The actual emission values can only be estimated from the graphs and therefore, the data was assigned a rating of D.

<u>Reference 27</u>

This test report contained data from a pilot-scale 1MW CFBC. N_2O emissions were continuously monitored by a non-dispersive infrared spectrometer. A rating of C was assigned to the data for the lignite-fired boiler; therefore, the emission factor rating could not be higher than an E because the emission factor was developed from C quality data. The N_2O emission factors for lignite-fired FBC units are summarized in Table 4-15.

4.3 HAZARDOUS AIR POLLUTANTS

4.3.1 <u>Review of New Data</u>

A discussion of the hazardous air pollutants (HAPs) data evaluated for the development of emission factors for boilers fired on lignite is presented in this section. The discussion includes a summary of the information presented in the source and an evaluation of the quality of the data for use in generating emission factors. The discussions are presented by the source. The data and emission factors presented in this section were rated with the criteria outlined in Section 3.3.3.[19]

Reference 28

This article summarizes the emissions of certain trace metals and HAPs from lignite coal combustion. The data presented are a summary of a literature review. Emission factors are presented in the units of mass emitted per heat unit combusted and are presented for boilers of different sizes and configurations. The article references several primary references which were evaluated and determined to be of insufficient quality for emission factor development.

Reference 29

This document is a compilation of the available information on sources and emissions of POM and is not a primary reference. The document cautions the use of these data for development of an exact assessment of emissions from any particular facility; however, the data are useful for providing rough estimates of POM emissions from boilers firing lignite coal. The emission factors provided are for post-control devices. Data for utility boilers is used in this update because this is the largest and most complete data set for coal combustion.

Reference 30

The data quality and documentation in this report are of unacceptable quality to generate emission factors due to low quality sampling and analytical methods and lack of information on fuel composition and control device performance.

Reference 31

The purpose of this document is to provide a preliminary emission assessment of conventional stationary combustion sources. The data presented deals with national averages or ranges based on the best available information. Emission factors in mass emitted per heat unit input are not provided.

Reference 33

This report summarizes testing performed on several sizes and types of boilers; however, only criteria pollutant testing was performed.

Reference 34

Measured and calculated emission factors for lignite coal are presented in this document. The emission factors are rated with a low quality because the document is not a primary source and the quality of the data cannot be verified.

Reference 35

This document provides a summary of the emissions factors for metals, polycyclic organic matter (POM), and formaldehyde for lignite coal-fired boilers. Control efficiencies are reported for some control devices. No data are reported for uncontrolled emissions of POM and radionuclides. The formaldehyde data are from 1964 and are considered to be of insufficient quality. The emission factors are based on source test data from coal-fired utility and industrial boilers. Data for different boiler configurations are presented in the units of mass emitted per unit of fuel input.

This reference is not a primary source. The document cautions that relatively limited data are available on HAPs resulting from these types of processes and that emissions data in the document should not be used to develop an exact assessment of emissions from any particular facility. Emission factors for the processes outlined in the document are summarized and provided for use in determining order of magnitude emissions. The emission factors are rated with a low quality because the data acquisition and manipulation could not be verified.

Reference 36

The data quality and documentation in this report are of high enough quality to develop enrichment ratios for metals and radionuclides on the boilers and their associated abatement devices. Emission factors are calculated in the units of mass emitted per heat unit combusted for PAH compounds.

Reference 37

This document presents emission factors for sources of chromium. A literature survey was used to compile emission estimates from lignite-fired boilers. The emission factor for utility boilers is used for generating the emission factor.

4.3.2 Baseline Emission Factors

Emission factors for trace metals, radionuclides, and other HAPs are quite often presented in units of mass emitted per unit of thermal heat input. These units are adequate for performing emission estimates of the organic HAPs but are not ideal for estimating emission factors of metals and radionuclides. Ideally, emission factors for trace elements should be developed as a function of the boiler firing configuration, boiler size, trace element concentration in the fuel, ash content, higher heating value, enrichment ratio, and the collection efficiency of the control device. The concepts of partitioning and enrichment are often used to characterize the behavior of trace elements in the combustion process. The concept of partitioning is used to describe the distribution of trace elements among the boiler outlet streams. These streams may include the bottom ash, fly ash, and flue gas. Enrichment refers to the difference in the trace element concentrations in the outlet streams. The process of enrichment can also take place in a control device. The physical and chemical properties of a trace metal governs how that metal will distribute in the outlet streams. For example, mercury (Hg) is a highly volatile metal and therefore, the majority of the mass of Hg in the feed coal tends to be entirely emitted from the boiler in the flue gas and not in the bottom ash or in the fly ash.

A method for describing partitioning behavior is to report the fraction of the total elemental mass input that has left the boiler in an outlet stream. Another method for quantifying the distribution of a metal is to calculate an enrichment factor by comparing the trace element concentration of an outlet stream to the trace element concentration of the inlet stream. The enrichment ratio calculation that is outlined in Reference 38 is performed using the following equation:

$$ER_{ij} = (C_{ij}/C_{Rj})/(C_{ic}/C_{Rc})$$

where:

ER_{ij} = enrichment ratio for element i in stream j

C_{ij} = concentration of element i in stream j

C_{Rj} = concentration of reference element R in stream j

C_{ic} = concentration of element i in fuel

C_{Rc} = concentration of reference element R i fuel

Enrichment ratios greater than 1 indicate that an element is enriched in a given stream, or that it partitions to a given stream. The reference element is used because its partitioning and enrichment behavior is often comparable to that for the total ash. In other words, the reference element partitions with consistent concentrations in all ash streams and normalizes the calculation. Typical reference elements are aluminum (Al), iron (Fe), scandium (Sc), and titanium (Ti). The enrichment behavior of elements is somewhat consistent in different types of boilers and can be explained by a volatilization-condensation or adsorption mechanism. A summary of the enrichment behavior for the air toxic metals and the reference metals is presented in Table 4-16. Table 4-17 presents a summary of enrichment behaviors including approximate enrichment ratios for particular classes of compounds.

The enrichment ratio can be used in conjunction with additional data from a specific facility in order to estimate emissions of trace elements. The equation outlined in Reference 38 which is used to calculate the emission factor for a trace element is as follows:

$$EF = (C/H)*F*(1-E)*ER*10^3$$

where:

- EF = emission factor for a specific trace element, ng/J
- C = concentration of element in coal, ug/g
- H = higher heating value of coal, kJ/kg
- F = fraction of coal ash as fly ash
- E = fractional particulate collection efficiency of control device, which is 0 for uncontrolled emissions
- ER = enrichment factor for the trace element (ratio of concentration of element in emitted fly ash to concentration of element in coal ash) sometimes based on Al

In many cases, the source test programs did not include key parameters such as: ultimate analyses and speciation of coal used for the test, measurements of the boiler effluent for metals and ash, and measurements of metals and ash after the collection device. This made it impossible to calculate partitioning of metals within the bottom and fly ash. When supporting documentation to develop enrichment ratios were not available, emission factors in the units of mass emitted per heat input were provided. Though this is not the optimal method of estimating emissions, it provides a means of performing a rough emission estimation.

Table 4-18 summarizes the enrichment ratios for metals and radionuclides for an uncontrolled boiler and for a high efficiency cold-side ESP. The quality of these enrichment ratios is low (E quality) because of the low number of boilers and control data used to perform the calculations. Enrichment ratio data are a significant data gap in the HAP data bases.

Tables 4-19 and 4-20 present a summary of emission factors in the units of mass emitted per unit thermal heat input for uncontrolled utility boilers. Data on utility boilers are the most studied group of boilers and, therefore, have the most significant amount of data. Data are presented for metals. No POM or formaldehyde uncontrolled emissions data were found. The tables are presented in metric units and English units, respectively. The quality rating of these data are low because many of the sources of information are of insufficient quality and the number of data points are too small to represent an entire source category.

4.3.3 Controlled Emission Factors

Tables 4-21 and 4-22 present the summary of emission factors for various controlled emissions in the units of mass emitted per unit thermal heat input. The data obtained in the literature review were very limited. The quality rating of these data are low because many of the sources of information are of insufficient quality and the number of data points are too small to represent an entire source category.

4.4 PARTICULATE SIZE DISTRIBUTION

The scope of AP-42 is being extended to augment particulate size distribution emission factors with data on the split between filterable and condensible PM-10. The current AP-42 includes detailed analysis of particle size distribution data. Filterable PM-10 data is included in this analysis by default because it is among the cumulative size fractions considered. Condensible PM-10 is not in the current AP-42 and needs to be added to future versions of AP-42.

4.4.1 Review of Previous AP-42 Data

The 1986 AP-42 particle sizing update was evaluated with respect to sources of data, data analysis and emission factor development procedure. Data retrieved and analyzed for that update were exclusively filterable PM.

Very few lignite data sets were available through FPEIS or other sources at the time of the previous update.[39] All the data sets were considered C-quality. The FPEIS printouts were checked, as was the partial report referenced in the 1986 Emission Factor Documentation report as ERC No. 7246. The spot-checking indicated that the previous analysis was as accurate as possible given the data quality.

4.4.2 Review of New Data

A search for additional data was conducted. Of primary interest was CPM data collected via EPA Method 202 because this particulate fraction has not been addressed in previous AP-42 updates. Unfortunately, only method development source test data were uncovered.

Although a variety of sources were contacted with regards to particulate sizing and PM-10 data, very little additional data were located. State and district offices that were contacted either had no PM-10 data available or were unable to process such a request due to time limitations and other staff limitations.

Two sets of data are available for filterable PM from pilot-scale atmospheric fluidized bed combustors (AFBCs).[38] A pilot AFBC unit was tested while firing either subbituminous coal or lignite. The purpose of the tests was to investigate the corrosive and/or erosive properties of low-rank coal ash on heat transfer surfaces.

As part of the test, the particulate emissions exiting a multiclone system were measured for particulate size distribution. A flow sensor multiclone and laser aerodynamic particle sizer (APS) provided particle size distribution data at the inlet to the scrubber (after the multiclone controls).

The data is ranked C due to the pilot-scale size, the particulate collection methods, and lack of sufficient background data. In addition, the cumulative percent mass values were obtained via interpolation of log-log graphs of the results. The particulate size distribution data are shown on Table 4-23.

4.4.3 Compilation of Uncontrolled Emission Factors

The 1986 update was reviewed with respect to the procedure used to develop emission factors from the particle size distribution data. The uncontrolled emission factors were calculated for each size fraction by multiplying the total particulate emission factor by the cumulative percent mass for the given size interval. Therefore, all uncontrolled emission factors will change as a result of updating the total PM emission factors.

It is apparent that the level of uncertainty increases as one moves from the cumulative percent mass to the uncontrolled emission factors. The uncontrolled emission factors are functions of two numbers estimated generally from different sets of data: the cumulative percent mass, and the total particulate emission factor.

The filterable PM-10 emission factors are included in the particulate size distribution tables. There is currently no need to prepare tables devoted only to PM-10. As CPM data becomes available, a new table should be added to each AP-42 section. The table should include columns for filterable PM-10, inorganic CPM, and organic CPM.

4.4.4 Control Technology Emission Factors

There were two calculation steps in the development of controlled emission factors in the previous PM sizing update in 1986.[39] First, a controlled emission factor was developed for total PM by multiplying the uncontrolled total PM emission factor from the criteria pollutant table by one of the following control efficiency factors:

- Multiple cyclone - 80 percent,
- Baghouse - 99.8 percent,
- ESP - 99.2 percent, and
- Scrubber - 94 percent.

Next, a controlled emission factor was developed for each of the cumulative size ranges by multiplying the controlled emission factor for total particulate by the cumulative percent mass for the size range. Thus the quality of the right-hand side of every size distribution table in Section 1.7 of AP-42 is directly related to the quality of three other numbers: (1) the control efficiency factors, (2) the total particulate emission factor (from the criteria pollutant table), and (3) the cumulative percent mass data. This, in part, explains the low data rating generally listed in AP-42 for the controlled emission factors for the particulate size fractions.

The disadvantage of this procedure is the loss of emission factor quality. The advantage of the procedure is that it allows the determination of control-specific emission factors rather than using generalized control efficiency results. Control-specific emission factors are better than generalized control efficiency results because control efficiency is dependent on particulate parameters, such as the resistivity, not just the particle size distribution.

It is useful to note that the procedure does not assume a single control efficiency for each particle size. Rather, it assumes a single overall efficiency and applies this to the total particulate emission factor. The size-based emission factors depend on the total controlled emission factor and the percent of the total controlled mass within a particular size range. For example, collected data indicated that 41 percent of controlled PM from a multiple cyclone operating on lignite-fueled spreader stokers was less than or equal to 10 microns. Based on this value; on an uncontrolled emission factor of 3.4A kg/Mg; and on an estimated multiple cyclone efficiency of 80 percent, the controlled PM-10 emission factor is calculated as 0.279A:

$$0.41 \times 3.4A \times (1.0 - 0.80) = 0.279A \text{ kg/Mg.}$$

Although different methods could be used to develop controlled emission estimates, the procedures used in the 1986 document are a logical way to compensate for sparse data. The process appears to create conservatively high values for the controlled emission factors, as there are occasionally controlled emission factors in the tables that are larger than the uncontrolled factors. The particulate control efficiencies cited above are reasonable in light of available data for lignite-fired boilers and were retained in the current update.

Tests of ash from lignite combustion have indicated ash characteristics that may significantly affect the ability of a fabric filter to achieve high collection efficiencies.[40] For instance, lignite ash particles are noncohesive, smooth spheres with few surface deposits. The ash particles tend to penetrate through the fabric leading to bleed-through. The noncohesive particles form an unstable dustcake on the fabric surface. Low collection efficiencies are expected for shake/deflate and reverse gas-cleaned baghouses because the dustcake is the primary filter medium for those baghouses. Pulsed-jet cleaned baghouses can achieve higher efficiencies because the bag acts as the primary filter medium.

A transportable pulsed-jet fabric filter pilot plant was tested at the 575 MW Big Brown Unit 1 of the TU Electric Company in Fairfield, TX. A medium to low-sulfur Texas lignite was fired throughout the tests. Two pulse jet cleaning systems were tested: high-pressure/low-volume and low-pressure/high-volume. During the low-pressure/high-volume tests, the average particulate collection efficiency was 99.95% with outlet emissions equivalent to 0.0002 to 0.0003 ng/J (0.005 to 0.008 lb/MMBtu). During the high-pressure/low-volume tests the particulate efficiency was 99.81% with outlet emissions of 0.00007 ng/J (0.0017 lb/MMBtu).[40]

TABLE 4-1. BASELINE SULFUR OXIDES EMISSION DATA[a]

Na_2O in ash, % by weight	Emission factor[b]			
	kg SO_x/Mg coal x S[c]		lb SO_x/ton coal x S[c]	
	Individual tests	Average for Na_2O range	Individual tests	Average for Na_2O range
0.4	16.9		33.7	
0.7	17.3		34.6	
0.8	18.1		36.1	
0.9	16.7	16.7	33.3	33.4
1	15.1		30.2	
1.1	14.7		29.3	
1.6	18.3		36.5	
1.7	16.7		33.4	
2	17.1		34.2	
2.1	18.7		37.4	
3	20.0		40.0	
3.1	16.6		33.2	
3.5	17.8		35.5	
3.8	13.9		27.8	
4.8	14.6		29.1	
5.1	13.4		26.8	
5.3	11.6		23.1	
5.4	13.0	16.2	25.9	32.3
5.5	15.1		30.2	
5.6	12.7		25.4	
5.8	16.7		33.4	
6	17.7		35.3	
6.1	12.3		24.5	
6.2	15.9		31.7	
7	16.0		31.9	
7.5	13.2		26.4	
7.7	17.7		35.3	
7.8	13.6		27.2	
8	16.8		33.5	
8.2	9.2		18.4	
8.6	8.5	11.0	16.9	21.9
8.8	15.6		31.2	
9	10.5		21.0	
10.9	5.5		10.9	

[a]Reference 2.
[b]Excluding fluidized beds which capture SOx by bed absorption.
[c]S = % sulfur wet basis.

TABLE 4-2. SUMMARY BASELINE NO_x AND CO EMISSIONS DATA FOR PULVERIZED LIGNITE UNITS[a]

Firing configuration	NO_x,		Data quality rating	Ref.	CO,		Data quality rating	Ref.
	kg/Mg	lb/ton			kg/Mg	lb/ton		
Tangential	4.25	8.5	B	2				
Tangential	3.05	6.1	B	3				
Horizontally Opposed Wall Fired	6.7 5.2 2.35	13.4 10.4 10.7	B B B	8 7 2	0.125	0.25	B	7
Front Wall Fired	5.0	10.0	B	2				

[a]All data, except for front wall firing configuration, taken after PM controls.

TABLE 4-3. SUMMARY BASELINE PM EMISSION DATA FOR PULVERIZED LIGNITE UNITS

Firing configuration	Particulate,[a]		Data quality rating	Reference
	kg/Mg	lb/ton		
Tangential	3.25 A	6.5 A	D	6
Front Wall	2.55 A	5.1 A	D	5

[a]A = wet basis % ash content of lignite.

TABLE 4-4. SUMMARY BASELINE NO_x EMISSIONS DATA FOR CYCLONE-FIRED UNITS

NO_x, kg/Mg	NO_x, lb/ton	Data quality rating	Reference	Controls[a]
6.05	12.1	B	2	
6.1	12.2	B	8	P
6.6	13.2	B	15	P,S

[a]Data taken after PM controls is designated by P. Data taken after SO_2 controls is designated by S.

TABLE 4-5. SUMMARY BASELINE PM EMISSION DATA FOR CYCLONE-FIRED UNITS

Particulate,[a] kg/Mg	Particulate,[a] lb/ton	Data quality rating	Reference
2.65A	5.3A	B	12
3.1A	6.2A	B	12
4.3A	8.6A	B	12

[a]A = wet basis % ash content of lignite.

TABLE 4-6. SUMMARY BASELINE NO_x EMISSIONS DATA FOR SPREADER STOKER UNITS

NO_x, kg/Mg	NO_x, lb/ton	Data quality rating	Reference	Controls[a]
2.6	5.2	B	2	P
3.2	6.4	B	15	P

[a]Data taken after particulate controls is designated by P.

TABLE 4-7. SUMMARY BASELINE PM EMISSIONS DATA FOR SPREADER STOKER UNITS

Particulate,[a]		Data quality rating	Reference
kg/Mg	lb/ton		
3.2A	6.4A	C	14
5.95A	11.9A	C	14
2.85A	5.7A	C	14

[a]A = wet basis % ash content of lignite.

TABLE 4-8. SUMMARY BASELINE PM EMISSIONS DATA FOR OTHER STOKER UNITS

Stoker type	Particulate,[a]		Data quality rating	Reference
	kg/Mg	lb/ton		
Underfeed	2.0A	4.0A	C	14
Overfeed	1.2A	2.4A	C	14
Overfeed	1.85A	3.7A	C	14

[a]A = wet basis % ash content of lignite.

TABLE 4-9. ATMOSPHERIC FLUIDIZED BED BASELINE NO_x, SO_x, AND CO EMISSIONS DATA[a]

Firing configuration	NO_x,		SO_x,[b]		CO,	
	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
North Dakota Region[c]						
66 MW Bubbling Bed Multiclone, ESP	2.3	4.6	4.95S	9.9S		
Texas Region[d]						
180 MW Circulating Bed Drum Type	1.3	2.6			0.075	0.15

[a]All of the source testing conducted at the stack downstream of controls.
[b]S = wet basis weight % sulfur content of lignite.
[c]Reference 15. All data are rated B.
[d]Reference 16. All data are rated A.

TABLE 4-10. CONTROLLED NO_x, SO_x, AND CO EMISSIONS DATA[a]

Firing configuration	NO_x,		SO_x,		CO,	
	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
<u>Subpart D Boilers,</u> <u>Pulverized Coal</u> <u>Tangential Firing</u>						
North Dakota Region[c]						
440 MW Unit Spray Dryers, Baghouse Overfire Air	2.6	5.1	3.1S	6.1S		
440 MW Unit Spray Dryers, Baghouse Overfire Air	2.4	4.8	4.2S	8.4S		
500 MW Unit ESP, Wet lime scrubbers FGD 60 % of flue gas Overfire Air	3.6	7.2	8.3S	16.6S		
500 MW Unit ESP, Wet lime scrubbers FGD 60 % of flue gas Overfire Air	4.0	7.9	8.5S	16.9S		
Texas Region[d]						
780 MW Unit ESP, Wet lime scrubbers Overfire Air	3.7	7.4	7.8S	15.6S		
780 MW Unit ESP, Wet lime scrubbers Overfire Air	4.3	8.5	7.7S	15.3S		
<u>Subpart D Boilers,</u> <u>Horizontally Opposed Firing</u>						
730 MW Unit ESP, Wet lime scrubbers Overfire Air, Low NO_x burners	2.7	5.3	6.9S	13.7S	0.24	0.48
750 MW Unit ESP, Wet limestone scrubbers Overfire Air, Low NO_x burners	2.0	3.9	9.7S	19.4S		

TABLE 4-10. CONTROLLED NO_x, SO_x, AND CO EMISSIONS DATA (Continued)[a]

Firing configuration	NO_x,		SO_x,		CO,	
	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
Subpart Da Boilers, Pulverized Coal Tangential Firing						
North Dakota Region[c]						
55 MW Spray Dryer, Baghouse Overfire Air	3.3	6.6	4.0S	7.9S		
Texas Region[d]						
780 MW ESP, Wet limestone scrubbers Overfire Air	2.4	4.8	2.1S	4.2S	0.03	0.06
780 MW ESP, Wet limestone scrubbers Overfire Air	3.3	6.6	1.6S	3.2S	0.07	0.13

[a]All of the source testing conducted at the stack after all controls.
[b]S = wet basis weight % sulfur content of lignite.
[c]Reference 15. All data are rated B.
[d]Reference 16. All data are rated A.

TABLE 4-11. ATMOSPHERIC FLUIDIZED BED UNITS CONTROLLED SO_x EMISSIONS DATA[a]

Firing configuration	SO_x,[b]	
	kg/Mg	lb/ton
Texas Region[c]		
180 MW Circulating Bed Drum Type Limestone injection	3.5S	7.0S

[a]All of the source testing conducted at the stack after all controls.
[b]S = wet basis weight % sulfur content of lignite.
[c]Reference 16. All data are rated A.

TABLE 4-12. CONTROLLED PM EMISSIONS DATA[a]

Firing configuration	PM[b]	
	kg/Mg	lb/ton
<u>Subpart D Boilers, Pulverized Coal Tangential Firing</u>		
North Dakota Region[c]		
440 MW Unit Spray Dryers, Baghouse Overfire Air	0.05A	0.09A
440 MW Unit Spray Dryers, Baghouse Overfire Air	0.03A	0.06A
500 MW Unit ESP, Wet lime Scrubbers FGD 60 % of flue gas Overfire Air	0.01A	0.02A
500 MW Unit ESP, Wet lime Scrubbers FGD 60 % of flue gas Overfire Air	0.04A	0.08A
Texas Region[d]		
780 MW Unit ESP, Wet limestone scrubbers Overfire Air	0.02A	0.04A
780 MW Unit ESP, Wet lime scrubbers Overfire Air	0.04A	0.07A
<u>Subpart D Boilers, Horizontally Opposed Firing</u>		
730 MW Unit ESP, Wet limestone scrubbers Overfire Air, Low-NO_x burners	0.03A	0.05A
750 MW Unit ESP, Wet limestone scrubbers Overfire Air, Low NO_x-burners	0.02A	0.04A

TABLE 4-12. CONTROLLED PARTICULATE EMISSIONS DATA (Continued)[a]

Firing configuration	PM,[b]	
	kg/Mg	lb/ton
<u>Subpart Da Boilers, Pulverized Coal Tangential Firing</u>		
Texas Region[d]		
780 MW ESP, Wet limestone scrubbers Overfire Air	0.005A	0.01A
780 MW ESP, Wet limestone scrubbers Overfire Air	0.005A	0.01A

[a]All of the source testing conducted at the stack after all controls.
[b]A = wet basis % ash content of lignite.
[c]Reference 15. All data are rated B.
[d]Reference 16. All data are rated A.

TABLE 4-13. ATMOSPHERIC FLUIDIZED BED UNITS CONTROLLED PM EMISSIONS DATA[a]

Firing configuration	PM,[b]	
	kg/Mg	lb/ton
North Dakota Region[c]		
66 MW Bubbling Bed Multiclone, ESP	0.055A	0.11A
Texas Region[d]		
180 MW Circulating Bed Drum Type	0.01A	0.02A

[a]All of the source testing conducted at the stack after all controls.
[b]A = wet basis weight % ash content of lignite.
[c]Reference 15. All data are rated B.
[d]Reference 16. All data are rated A.

TABLE 4-14. CONTROLLED ORGANIC EMISSIONS DATA[a]

Firing configuration	Nonmethane TOC,		Methane,	
	kg/Mg	lb/ton	kg/Mg	lb/ton
<u>Subpart Da Boilers,</u> <u>Pulverized Coal</u> <u>Tangential Firing</u>				
Texas Region[c]				
780 MW ESP, Wet limestone scrubbers, Overfire Air	0.14	0.27		
780 MW ESP, Wet limestone scrubbers, Overfire Air	0.08[b]	0.16[b]	0.01	0.02
<u>Subpart D Boilers,</u> <u>Horizontally Opposed</u>				
730 MW ESP, Wet limestone scrubbers Overfire Air, Low-NO_x burners	0.01	0.02	0.01	0.02

[a]All of the source testing conducted at the stack after all controls.
[b]Nonmethane nonethane hydrocarbons as propane.
[c]Reference 16. All data are rated A.

TABLE 4-15. N_2O EMISSION FACTORS FOR EXTERNAL COMBUSTION OF LIGNITE

Firing configuration	Emission factor rating	N_2O,	
		kg/Mg	lb/ton
Fluidized Beds	E	1.24	2.48

TABLE 4-16. METAL ENRICHMENT BEHAVIORS

Class	Description	Reference 38	Reference 39	Reference 40
I	Equal distribution between fly ash and bottom ash		Al[a], Co, Fe[a], Mn, Sc[a], Ti[a]	Al[a], Co, Cr, Fe[a], Mn, Sc[a], Ti[a]
II	Enriched in fly ash relative to bottom ash	As, Cd	As, Cd, Pb, Sb	As, Cd, Pb, Sb
III	Somewhere in between Class I and II, multiple behavior	Be, Cr, Ni, Mn	Cr, Ni	Ni
IV	Emitted in gas phase	Hg	Hg	Hg

[a]Reference metals.

TABLE 4-17. ENRICHMENT RATIOS FOR CLASSES OF ELEMENTS

Class	Description	Metals	Fly ash enrichment ratio (ER)
I	Nonvolatile	Cr, Sc, Ti, Fe	ER ≈ 1
IIa	Volatile with varying condensation on ash particles	As, Cd, Pb, Sb	ER > 4
IIb		Be, Co, Ni	2 < ER < 4
IIc		Mn	1.3 < ER ≤ 2
III	Very volatile, almost no condensation	Hg, Se	

TABLE 4-18. FLY ASH ENRICHMENT RATIOS FOR A BOILER AND CONTROL DEVICE[a]

Device	Sb	As	Be	Cd	Cr	Co	Pb	Mn	Hg	Ni	Se	Th 232	Th 228	U 238	Th 230	Ra 226	Pb 210
Pulverized coal boiler (10100301)	1.09	1.13	0.56	0.61	0.97	1.02	1.21	1.03	0.64	0.96	1.07	1.19	1.20	1.24	1.31	1.20	1.43
High efficiency cold-side ESP	6.6	6.3			3.0	2.1	6.1	2.2		2.4	4.5	0.70		0.86			

[a]All enrichment ratios are rated E quality.

TABLE 4-19. TRACE METAL EMISSION FACTORS (METRIC UNITS) FOR UNCONTROLLED LIGNITE-FIRED BOILERS[a]

Firing configuration (SCC)	As	Be	Cd	Cr	Mn	Hg	Ni
Pulverized Wet Bottom (no SCC)	1175	56	21-33	525-809	1917-7065	9	70-504
Pulverized Dry Bottom (no SCC)	598	56	21	645-809	7043	9	404-504
Cyclone Furnace (10100303)	101-272	56	13	109-809	1635	9	68-504
Stoker Configuration Unknown (no SCC)		51			5130	9	303-504
Spreader Stoker (10100306)	231-473		10-20	486-809			
Traveling Grate (Overfed) Stoker (10100304)	473-904		20-39				

[a]All emission factors in pg/J. All emission factors are rated E.

TABLE 4-20. TRACE METAL EMISSION FACTORS (ENGLISH UNITS) FOR UNCONTROLLED LIGNITE-FIRED BOILERS[a]

Firing configuration (SCC)	As	Be	Cd	Cr	Mn	Hg	Ni
Pulverized (10100301)							
Pulverized Wet Bottom (no SCC)	2730	131	49-77	1220-1880	4410-16,250	21	154-1160
Pulverized Dry Bottom (no SCC)	1390	131	49	1500-1880	16,200	21	928-1160
Cyclone Furnace (10100303)	235-632	130	31	253-1880	3760	21	157-1160
Stoker Configuration Unknown (no SCC)		118			11800	21	
Spreader Stoker (10100306)	538-1100		23-47	1130-1880			696-1160
Traveling Grate (overfed) Stoker (10100304)	1100-2100		47-90				

[a]All emission factors in lb/10^{12} Btu. All emission factors are rated E.

TABLE 4-21. HAP EMISSION FACTORS (METRIC UNITS) FOR CONTROLLED LIGNITE-FIRED BOILERS[a]

Boiler configuration	Control device	Cr	Mn	POM
Pulverized Coal (10100301)	Multi-cyclones	29-32		
	ESP	8.6		
	High Efficiency Cold-Side ESP			0.99
Pulverized Wet Bottom (no SCC)	ESP		14.7	
Pulverized Dry Bottom (no SCC)	Multi-cyclones			0.78-7.9[b]
	ESP		18.1	1.1[b]
Cyclone Furnace (10100303)	ESP	<3.3	57.2	0.05[c]-0.68[b]
	Multi-cyclones		711	
Stoker Configuration Unknown (no SCC)	Multi-cyclones	13	47.3	
	ESP	<2.3		
Spreader Stoker (10100306)	Multi-cyclones			6.3[b]

[a]All emission factors in pg/J. All emission factors are rated E.
[b]Primarily trimethyl propenyl naphthalene.
[c]Primarily biphenyl.

TABLE 4-22. HAP EMISSION FACTORS (ENGLISH UNITS) FOR CONTROLLED LIGNITE-FIRED BOILERS[a]

Boiler configuration	Control device	Cr	Mn	POM
Pulverized Coal (10100301)	Multi-cyclones	67-74		
	ESP	20		
	High Efficiency Cold-Side ESP			2.32
Pulverized Wet Bottom (no SCC)	ESP		34.2	
Pulverized Dry Bottom (no SCC)	Multi-cyclones			1.8-18.3[b]
	ESP		42.2	2.6[b]
Cyclone Furnace (10100303)	ESP	27.7	133	0.11[c]-1.6[b]
	Multi-cyclones		1656	
Stoker Configuration Unknown (no SCC)	Multi-cyclones	30	110	
	ESP	<5.4		
Spreader Stoker (10100306)	Multi-cyclones			14.6[b]

[a]All emission factors in lb/10^{12} Btu. All emission factors rated E.
[b]Primarily trimethyl propenyl naphthalene.
[c]Primarily biphenyl.

TABLE 4-23. FILTERABLE PARTICULATE FOR LIGNITE-FIRED FLUIDIZED BED COMBUSTORS WITH MULTICLONE CONTROLS

Fuel	Filterable Particulate, cumulative mass percent less than stated size (microns)							Data quality rating	Reference
	0.625	1.00	1.25	2.50	6.00	10	15		
Gibbons Creek lignite	< 2	11	18	41	82	90	94	C	38

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5. AP-42 SECTION 1.7: LIGNITE COMBUSTION

The revision to Section 1.7 of AP-42 is presented in the following pages as it would appear in the document. A marked-up copy of the 1986 version of this section is included in Appendix B.

APPENDIX A

CONVERSION FACTORS

TABLE A-1. CONVERSION FACTORS

Given	To Obtain	Multiply By
ppm	lb/MBtu	2.59×10^{-9} (MW)Fd (20.9/20.9-O_2) Where Fd from 40 CFR Part 60 Appendix A M19 - usually 9820
lb/MBtu	lb/ton	HHV (as rec'd) = $2,000/10^6$
lb/ton	kg/Mg	0.5
HHV dry, mineral matter free	HHV (as rec'd)	(100-M-A)/100

MW = Molecular weight of pollutant.

O_2 = Oxygen concentration at sampling point in percent.

M = Moisture in as received coal sample in percent.

A = Ash in as received coal sample in percent.

APPENDIX B

MARKED-UP 1986 AP-42 SECTION 1.7

REPORT ON REVISIONS TO

5TH EDITION AP-42

Section 1.7

Lignite Combustion

Prepared for:

Contract No. 68-D2-0160, Work Assignment 50
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August 2, 1996

Table of Contents

1.0 INTRODUCTION

This report supplements the Emission Factor (EMF) Documentation for AP-42 Section 1.7, Lignite Combustion, dated April 1993. The EMF describes the source and rationale for the material in the most recent updates to the 4th Edition, while this report provides documentation for the updates written in both Supplements A and B to the 5th Edition.

Section 1.7 of AP-42 was reviewed by internal peer reviewers to identify technical inadequacies and areas where state-of-the-art technological advances needed to be incorporated. Based on this review, text was updated or modified to address any technical inadequacies or provide clarification.

Emission factors were checked for accuracy with information in the EMF Document, and new emission factors generated if recent test data were available. If discrepancies were found when checking the factors with the information in the EMF Document, the appropriate reference materials were then checked. In some cases, the factors could not be verified with the information in the EMF Document or from the reference materials, in which case the factors were not changed.

Four sections follow this introduction. Section 2 of this report documents the revisions and the basis for the changes. Section 3 presents the references for the changes documented in this report. Section 4 presents the revised AP-42 Section 1.7, and Section 5 contains the EMF documentation dated April 1993.

2.0 REVISIONS

2.1 General Text Changes

Information in the EMF Document and the Utility Boiler Alternative Control Techniques (ACT) Document[1] was used to enhance text concerning lignite characteristics; firing practices, emissions and controls. Additionally, at the request of EPA, the metric units were removed.

2.2 Nitrogen Oxides, NO_x

2.2.1 Uncontrolled NO_x

The factors were checked against information in Tables 4-2, 4-4, 4-6, and 4-9 of the EMF Document and the 9/88 version of Section 1.7 and no changes were required.

2.2.2 Controlled NO_x

The controlled NO_x emission factors were changed from two categories of NO_x controls (tangential boilers with overfire air and tangential boilers with overfire air plus low NO_x burners) to three categories based on information in Table 4-10 of the EMF Document. The three categories of boilers and NO_x controls are Subpart D tangential boilers with overfire air; Subpart D wall-fired boilers with overfire air plus low NO_x burners; and Subpart Da tangential boilers with overfire air. The changes made are shown in the following table:

NO_x Emission Factors for Controlled Lignite Boilers

Firing Configuration and NO_x Control	Revised NO_x Emission Factor (lb/ton)	Emission Factor Rating
Subpart D boilers, pulverized coal, tangential-fired overfire air	6.8	C
Subpart D boilers, pulverized coal, wall-fired, overfire air plus low NO_x burners	4.6	C
Subpart Da boilers, pulverized coal, tangential-fired overfire air	6.0	C

2.3 Sulfur Oxides, SO_x

2.3.1 Uncontrolled SO_x

The factors were checked against information in Tables 4-1 and 4-9 of the EMF Document and the 9/88 version of Section 1.7 and the following typographical error was corrected for the Atmospheric Fluidized Bed Boiler category:

Source Category	Previous Factor (lb/ton)	Revised Factor (lb/ton)
Atmospheric Fluidized Bed	30S	10S

2.3.2 Controlled SO_x

Table 4-10 of the EMF Document contained SO_x emission factors for various lignite boilers with SO_x controls; however, this data was not included in the 4/93 version of AP-42. The data were divided into four categories according to boiler age (i.e., Subpart D or Da) and SO_x control type (i.e., spray dryer or wet scrubber). The emission factors added are shown in the following table:

SO_x Emission Factors for Controlled Lignite Boilers

Boiler Type and SO_x Control	SO_x Emission Factor (lb/ton)	Rating
Subpart D, pulverized coal, tangential and wall-fired, spray dryer	7.3S	D
Subpart D, pulverized coal, tangential-fired, wet scrubber	16.8S	C
Subpart Da, pulverized coal, tangential-fired spray dryer	7.9S	D
Subpart Da, pulverized coal, tangential-fired, wet scrubber	3.7S	C

2.4 Carbon Monoxide, CO

2.4.1 Uncontrolled CO

The factors were checked against information in Tables 4-2, 4-9, and 4-10 of the EMF Document and the 10/86 version of AP-42 and no changes were required.

2.4.2 Controlled CO

The controlled CO emission factors were changed from two categories (tangential boilers with overfire air and tangential boilers with overfire air plus low NO_x burners) to three categories based on information in Table 4-10 of the EMF Document. Three categories of boilers and NO_x controls are Subpart D tangential boilers with overfire air; Subpart D wall-fired boilers with overfire air plus low NO_x burners; and Subpart Da tangential boilers with overfire air. (NO_x controls may affect CO emission whereas SO_2 controls should not.) The changes made are shown in the following table:

CO Emission Factors for Controlled Lignite Boilers

Firing Configuration and No_x Control	Revised CO Emission Factor (lb/ton)	Emission Factor Rating
Subpart D boilers, pulverized coal, tangential-fired overfire air	No data	Not applicable
Subpart D boilers, pulverized coal, wall-fired, overfire air plux low NO_x burners	0.48	D
Subpart Da boilers, pulverized coal, tangential-fired, overfire air	0.1	D

2.5 Particulate Matter, PM

2.5.1 Uncontrolled PM

The uncontrolled PM emission factors were checked against information in Tables 4-3, 4-5, 4-7, and 4-8 of the EMF Document and no changes were required.

2.5.2 Controlled PM

The controlled PM emission factors were checked against information in Tables 4-12 and 4-13 of the EMF Document and no changes were required.

2.6 Particle Size Distribution

The particle size factors remain the same as in the 10/86 version of AP-42.

2.7 Trace Metals and Polycyclic Organic Matter (POM)

These emission factors were checked against information in Tables 4-18, 4-19, and 4-20 of the EMF Document and no changes were required. However, the controlled emission factors for those metals were replaced with new factors. See Section 2.9, Toxic Air Pollutants.

2.8 Greenhouse Gases

2.8.1 Carbon Dioxide, CO_2

CO_2 emission factors for Table 1.7-2 were developed assuming 99 percent conversion of fuel carbon content to carbon dioxide during combustion.[2-4] An emission factor of 72.6C, where C is carbon content (weight percentage based on an ultimate analysis, dry basis), was developed using the following equation:

$$\frac{44 \text{ ton } CO_2}{12 \text{ ton } C} \times 0.99 \times 2000 \frac{\text{lb } CO_2}{\text{ton } CO_2} \times \frac{1}{100\%} = 72.6 \frac{\text{lb } CO_2}{\text{ton} - \%C}$$

Where:
- 44 = molecular weight of CO_2;
- 12 = molecular weight of carbon; and
- 0.99 = fraction of fuel oxidized during combustion (Reference 2-4).

If an ultimate analysis is not available, a default CO_2 emission factor was computed based on the emission factor equation presented above and the average carbon content (dry basis) for several U.S. lignite samples.[5-8] Because of the variance of carbon content with the geographical location of the mine, this default factor was assigned a “B” rating.

Table 3-2. Default CO_2 Emission Factors for U.S. Coals
Quality Rating: B

Fuel Type	Average %C[a]	Conversion Factor	Emission Factor (lb/ton coal)
Lignite	63.4	72.6	4600

[a] An average of the values given in References 5-8. Each of these references listed average carbon contents based on extensive sampling of U.S. coals.

2.8.2 Methane, CH_4

No emissions data were located.

2.8.3 Nitrous Oxide, N_2O

No emissions data were located.

2.9 Toxic Air Pollutants

An evaluation of toxic emissions data resulted in the development of new factors that were added to the section. In addition, the evaluation resulted in the replacement of controlled emission factors for chromium and manganese because the new factors were of higher quality. Most of the emissions data were stack test reports that presented emission factors, or reports that presented emissions and process data from which emission factors were developed. The following sections describe the documents evaluated and the methods used to develop the toxic emission factors.

2.9.1 General Document Evaluation and Emission Factor Development

Section 1.1, Bituminous And Subbituminous Coal Combustion and Section 1.7, Lignite Combustion were updated simultaneously and, therefore, emissions data from both types of combustion were of interest during the emissions data evaluation. Originally, the intent was to develop separate emission factors for the two sections, but after all data were assembled and examined, the emission factors for the two types of combustion were very similar in value. Because the factors were similar, it was decided to combine all data and develop one set of emission factors that would represent bituminous/subbituminous coal combustion as well as lignite combustion.

The focus of the emissions data evaluation was on toxic air pollutants, especially metals. Several documents provided emissions data for compounds that are not considered hazardous air pollutants and these data were not used to develop emission factors. Because of the limited scope of the emission factor development project, some data for toxic air pollutants were not used. Emissions data for radionuclides were encountered but were not used because the list of potential radionuclide emission factors is quite extensive. Emissions data for dioxins/furans were not used unless data for all congeners was included.

Because of budget constraints, the document evaluation concentrated on air emissions, or final stack emissions, only. Emissions data obtained from sampling at control device inlets, or outlets of intermediate control devices, were not used to develop emission factors.

Following EPA guidance, the emission factors developed for Section 1.7 of AP-42 are expressed in units of pound of pollutant emitted per ton of coal fired (lb/ton). Thus, the emissions documents were evaluated in order to identify emission factors, or information from which emission factors could be developed, in units of lb/ton. Many of the documents presented emission factors, but they were in units of pound of pollutant emitted per million British thermal units of heat input (lb/MMBtu). In such cases, a higher heating value (HHV) for coal in units of

Btu/lb was used to convert the factor to units of lb/ton. Several of the documents provided emissions and process information, such as emission rates and coal feed rates, that were used to develop emission factors. Some of the documents provided coal data, such as the HHV and coal feed rate, on a dry-basis. When the moisture content of the coal was provided, the dry-basis data were converted to as-fired, or as-received, data. The methods used for each document to develop the emission factors are described in Section 2.9.2, Description Of Documents Evaluated.

The majority of the documents evaluated were emissions test reports obtained from various sources. One source of emissions information was test reports provided by the Electric Power Research Institute (EPRI) and the U.S. Department of Energy (DOE). EPRI and DOE conducted an extensive emissions test program at several coal-fired power plants in order to characterize their emissions. Most of the individual facility test reports and the summary report of the test program were provided to EPA for use in emission factor development.

Another source of information was several emissions test reports from coal-fired power plants provided to EPA by the Northern States Power Company (NSP). In addition, several test reports obtained by EPA from other sources were evaluated.

A computer spreadsheet was constructed for each document where calculations were required to develop and characterize emission factors from information presented in the document. A spreadsheet was created for every reference except Reference 9. Reference 9 is a summary of an emissions test program conducted by EPRI and DOE. The spreadsheets were used as mathematical tools and as a means of documenting all calculations and assumptions. Also, information from each document that was used to characterize the emission factors was included in the spreadsheets. For example, information provided about the boiler(s) tested was used to assign a source classification code (SCC). In addition, any control devices in use by the emission source were noted. Copies of each computer spreadsheet are included in Appendix A.

When assigning SCCs to an emission source described in a reference, the boiler was assumed to be dry bottom unless the document specified that the boiler was wet bottom or mentioned an ash removal method that would be indicative of a wet bottom boiler. All emission controls described by the reference as being in use at the time the emissions data were collected were noted and no attempt was made to judge the effect of a control device on any of the sampled pollutants. Emissions data were not characterized as "uncontrolled" unless there was no type of pollution control device at all in use when the emissions data were collected.

2.9.2 Description of Documents Evaluated

The following paragraphs provide a summary of the information presented in each document that was evaluated for emission factors. Also, the methods used to develop emission factors from the information provided in each document are described. Copies of the computer spreadsheets that were constructed for each document (except Reference 9) are contained in Appendix A. The text descriptions are provided as a supplement to the spreadsheets in order to ensure that the development of all emission factors is fully explained.

Reference 9

This document summarizes the results of the emissions test program conducted by EPRI and DOE. This document presents emission factor equations for nine trace metals and emission factors for five organic pollutants that were developed from emissions data collected during the test program. The emission factor equations were judged to be of sufficient quality for inclusion in AP-42 and are presented there "as is," i.e. no adjustments or conversions were made. The organic emission factors were not used for AP-42 because they are a geometric, instead of arithmetic, mean. The reference was assigned a data quality rating of "A." The emission factor equations are discussed in detail in Section 2.9.3, Emission Factor Development.

Reference 10

This document presents the results of two emissions tests conducted at the NSP Sherco plant in Becker Minnesota. One emission test was conducted on Unit Three, which is a Babcock and Wilcox (B&W) 860 MW boiler firing pulverized subbituminous coal from Montana. Unit Three came on line in 1987. Emission controls utilized during the test were a spray dryer absorber and a baghouse.

The second emissions test was performed simultaneously on Units One and Two, which are identical Combustion Engineering 750 MW boilers that came on line in 1976. During the tests, both boilers were firing 70 percent Wyoming and 30 percent Montana pulverized subbituminous coal. Emissions from Units One and Two were controlled by a venturi scrubber spray tower during the emissions tests.

Both emissions tests consisted of three sampling runs for mercury and the results are presented as emission rates in units of lb/hr. The reference indicates that all sampling results were above the detection limits. In addition, the document presents the coal feed rates in ton/hr during both tests. Mercury emission factors in units of lb/ton were developed by dividing the emission rates by the coal feed rates.

The document was assigned a data quality rating of "A."

Reference 11

This reference presents the results of an emissions test conducted simultaneously on the Number One, Number Three, and Number Four boilers at the NSP Black Dog Plant located in Burnsville, Minnesota. The boilers are water tube boilers and were fired with pulverized subbituminous coal from the Antelope and North Antelope mines during the test. Emission controls utilized during the test were two electrostatic precipitators (ESPs) in series.

The emissions test consisted of three sampling runs for metals and the results are presented as emission rates in units of lb/hr. Full detection limit values were used to develop emission rates for pollutants that were not detected in any sampling run. Stack gas volumetric flow rates presented in the report (dscf/hr) and an average F-factor for coal of 9,780 dscf/MMBtu were used to develop an energy input rate in units of MMBtu/hr. The reference provides an HHV for the coal fired during the emissions test of 8,707 Btu/lb on an as-received basis. This value was used to convert the energy input rate to a coal feed rate in ton/hr. The emission rates were divided by the coal feed rate to arrive at emission factors in units of lb/ton.

The document was assigned a data quality rating of "B" because the coal feed rates during the emissions test were not provided.

Reference 12

The results of an emissions test conducted on the Number Two boiler at the NSP Black Dog plant in Burnsville, Minnesota, are presented in this report. The Number Two boiler is a 137 MW Foster-Wheeler atmospheric fluidized bed combustor (AFBC). At the time of the emissions test, Unit Two was firing 100 percent Western coal (blend of Antelope and Northern Antelope), which is subbituminous coal. Emission control devices in use during the test were a mechanical dust collector and two ESPs in series.

Three sampling runs were conducted for metals and the results are presented as emission rates in units of lb/hr. Full detection limit values were used to develop emission rates for pollutants that were not detected in any sampling run. Stack gas volumetric flow rates (dscf/hr) provided in the document and an average F-factor for coal of 9,780 dscf/MMBtu were used to develop an energy input rate in units of MMBtu/hr. The reference provides an HHV for the coal fired during the emissions test of 8,553 Btu/lb on an as-received basis. This value was used to convert the energy input rate to a coal feed rate in ton/hr. The emission rates were divided by the coal feed rates to arrive at emission factors in units of lb/ton.

The reference was assigned a data quality rating of "B" because the coal feed rates during the emissions test were not provided.

Reference 13

This reference presents the results of an emissions test conducted simultaneously on the Number Three, Number Four, Number Five, and Number Six boilers at the NSP High Bridge plant in St. Paul, Minnesota. All of these boilers are B & W boilers and are equipped to fire pulverized coal. During the test, the boilers were fired with subbituminous coal from the Rochelle mine. A coldside ESP was in use during the emissions test.

Three sampling runs were conducted for metals, benzene, toluene, ethylbenzene, and xylene and the results are presented as emission rates in units of lb/hr. All sampling results for metals were above the detection limits. Benzene, toluene, ethylbenzene, and xylene were not detected in any sampling run and no emission factors for these pollutants were developed. Stack gas volumetric flow rates (dscf/hr) provided in the document and an average F-factor for coal of 9,780 dscf/MMBtu were used to develop an energy input rate in MMBtu/hr. The reference presents an HHV for the coal fired during the emissions test of 8,498 Btu/lb on an as-received basis. This value was used to convert the energy input rate to a coal feed rate in ton/hr. The emission rates were divided by the coal feed rates to arrive at emission factors in units of lb/ton.

This reference was assigned a data quality rating of "B" because the coal feed rates during the emissions test were not provided.

Reference 14

This document presents the results of emissions tests conducted on the Units Six and Seven at the NSP Riverside plant in Minneapolis, Minnesota. These boilers are pulverized coal-fired boilers and were firing subbituminous coal from the Rochelle mine during the emissions tests. Emission controls in use during the test consisted of a baghouse.

Three sampling runs were conducted for metals, benzene, toluene, ethylbenzene and xylene. For metals, the emissions data from both units were combined and presented as emission rates in units of lb/hr. The benzene, toluene, ethylbenzene and xylene emissions data are presented separately for each unit as emission rates in lb/hr. All sampling results for metals were above the detection limits. Toluene, ethylbenzene, and xylene were not detected in any sampling run and no emission factors for these pollutants were developed. Stack gas volumetric flow rates (dscf/hr) provided in the document and an average F-factor for coal of 9,780 dscf/MMBtu were used to develop an energy input rate in MMBtu/hr. The reference provides an HHV for the coal fired during the emissions test of 8,602 Btu/lb on an as-received basis. This value was used to convert the energy input rate to a coal feed rate in ton/hr. The emission rates were divided by the coal feed rates to arrive at emission factors in units of lb/ton.

The reference was assigned a data quality rating of "B" because the coal feed rates during the emissions test were not provided.

Reference 15

The results of an emissions test conducted simultaneously on Units One and Two at the NSP Sherburne County Generating Station located in Becker, Minnesota, are presented in this reference. The units are identical Combustion Engineering 750 MW boilers which came on line in 1976 and were fired with 80 percent Rochelle and 20 percent Coalstrip pulverized subbituminous coal during the test. The boilers were controlled by a wet limestone scrubbing system consisting of twelve individual rod venturi scrubber spray towers during the test.

Three sampling runs were conducted for metals and the results are presented as emission rates in units of lb/hr. Full detection limit values were used to calculate emission rates for pollutants that were not detected in any sampling run. Stack gas volumetric flow rates (dscf/hr) provided in the document and an average F-factor for coal of 9,780 dscf/MMBtu were used to develop an energy input rate in MMBtu/hr. The reference provides an HHV for the coal fired during the emissions test of 8,547 Btu/lb on an as-received basis. This value was used to convert the energy input rate to a coal feed rate in ton/hr. The emission rates were divided by the coal feed rates to arrive at emission factors in units of lb/ton.

The reference was assigned a data quality rating of "B" because the coal feed rates during the emissions test were not provided.

Reference 16

This document presents the results of an emissions test conducted simultaneously on Units One and Two at the NSP Sherburne County Generating Station located in Becker, Minnesota. The units are identical Combustion Engineering 750 MW boilers which came on line in 1976. The document does not specify the type of coal being fired during the tests. One other test report from this facility is included in this documentation (Reference 15) and the boilers were firing pulverized subbituminous coal during that test. Thus, it was assumed that the boilers were firing pulverized subbituminous coal during the tests described in this reference. Emissions were controlled by a wet limestone scrubbing system consisting of 12 individual rod venturi scrubber spray towers during the emissions test.

Three sampling runs were conducted for metals and the results are presented as emission rates in units of lb/hr. Full detection limit values were used to develop emission rates for pollutants that were not detected in any sampling run. Stack gas volumetric flow rates (dscf/hr) provided in the document and an average F-factor for coal of 9,780 dscf/MMBtu were used to develop an energy input rate in MMBtu/hr. The reference does not provide an HHV for the coal fired during the emissions test and, therefore, an HHV for coal of 8,547 Btu/lb presented in Reference 15 (test report from the same facility) was used to convert the energy input rate to a coal feed rate in ton/hr. The emission rates were divided by the coal feed rates to arrive at emission factors in units of lb/ton.

The reference was assigned a data quality rating of "B" because the coal feed rates during the emissions test were not provided.

<u>Reference 17</u>

The results of an emissions test conducted on Unit Three at the NSP Sherburne County Generating Station located in Becker, Minnesota, are presented in this document. Unit Three is a B & W 860 MW boiler which came on line in 1987 and was fired with pulverized subbituminous coal from Montana during the emissions test. The boiler was controlled by a spray dryer absorber and a baghouse during the emissions test.

Three sampling runs were conducted for metals and the results are presented as emission rates in units of lb/hr. Full detection limit values were used to develop emission rates for pollutants that were not detected in any sampling run. Stack gas volumetric flow rates (dscf/hr) provided in the document and an average F-factor for coal of 9,780 dscf/MMBtu were used to develop an energy input rate in MMBtu/hr. The document does not provide an HHV for the coal fired during the test and, therefore, an HHV for coal of 8,547 Btu/lb presented in Reference 15 (test report from the same facility) was used to convert the energy input rate to a coal feed rate in ton/hr. The emission rates were divided by the coal feed rates to arrive at emission factors in units of lb/ton.

The reference was assigned a data quality rating of "B" because the coal feed rates during the emissions test were not provided.

<u>Reference 18</u>

This reference presents the results of emission testing at a facility designated as EPRI Site 10. The boiler at this site is a fluidized bed combustor capable of producing approximately 100 MW of power at full load. According to the EPRI Synthesis Report (Reference 9), the boiler is a circulating bed AFBC and was firing subbituminous coal during the tests. Emission controls utilized during the tests were flue gas desulfurization (FGD) by limestone injection into the boiler combustion chamber and a fabric filter.

Test sampling runs were conducted for metals and organics. Because of a forced boiler outage, only one sampling run was conducted for all compounds except benzene. Five samples for benzene were collected at a later date. Full detection limit values were used to develop emission factors for pollutants that were not detected in any sampling run.

Emissions test results for dibutyl phthalate, bis(2-ethylhexyl), and N-nitrosodimethylamine are presented as concentrations in units of microgram per cubic Normal cubic meter. The reference indicates that all sampling results for these pollutants were above the detection limits. The concentrations were converted to units of pounds per dry standard cubic feet (lb/dscf) and multiplied by the stack gas volumetric flow rate (dscf/hr) to arrive at an emission rate in lb/hr. The reference presents a dry-basis coal feed rate of 108,626 lb/hr during the test and a coal moisture percent of 7.3. The dry coal feed rate was divided by 100 percent minus 7.3 percent (92.7 percent) to obtain a coal feed rate, as fired, of 117,180 lb/hr. The emission rates for the three pollutants were divided by the coal feed rate, as fired, to obtain emission factors in units of lb/ton.

The emissions results for the other compounds are presented as emission factors in units of lb/10^{12} Btu. Full detection limit values were used to develop emission factors that are based only on sampling results that were below detection limits. The reference presents an HHV for the coal of 11,000 Btu/lb on a dry basis. The dry-basis HHV was divided by 100 percent plus 7.3 percent (107.3 percent) to obtain a HHV of 10,252 Btu/lb for the coal, as fired. The as-fired coal HHV was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This reference was assigned a data quality rating of "A."

Reference 19

This document presents the results of emissions testing at a facility designated as EPRI Site 11. The boiler tested is a 700 MW Combustion Engineering dry bottom, tangentially-fired unit with pulverized subbituminous coal from the Power River basin. Emission controls utilized during the test were over-fire air, an ESP, and a wet limestone scrubber/absorber.

Three sampling runs were conducted for metals, formaldehyde, and naphthalene and the results are presented as emission factors in units of lb/MMBtu. However, Run Three was invalid because of suspected contamination. For Run One, the vapor phase samples were lost and, therefore, were not analyzed. Emissions results for the solid phase of Run One and the Run Two solid and vapor phase results were used to calculate the average emission factors presented in the report. Rather than convert the emission factors presented in the reference from lb/10^{12} Btu to lb/ton, the data from Run Two were used to develop emission factors. Pollutant concentrations in ug/Nm^3 provided in the report for Run Two were converted to lb/dscf and then multiplied by the stack gas volumetric flow rate (dscf/hr) provided in the report to obtain emission rates in lb/hr. Full detection limit values were used to develop emission rates for pollutants that were not detected. An F-factor for coal of 9,780 dscf/MMBtu and the stack gas volumetric flow rate (dscf/hr) were used to calculate an energy input rate in MMBtu/hr. The reference presents an HHV for the coal fired during the emissions test of 8,300 Btu/lb, as received. This value was used to convert the energy input rate to a coal feed rate in ton/hr. The pollutant emission rates were divided by the coal feed rate to obtain emission factors in units of lb/ton.

This reference was assigned a data quality rating of "B" because the coal feed rate was not provided.

Reference 20

The results of emissions testing at a facility designated as EPRI Site 12 are presented in this report. The boiler at Site 12 is an approximately 700 MW which commenced commercial operation in the mid-1980's. The boiler is a B & W balanced draft, opposed-wall, natural circulation, pulverized coal-fired, dry bottom boiler. The boiler was firing western Pennsylvania bituminous coal and was controlled by a wet limestone scrubber and ESP during the emissions test.

Three sampling runs were conducted for metals and organics, however, one of the metals runs was declared invalid because of a sample processing error. The emissions results are presented as emission factors in units of lb/10^{12} Btu. Full detection limit values were used to develop emission factors that are based only on results that were below detection limits. The reference provides an average HHV for the coal fired during the emissions test of 13,733 Btu/lb on a dry basis and a coal moisture content of 4.12 percent The dry-basis HHV was converted to an as-fired basis by dividing 13,733 Btu/lb by 104.12 percent, resulting in an HHV of 13,190 Btu/lb. The as-fired coal HHV was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This reference was assigned a data quality rating of "A."

Reference 21

This reference presents the results of emissions testing at a facility designated as EPRI Site 15. Site 15 has a boiler with a capacity of approximately 600 MW which began commercial operation in 1970. The boiler is a tangentially fired furnace manufactured by Combustion

Engineering and was firing pulverized Eastern bituminous coal during the emissions test. The pollution control system in use during the test consisted of an ESP.

Three sampling runs were conducted for metals and organics and the results are presented as emission factors in units of lb/10^{12} Btu. Full detection limit values were used to develop emission factors that are based only on results that were below detection limits. The reference provides an HHV for the coal fired during the test of 13,000 Btu/lb, which was assumed to be on an as-fired basis. This value was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

A data quality rating of "A" was assigned to this reference.

<u>Reference 22</u>

The results of emissions testing at a facility designated as EPRI Site 19 are presented in this report. The boiler tested at Site 19 is a B & W opposed, wall-fired unit and was burning bituminous coal from western Virginia and Kentucky during the emissions test. An ESP was in use during the test.

Three sampling runs were conducted for various metals. The results for antimony, beryllium, and cobalt are presented as concentrations in units of microgram per Normal cubic meter. The results for the three compounds were above detection limits for all sampling runs. The concentrations were converted to lb/dscf and multiplied by the stack gas volumetric flow rate (dscf/hr) to obtain emission rates in units of lb/hr. The reference provides an average coal feed rate during the test of 694,000 lb/hr on a dry-basis and a coal moisture content of 6.1 percent. The dry-basis coal feed rate was converted to an as-fired basis by dividing 694,000 by 93.9 percent (100 percent - 6.1 percent), resulting in a value of 739,084. The pollutant emission rates were divided by the coal feed rate to obtain emission factors in units of lb/ton.

The results for the other metals are expressed as emission factors in units of lb/10^{12} Btu. The reference indicates that sampling results for all compounds were above the detection limits. The reference provides an average HHV of the coal fired during the test of 13,467 Btu/lb on a dry basis. This HHV was converted to an as-fired HHV of 12,693 Btu/lb by dividing 13,467 by 106.1 percent. The as-fired coal HHV was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This reference was assigned a data quality rating of "A."

Reference 23

This reference presents the results of emissions testing at a facility designated as EPRI Site 20. The boiler tested at Site 20 is a B & W wall-fired, drum type boiler with a normal full-load value of 680 MW. The boiler was firing pulverized lignite from Wilcox, Texas during the emissions test. Emission controls in use during the test include two parallel cold-side ESPs and a FGD system that uses limestone slurry for reagent.

Four sampling runs were conducted for various metals. The results for antimony are presented as concentrations in units of microgram per Normal cubic meter. Antimony was not detected in any of the sampling runs and the concentrations are based on full detection limits. The concentrations were converted to lb/dscf and multiplied by the stack gas volumetric flow rate (dscf/hr) to obtain emission rates in units of lb/hr. The reference provides a coal feed rate during the test of 618,000 lb/hr on a dry-basis and a coal moisture content of 34.4 percent. The dry-basis coal feed rate was converted to an as-fired basis by dividing 618,000 by 66.4 percent (100 percent - 34.4 percent), resulting in a value of 942,073. The average antimony emission rate was divided by the coal feed rate to obtain an emission factor in units of lb/ton.

The results for the other metals are expressed as emission factors in units of lb/10^{12} Btu. The reference indicates that all pollutants were detected in all sampling runs. The reference provides an HHV of the coal fired during the test of 6,760 Btu/lb on an as-received basis. This value was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This reference was assigned a data quality rating of "A."

Reference 24

The results of emissions testing at a facility designated as EPRI Site 21 are presented in this reference. The boiler at Site 21 is rated at 667 MW, gross load, and was firing bituminous coal from Pennsylvania and West Virginia during the emissions test. Emission controls utilized during the emissions test were a pilot ESP and FGD system. The FGD system is a spray tower absorber using an alkaline slurry. The pilot system has demonstrated the capability to produce the same results as a full-scale FGD system.

Eight sampling runs were conducted for metals and seven for PAHs. The results of the sampling runs are presented as emission factors in unit of lb/10^{12} Btu. Full detection limit values were used to develop emission factors that are based only on sampling results that were below the detection limits. The reference presents an average HHV for the coal fired during the test of 14,032 Btu/lb on a dry basis and a coal moisture content of 7 percent. The dry-basis HHV was converted to an HHV on an as-fired basis by dividing 14,032 by 107 percent, resulting in a value of 13,114. The as-fired coal HHV was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

A data quality rating of "A" was assigned to this reference.

Reference 25

This reference presents the results of emissions testing at a facility designated as EPRI Site 22. The boiler tested at Site 22 is a B & W 700 MW, wall-fired, radiant boiler. The boiler was burning pulverized subbituminous coal from the Powder River regions during the emissions test. Emission controls used during the test were two parallel cold-side ESPs.

Three sampling runs were conducted for metals, dioxins/furans, and polycyclic aromatic hydrocarbons (PAHs) and the results are presented as emission factors in units of lb/10^{12} Btu. Full detection limit values were used to develop emission factors that are based only on results that were below the detection limits. The reference provides an average HHV for the coal fired during the emissions test of 11,981 Btu/lb on a dry-basis and a coal moisture content of 29.5 percent. The dry-basis HHV was converted to an as-fired HHV of 9,252 Btu/lb by dividing 11,981 by 129.5 percent. The as-fired coal HHV was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This report was assigned a data quality rating of "A."

Reference 26

This reference presents the results of emissions testing at a facility designated as EPRI Site 101. The boiler tested at this site is a B & W, 800 MW, wall-fired unit and was burning pulverized subbituminous coal from New Mexico during the emissions test. Emission controls in use during the test include low NO_x burners, a fabric filter, and FGD system consisting of a wet lime scrubber.

Three sampling runs were conducted for metals and organics. The solid phase sample for metals test Run Two was destroyed prior to analysis and, therefore, except for mercury, the metals emissions results are based on two sampling runs. Because mercury is present primarily in the vapor phase, the solid phase average of Runs One and Three was used to represent the solid phase results for mercury for Run Two.

The test runs results are presented as emission factors in units of lb/10^{12} Btu. The reference presents an average HHV for the coal fired during the test of 10,190 Btu/lb on a dry basis and a coal moisture content of 14 percent. The dry-basis HHV was converted to an as-fired HHV by dividing 10,190 by 114 percent, resulting in a value of 8,939. The as-fired coal HHV was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

A data quality rating of "A" was assigned to this reference.

Reference 27

The results of emissions testing at a facility designated as EPRI Site 111 are presented in this reference. The boiler at this site is 267 MW, two-flow, single-reheat, balanced draft, drum type boiler. The boiler was burning a Western subbituminous coal during the tests. The pollution control system in use during the test consists of a fabric filter and spray dryers for FGD.

Two sampling runs were conducted for metals, PAHs, and various other organics. The results are expressed as emission factors in units of lb/10^{12} Btu. Full detection limit values were used to develop emission factors that are based only on sampling results that were below detection limits. The reference provides an average HHV for the coal fired during the test of 10,020 Btu/lb on an as-received basis. This value was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This report was assigned a data quality rating of "A."

Reference 28

This reference presents the results of emissions testing at a facility designated as Site 114. The unit at Site 114 is a B & W, cyclone-fired reheat boiler rated at 100 MW. Bituminous coal from Indiana was fired during the emissions tests. Emissions sampling was conducted under two boiler operating conditions, baseline and reburn. Emission controls used under the baseline operating condition consisted of an ESP. Controls used during the reburn operating condition were an ESP along with wall-fired burners located at a higher elevation in the boiler and overfire air to reduce NO_x emissions.

Three sampling runs for metals, PAHs, and various other organics were conducted under each operating condition and the results for each condition are reported separately and are expressed as emission factors in units of lb/10^{12} Btu. PAHs are reported as "not detected" and no emission factors were developed. For the other "not detected" pollutants, full detection limit values were used to develop emission factors.

The reference reports an average HHV for the coal fired during the baseline condition of 13,490 Btu/lb on a dry-basis and a coal moisture content of 15.6 percent. The dry-basis HHV was converted to an as-fired basis by dividing 13,490 by 115.6 percent, resulting in an as-fired HHV of 11,670 Btu/lb. The reported average HHV for the coal fired during the reburn condition was 13,280 Btu/lb, dry-basis, and the average content was 12.5 percent. The dry-basis HHV was converted to an as-fired HHV by dividing 13,280 by 112.5 percent, resulting in an as-fired HHV of 11,804 Btu/lb. The as-fired coal HHVs were used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This reference was assigned a quality rating of "A."

<u>Reference 29</u>

The results of emissions testing at a facility designated as EPRI Site 115 are presented in this report. The unit tested at this site is a 117 MW B & W roof-fired boiler commissioned in 1955. The boiler was firing pulverized Western bituminous coal during the emissions tests. Emissions tests were conducted in two phases. Emission controls in use during both phases included low NO_x burners, overfire air, and a fabric filter. Additional controls used in Phase II included a urea injection system for selective non-catalytic NO_x reduction.

Three sampling runs were conducted for metals and organics during both operating conditions and the results are presented separately and are expressed as emission factors in lb/10^{12} Btu. Full detection limit values were used to develop emission factors that are based only on sampling results that were below detection limits.

The report presents an average HHV for the coal of 12,565 Btu/lb and 12,638 Btu/lb fired during Phase I and Phase II, respectively. The reported HHV for the coal is on a dry basis and the reference does not provide the moisture content of the coal, as received. A test report the facility designated as EPRI Site 111 (Reference 27) where the boiler was firing a Western bituminous coal reports a moisture content of 9.8 percent. This value was used to convert the dry-basis coal HHV at Site 115 to an as-fired basis by dividing 12,565 and 12,638 by 109.8 percent, resulting in an as-fired HHV for the coal fired during Phase I testing of 11,444 Btu/lb and 11,510 Btu/lb for the coal fired during Phase II. The as-fired coal HHVs were used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This reference was assigned a data quality rating of "C" because an as-fired coal HHV or information that could be used to calculate it were not provided.

Reference 30

This reference presents the results of DOE emissions testing at Springerville Generating Station Unit No. 2. This facility is owned and operated by the Tucson Electric Power Company and is located near Springerville, Arizona. Unit No. 2 was manufactured by Combustion Engineering and is a 397 MW, corner-fired, balanced-draft design. According to the EPRI Synthesis Report (Reference 9), this boiler is tangentially-fired. The unit was burning pulverized subbituminous coal from the Lee Ranch Mine in New Mexico during the emissions tests.

Emission controls in use during the emissions test included overfire air and spray dryer absorbers.

Three sampling runs were conducted for metals and the results are expressed as emission factors in units of lb/10^{12} Btu. Full detection limit values were used to develop emission factors that were not detected in any sampling run. The report presents an average as-received HHV for the coal fired during the emissions test of 9,446 Btu/lb. This value was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This reference was assigned a data quality rating of "A."

Reference 31

The results of DOE emissions testing at the Niles Station Unit No. 2 of Ohio Edison are presented in this reference. Unit No. 2 is a B & W, 108 MW, cyclone boiler and was burning pulverized bituminous coal during the emissions test. The coal is a blend of eastern Ohio and western Pennsylvania coals and is received in the respective proportions of 70/30. Emission controls in use during the test consisted of an ESP.

Three sampling runs were conducted for metals and various organics and the results are presented as emission factors expressed in units of lb/10^{12} Btu. Emission factors for pollutants that were not detected in any sampling run were developed using one-half of the detection limit value. The average as-received HHV of the coal fired during the emissions test was 12,184 Btu/lb. This value was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This reference was assigned a data quality rating of "A."

Reference 32

This reference presents the results of DOE emissions testing at the Coal Creek Station which is operated by Cooperative Power and is located about 50 miles north of Bismarck, North Dakota. The unit tested is a 550 MW, tangentially-fired, water walled, dry bottom furnace, with a Combustion Engineering controlled circulation boiler. The furnace is fueled by lignite from the Falkirk mine located adjacent to the plant. Emission controls used during the test were an ESP and wet limestone scrubber.

Three sampling runs were conducted for metals and various organics and the results are presented as emission factors expressed in units of lb/10^{12} Btu. Emission factors for pollutants that were not detected in any sampling run were developed using one-half of the detection limit value. The average as-received HHV for the lignite fired during the emissions test was 6,230 Btu/lb. This value was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This reference was assigned a data quality rating of "A."

<u>Reference 33</u>

The results of DOE emissions testing at Baldwin Power Station Unit 2 are presented in this reference. Unit 2, located in Baldwin, Illinois, is a B & W cyclone furnace rated at 568 MW and was built in 1973. The furnace was firing Illinois bituminous coal during the emissions test. Emission controls used during the test were an ESP.

Three sampling runs were conducted for metals and various organics, including PAHs and dioxins/furans. Test results are reported as emission factors expressed in units of lb/10^{12} Btu. Full detection limit values were used to develop emission factors for pollutants that were not detected in any sampling run. The average of the HHV values reported in the reference for the coal fired during the emissions test was 10,633 Btu/lb, as received. The as-received coal HHV was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This reference was assigned a data quality rating of "A."

Reference 34

This reference presents the results of DOE emissions testing at the Boswell Energy Center Unit 2 located in Cohasset, Minnesota. This unit is a Riley Stoker front-fired boiler built in 1957 and rated at 69 MW. The boiler was burning pulverized western subbituminous coal from the Powder River Basin area of Wyoming and Montana during the emissions tests. Emission controls in use during the test were a baghouse.

Three sampling runs were conducted for metals and various organics, including PAHs and dioxins/furans. Emissions results are reported as emission factors expressed in units of lb/10^{12} Btu. When a pollutant was not detected in any sampling run, full detection limit values were used to calculate an emission factor. The average of the HHV values reported in the reference for the coal fired during the emissions test was 8,798 Btu/lb, as received. This value was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This reference was assigned a data quality rating of "A."

Reference 35

The results of DOE emissions testing at Cardinal Plant Unit 1 located in Brilliant, Ohio, are presented in this reference. Unit 1 is a wall-fired boiler rated at 615 MW and was burning pulverized Pittsburgh No. 8 bituminous coal during the emissions test. The unit is equipped with two ESPs arranged in parallel.

Three sampling runs for metals and various organics were conducted during sootblowing operations and three were conducted during non-sootblowing conditions. Emissions results are presented for both conditions, but only the results for non-sootblowing conditions were used to develop AP-42 emission factors. The emissions test results are reported as emission factors expressed in units of lb/10^{12} Btu. For pollutants where the results for all sampling runs were below the detection limit, the average of the run detection limits was used to develop an emission factor. The reference does not report a coal feed rate or the HHV of the coal fired during the emissions test and, therefore, a value of 13,000 Btu/lb listed in Appendix A of AP-42 was used to convert the reported emission factors to emission factors in units of lb/ton.

A data quality rating of "C" was assigned to this reference because the coal feed rate and the coal HHV were not reported.

Reference 36

This reference presents the results of DOE emissions testing at a facility designated as Site 16. The unit tested is a Foster Wheeler wall-fired boiler rated at 500 MW. The EPRI Synthesis Report (Reference 9) indicates that the boiler was burning pulverized bituminous coal from Virginia and Kentucky during the emissions test. Emission controls in use during the test were low NO_x burners with overfire air and an ESP.

Three sampling runs were conducted for metals and various organics and the emissions results are presented as emission factors in units of lb/10^{12} Btu. Full detection limit values were used to develop emission factors that are based only on results that were below the detection limit. The reference reports an average HHV for the coal fired during the emissions test of 13,800 Btu/lb, dry-basis, and a coal moisture content of 3.8 percent. The average dry-basis HHV was divided by 103.8 percent to obtain an average as-fired HHV of 13,295 Btu/lb. The as-fired coal HHV was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This reference was assigned a data quality rating of "A."

Reference 37

The results of emissions testing at a facility designated as EPRI Site 122 are presented in this reference. The unit tested is a cyclone boiler constructed during the 1950s and has a nominal power production capacity of 275 MW. The boiler was burning bituminous coal from the Illinois No. 5 Seam in Saline County, Illinois. An ESP was in use during the emissions test.

Three sampling runs were conducted for metals and organics and the emissions results are reported as emission factors that are expressed in units of lb/10^{12} Btu. Full detection limit values were used to develop emission factors that are based only on results that were below the detection limit. The average HHV of the coal fired during the emissions test was 12,327 Btu/lb, as fired. This value was used to convert the emission factors in units of lb/10^{12} Btu to factors in units of lb/ton.

This reference was assigned a data quality rating of "A."

Reference 38

This reference presents hydrogen chloride (HCl) and hydrogen fluoride (HF) emission factors that were developed from the results of a literature search. The literature search was conducted under the National Acid Precipitation Assessment Program (NAPAP).

The reference lists four emission factors each, or four pairs of factors, for HCl and HF. The factors are in units of lb/ton and represent both controlled and uncontrolled boilers. One pair of emission factors is for electric generation (utility) and industrial boilers firing bituminous or subbituminous coal. The second pair of factors is for utility and industrial boilers firing lignite. The third pair of emission factors is for commercial/institutional boilers firing bituminous or subbituminous coal. The fourth pair of factors is for commercial/institutional boilers firing lignite.

The reference states that AP-42 procedures for assigning quality ratings were used to assign ratings to the factors. The emission factor quality ratings were retained and it was not necessary to assign a data quality rating to this reference.

References Examined But Not Used For Emission Factor Development

Several documents were examined and the emissions data they contained were not used to develop emission factors because the data were not considered representative of the general population of coal or lignite-fired boilers. For example, data from boilers that were not burning 100 percent coal or lignite were excluded. Data from boilers that were not operating normally or were using experimental control devices were not used. Also, data whose use would result in relatively low quality emission factors were not used. The following paragraphs describe the documents that were examined but not used and an explanation of why they were not used.

Results of the May 28 - 31, 1991 Trace Metal Characterization Study and Dioxin Emission Test on Unit 1 at the A.S. King Plant in Bayport, Minnesota. Interpoll Laboratories, Inc., Circle Pines, Minnesota. November 6, 1991. The boiler was firing a mixture of coal (90 percent) and petroleum coke (10 percent) at the time of the emissions tests.

Results of the July 1992 Air Toxic Emission Study on Unit 8 at the NSP Riverside Plant. Interpoll Laboratories, Inc., Circle Pines, Minnesota. September 29, 1992. The boiler was firing a mixture of coal (90 percent) and coke (6 percent) at the time of the emissions tests.

Measurement of Chemical Emissions Under the Influence of Low-NOx Combustion Modifications. Submitted To Southern Company Services, Inc. Final Report. October 8, 1993. This facility was included in the emissions sampling program sponsored by EPRI and was designated Site 110. The reference states, "Site 110 provides control over the emissions of NO_x, however, it does so with modified combustion conditions having the potential of producing unwanted increases in the emissions of toxic organic compounds and conceivably undesirable changes in the emissions of inorganic substances."

A Study of Toxic Emissions From a Coal-fired Power Plant Utilizing an ESP While Demonstrating the ICCT CT-121 FGD Project. Radian Corporation, Austin, Texas. December 28, 1993. This facility was included in the emissions sampling program sponsored by EPRI and was designated DOE Site 4. The boiler was utilizing an experimental, or "demonstration," type of flue gas desulfurization technology during the emissions tests.

Preliminary Draft. Field Chemical Emissions Monitoring Project: Site 14 Emissions Monitoring. Radian Corporation, Austin, Texas. November 1992. This facility was included in the emissions sampling program sponsored by EPRI and was designated Site 14. The facility was utilizing a pilot-scale dry flue gas desulfurization system (FGD) at the time of the test. The pilot system consisted of a spray dryer followed by a pulse-jet fabric filter. A portion of the flue gas exiting the boiler was treated by the FGD system and then recombined with the gas entering the outlet stack.

Preliminary Draft. Field Chemical Emissions Monitoring Project: Site 18 Emissions Monitoring. Radian Corporation, Austin, Texas. April 1993. This facility was included in the emission sampling program sponsored by EPRI and was designated Site 18. At the time of the emissions test, the unit was not operating under optimal conditions. One of the five coal pulverizing mills was out of service and adjustments were made to the other four in order to maintain a steady operating load. Due to the adjustments, operating conditions for the unit were not normal. In addition, one of the control devices utilized by the boiler was experiencing problems and had to be repaired after the emissions test.

Field Chemical Emissions Monitoring Project: Site 116 Emissions Report. Radian Corporation, Austin, Texas. Preliminary Draft Report, October 1994. This facility was included in the emission sampling program sponsored by EPRI and was designated Site 116. The facility was utilizing a "demonstration" pollution control system at the time of the emissions tests. A portion of the flue gas was treated by the system and then rejoined with the flue gas exiting the boiler prior to entering another control device.

2.9.3 Emission Factor Development

Once the evaluation of all documents was completed and spreadsheets were created to contain the emissions information extracted from each reference, the emission factors from the individual spreadsheets were combined into groups of factors according to pollutant type. This grouping was performed in order to more easily identify patterns in the emission factor values that could be attributed to coal type, boiler configuration (SCC), and/or control devices employed. Emission factors making up a pattern would be averaged together in order to develop an AP-42 emission factor that represents the boilers and emission controls included in the pattern. The groups are: (1) metals emission factor equations; (2) hydrogen chloride and hydrogen fluoride emission factors; (3) dioxin/furan emission factors; (4) metals emission factors; (5) PAH emission factors; and, (6) emission factors for various organics. A spreadsheet was constructed for each group of emission factors, except for the metals emission factor equations. These spreadsheets are hereafter referred to as "main" spreadsheets.

The metals emission factor equations were not revised or converted. Because no calculations were necessary, a main spreadsheet for the emission factor equations was not constructed. The main spreadsheet containing the HCl and HF emission factors has only four factors for each pollutant and no extensive data manipulation was necessary. The main spreadsheets for dioxins/furans, metals, PAHs, and organics contain factors from numerous sources, and some processing of the data was necessary in order to develop AP-42 emission factors. The following paragraphs describe how these data were processed.

Each main spreadsheet for dioxins/furans, metals, PAHs, and organics was constructed with all emission factors from a single reference arranged on one row, except in the case of multiple emission factors representing different operating conditions. In such cases, the factors for each operating condition were arranged on one row. In addition to the emission factors, other data obtained from the reference were included on the appropriate spreadsheet row. These data included the reference number, number of boilers tested, coal type, boiler type, boiler MW rating, boiler SCC, control devices used, reference data quality, and number of test runs. These data were included in order to document and characterize the emission factors. Each type of data was entered in a single column of the spreadsheet. For example, all SCCs are in a single column, all coal types are in a single column, all emission factors for arsenic are in a single column, etc. With this arrangement, the data can be sorted by SCC, coal type, and control device in order to identify patterns in the emission factor values.

According to EPA guidance, emission factors that are based completely on detection limits should be calculated using one half of the detection limit. When the emission factors were extracted from the references, those factors based completely on detection limits were identified and it was noted if full value or one-half value detection limits were used to calculate them. All such factors were calculated using full detection limit values except for factors from Reference 31 and Reference 32, which were based on one-half detection limit values. All emission factors in the main spreadsheets that are based completely on detection limits were divided by two except for factors from Reference 31 and Reference 32. The factors from all references that are based completely on detection limits are identified by a "DL/2" in the column to the right of the emission factor.

EPA guidance also prescribes that when averaging emission factors together in order to obtain an AP-42 factor, the average should be an arithmetic mean. In addition, values representing factors based completely on detection limits that are larger than values representing factors that are based on detectable sample quantities (the pollutant was detected in at least one sampling run) should not be included in the overall averaging. In the main spreadsheets, after a group of emission factors for a pollutant were selected to be averaged together, the factors based only on detection limits were examined to determine if they should be included in the overall average. The "non-detected" factors that were higher in value than "detected" factors were not included in the overall average. In each column of pollutant emission factors, the factors (detected and non-detected) that are included in the overall average are marked with an asterisk in the column to the left of the factors. The average of the selected factors is at the bottom of the column. The quality rating of the average factor is included in the column to the right of the average factor.

When a pollutant was not detected at any facility, no AP-42 emission factor was developed for that pollutant. These pollutants appear in the main spreadsheets with a "DL/2" to the right of every factor for the pollutant. Although no emission factor was developed for these pollutants, they are identified in the footnotes of the AP-42 table that they would appear in if a factor had been developed.

The metals emission factor equations and the development of the HCl/HF emission factors are discussed below. The factors in the dioxin/furan, metals, PAHs, and organic main spreadsheets were sorted by SCC and control devices in order to identify patterns in the factor values that could be attributed to one or more of these parameters. The result of this sorting is also discussed below.

Metals Emission Factor Equations

The emission factor equations provided in Reference 9 are included in AP-42 "as is," (i.e., no conversions or revisions were made to the equations). There are equations for nine metals and they may be used to generate emission factors for both controlled and uncontrolled boilers. In addition, the equations may be used to generate emission factors for all typical firing configurations for utility, industrial, and commercial/industrial boilers. The emission factor equations are based on statistical correlations among measured trace element concentrations in coal, measured fractions of ash in coal, and measured particulate matter emission factors. Because these are the major parameters affecting trace metals emissions from coal combustion, it is recommended that the emission factor equations be used to generate emission factors when the inputs to the equations are available. If the inputs to the emission factor equations are not available for a pollutant and there is an emission factor for the provided in Section 1.7, then the factor should be used. The emission factor equations are provided in Table 1.

Hydrogen Chloride and Hydrogen Fluoride Emission Factors

All HCl and HF emission factors were obtained from Reference 38. These factors are shown in Table 2. The factors for utility/industrial boilers firing bituminous/subbituminous coal, commercial/industrial boilers firing bituminous/subbituminous coal, and commercial/industrial boilers firing lignite were averaged together to obtain an overall factor (one for HCl and one for HF) that represents all three categories. The emission factors for utility/industrial boilers firing lignite were not used in developing the AP-42 emission factors because of the relatively low value of the emission factors.

Dioxin/Furan, Metals, PAHs, and Various Organic Emission Factors

As described above, the emission factors for these pollutants were sorted by SCC and control device in order to identify patterns. No patterns became apparent in any of the four spreadsheets except in the spreadsheet containing the dioxin/furan emission factors. The emission factors for dioxins/furans are from bituminous and subbituminous coal only. None of the factors are from lignite combustion. For this reason, it was decided to include the dioxin/furan emission factors that were developed for AP-42 in Section 1.1 Bituminous and Subbituminous Coal Combustion but not in Section 1.7 Lignite Combustion. The factors for metals, PAHs, and organics are were averaged together to arrive at one AP-42 factor for each pollutant. The SCCs and controls attributed to the AP-42 factor are a combination of the SCCs and controls represented by the individual factors. These factors are included in both Section 1.1 and Section 1.7.

Copies of the spreadsheets used to develop the metals, PAHs, and various organic emission factors are shown in Tables 3, 4, and 5, respectively.

Table 1. METALS EMISSION FACTOR EQUATIONS FOR SECTION 1-7[a,b]

Pollutant	Emissions Equation[c] ($lb/10^{12}$ Btu)
Antimony	$0.92 \times (C/A \times PM)^{0.63}$
Arsenic	$3.1 \times (C/A \times PM)^{0.85}$
Beryllium	$1.2 \times (C/A \times PM)^{1.1}$
Cadmium	$3.3 \times (C/A \times PM)^{0.5}$
Chromium	$3.7 \times (C/A \times PM)^{0.58}$
Cobalt	$1.7 \times (C/A \times PM)^{0.69}$
Lead	$3.4 \times (C/A \times PM)^{0.80}$
Manganese	$3.8 \times (C/A \times PM)^{0.60}$
Nickel	$4.4 \times (C/A \times PM)^{0.48}$

[a] Reference 9.

[b] All equations are rated "A." The emission factor equations are applicable to all typical firing configurations (SCCs) for electric generation (utility) boilers, industrial boilers,and commercial/industrial boilers firing bituminous coal, subbituminous coal, or lignite. Also, the equations apply to boilers using typical control devices, including no controls.

[c] C = concentration of trace metal in the coal, parts per million by weight (ppm wt).
A = weight fraction of ash in coal, (dimensionless).
PM= site-specific emission factor for total particulate matter, ($lb/10^6$ Btu).

Table 2. Data Used to Develop Hydrogen Chloride and Hydrogen Fluoride Emission Factors for Section 1.7 of AP-42[a,b]

Boiler SCC Descriptions	Source Classification Codes[c]	Hydrogen Chloride (lb/ton[c]	Hydrogen Fluoride (lb/ton)
Commercial/Industrial Boilers			
Bituminous and Subbituminous Coal Firing Types			
Pulverized Coal Wet Bottom	1-03-002-05/21	*1.48	*0.17
Pulverized Coal Dry Bottom	1-03-002-06/22		
Overfeed Stoker	1-03-002-07		
Underfeed Stoker	1-03-002-08		
Spreader Stoker	1-03-002-09/24		
Hand-fired	1-03-002-14		
Pulverized Coal Dry Bottom Tangential	1-03-002-16/26		
Atmospheric Fluidized Bed Combustor	1-03-002-17/18		
Cyclone Furnace	1-03-002-23		
Traveling Grate Overfeed Stoker	1-03-002-25		
Electric Generation and Industrial Boilers			
Bituminous and Subbituminous Coal Firing Types			
Pulverized Coal Wet Bottom	1-01-002-01/21	*1.9	*0.23
	1-02-002-01/21		
Pulverized Coal Dry Bottom	1-01-002-02/22		
	1-02-002-02/22		
Cyclone Furnace	1-01-002-03/23		

(continued)

Table 2. Data Used to Develop Hydrogen Chloride and Hydrogen Fluoride Emission Factors for Section 1.7 of AP-42 (Continued)[a,b]

Boiler SCC Descriptions	Source Classification Codes[c]	Hydrogen Chloride (lb/ton[c]	Hydrogen Fluoride (lb/ton)
	1-02-002-03/23		

(continued)

Table 2. Data Used to Develop Hydrogen Chloride and Hydrogen Fluoride Emission Factors for Section 1.7 of AP-42 (Continued)[a,b]

Boiler SCC Descriptions	Source Classification Codes[c]	Hydrogen Chloride (lb/ton[c]	Hydrogen Fluoride (lb/ton)
Spreader Stoker	1-01-002-04/24		
	1-02-002-04/24		
Traveling Grate Overfeed Stoker	1-01-002-05/25		
	1-02-002-25		
Overfeed Stoker	1-02-002-05		
Pulverized Coal Dry Bottom, Tangential Firing	1-01-002-12/26		
	1-02-002-12		
Atmospheric Fluidized Bed	1-01-002-17		
	1-01-002-18		
	1-02-002-17		
	1-02-002-18		
Underfeed Stoker	1-02-002-06		
Commercial/Industrial Boilers			
Lignite Firing Types			
Pulverized Coal	1-03-003-05	*0.351	*0.063
Pulverized Coal Tangential Firing	1-03-003-06		
Traveling Grate Overfeed Stoker	1-03-003-07		
Spreader Stoker	1-03-003-09		

(continued)

Table 2. Data Used to Develop Hydrogen Chloride and Hydrogen Fluoride Emission Factors for Section 1.7 of AP-42 (Continued)[a,b]

Boiler SCC Descriptions	Source Classification Codes[c]	Hydrogen Chloride (lb/ton[c]	Hydrogen Fluoride (lb/ton)
Electric Generation and Industrial Boilers			
Lignite Firing Types			
Pulverized Coal	1-01-003-01	0.01	0.01
	1-02-003-01		
Pulverized Coal Tangential Firing	1-01-003-02		
	1-02-003-02		
Cyclone Furnace	1-01-003-03		
	1-02-003-03		
Traveling Grate Overfeed Stoker	1-01-003-04		
	1-02-003-04		
Spreader Stoker	1-01-003-06		
	1-02-003-06		
	Overall Average	1.2	0.15
	Quality Rating	B	B

[a] All factors are from Reference 9.
[b] Factors are for both uncontrolled and controlled boilers.
[c] An asterisk to the left of a factor indicates that it was used in calculating the overall emission factor.

TABLE 3. DATA USED TO DEVELOP CONTROLLED METALS EMISSION FACTORS FOR SECTION 1.7 OF AP-42

Reference No.	No. of Boilers	Fuel Type	Boiler Type[a]	MW	SCC	Control Device 1[b]	Control Device 2[b]	Control Device 3[b]	Data Quality	No. of Test Runs[c]	Antimony[c,d]	Arsenic[c,d]	Beryllium[c,d]	Cadmium[c,d]	Chromium[c,d]	Chromium VI[c,d]	Cobalt[d]
10	1	Subbituminous	PC, DB	860	10100222	FGD-SDA	FF	none	A	3	---	---	---	---	---	---	---
10	2	Subbituminous	PC, DB	750 ea.	10100222	FGD-VSST	none	none	A	3	---	---	---	---	---	---	---
11	3	Subbituminous	PC, DB	---	10100222	ESP	ESP	none	B	3	4.80e-05 DL/2	*1.06e-05	1.16e-06 DL/2	*5.31e-05	*4.89e-05	---	---
12	1	Subbituminous	AFBC, CB	137	10100238	Cyclone	ESP	ESP	B	3	4.66e-06 DL/2	*9.03e-06	2.33e-07 DL/2	*1.11e-04	*1.08e-04	---	---
13	4	Subbituminous	PC, DB	---	10100222	ESPC	none	none	B	3	*1.23e-05	*5.63e-06	*1.33e-06	*1.11e-05	*1.18e-04	---	---
14	2	Subbituminous	PC, DB	---	10100222	FF	none	none	B	3	*5.78e-06	*1.89e-05	*8.09e-06	*4.83e-04	*2.35e-04	---	---
15	2	Subbituminous	PC, DB	750 ea.	10100222	FGD-VSST	none	none	B	3	*9.12e-06	*4.42e-05	*4.34e-06	*1.80e-05	*1.95e-04	---	---
16	2	Subbituminous	PC, DB	750 ea.	10100222	FGD-VSST	none	none	B	3	*1.48e-05	*4.26e-05	*4.80e-06	*4.78e-05	*1.34e-04	---	---
17	1	Subbituminous	PC, DB	860	10100222	FGD-SDA	FF	none	B	3	*7.06e-06	*4.14e-07 DL/2	*1.11e-07	---	*1.59e-04	*1.49e-05	---
18	1	Subbituminous	AFBC, CB	110	10100238	FGD-FIL	FF	none	A	1	---	1.03e-05 DL/2	2.05e-06 DL/2	4.10e-06 DL/2	*3.28e-05	---	8.20e-06 DL/2
19	1	Subbituminous	PC, DB, T	700	10100226	OFA	FGD-WLS	ESP	B	1	---	*1.41e-05	1.41e-06 DL/2	*1.83e-05	*9.87e-05	---	*2.40e-05
20	1	Bituminous	PC, DB, O	700	10100202	ESP	FGD-WLS	none	A	2	---	*1.19e-05	2.11e-06 DL/2	*3.17e-05	*9.23e-05	---	1.32e-05 DL/2
21	1	Bituminous	PC, DB, T	600	10100212	ESP	none	none	A	3	---	*3.38e-04	*1.04e-05	*8.06e-05	*3.12e-04	---	*5.20e-05
22	1	Bituminous	PC, DB, O	1,160	10100202	ESP	none	none	A	3	*3.83e-05	*2.01e-04	*3.08e-05	*3.30e-06	*3.30e-04	---	*1.32e-04

(continued)

Table 3. Data Used to Develop Controlled Metals Emission Factors for Section 1.7 of AP-42 (Continued)[a,b]

Reference No.	No. of Boilers	Fuel Type	Boiler Type[a]	MW	SCC	Control Device 1[b]	Control Device 2[b]	Control Device 3[b]	Data Quality	No. of Test Runs[c]	Antimony[c,d]	Arsenic[c,d]	Beryllium[c,d]	Cadmium[c,d]	Chromium[c,d]	Chromium VI[c,d]	Cobalt[d]
23	1	Lignite	PC	680	10100301	ESP	FGD-W LS	none	A	4	8.70e-06 DL/2	*8.52e-06	*4.73e-06	*9.46e-06	*3.79e-05	---	*9.33e-06
24	1	Bituminous	PC, DB, O	667	10100202	ESP	FGD-W LS	none	A	8	---	*1.62e-04	*3.41e-06	*1.49e-05	*7.19e-05	---	*1.08e-04
25	1	Subbituminous	PC, DB, O	700	10100222	ESP	none	none	A	3	3.52e-05 DL/2	*1.61e-06	2.87e-07 DL/2	*2.96e-06	*9.81e-06	---	6.50-06 DL/2
26	1	Subbituminous	PC, DB, W	800	10100222	LNB	FF	FGD-W LS	A	2	---	*6.08e-06	*6.44e-07	*7.15e-06	*3.93e-05	---	*2.32e-06
27	1	Subbituminous	PC, DB	267	10100222	LNB	FGD-SD	FF	A	2	---	2.11e-06 DL/2	---	2.11e-05 DL/2	4.31e-05 DL/2	---	---
28	1	Bituminous	Cy-clone	100	10100203	ESP	none	none	A	3	---	*1.63e-04	*5.60e-05	*4.20e-05	*3.27e-04	---	---
28	1	Bituminous	Cy-clone	100	10100203	Reburn/ OFA	ESP	none	A	3	---	*1.89e-04	*1.89e-05	*9.44e-06	*1.09e-04	---	---
29	1	Bituminous	PC, DB	117	10100202	LNB/ OFA	FF	none	B	3	---	*1.72e-05	2.29e-07 DL/2	*2.75e-06	*1.51e-05	---	2.52e-06 DL/2
29	1	Bituminous	PC, DB	117	10100202	LNB/ OFA	SNCR	FF	B	3	---	*3.45e-06	2.30e-07 DL/2	*8.05e-07 DL/2	*6.91e-06	---	2.65e-06 DL/2
30	1	Subbituminous	PC, DB, T	422	10100226	LNB/ OFA	FGD-SDA	FF	A	3	*7.75e-07	*2.83e-06	3.78e-07 DL/2	*4.91e-07	*1.89e-06	---	2.84e-06 DL/2
31	1	Bituminous	Cy-clone	108	10100203	ESP	none	none	A	3	4.39e-06 DL/2	*1.02e-03	*4.63e-06	*1.71e-06	*7.31e-05	---	*1.46e-06 DL/2
32	1	Lignite	PC, DB, T	550	10100302	ESP	FGD-W LS	none	A	3	*2.24e-06	*1.50e-05	1.06e-05 DL/2	1.99e-05 DL/2	---	---	*1.87e-05
33	1	Bituminous	Cy-clone	568	10100203	ESP	none	none	A	3	*3.23e-05	*2.85e-04	*3.00e-05	*6.42e-05	*1.08e-03	---	*1.45e-04

(continued)

Table 3. Data Used to Develop Controlled Metals Emission Factors for Section 1.7 of AP-42 (Continued)[a,b]

Reference No.	No. of Boilers	Fuel Type	Boiler Type[a]	MW	SCC	Control Device 1[b]	Control Device 2[b]	Control Device 3[b]	Data Quality	No. of Test Runs[c]	Antimony[c,d]	Arsenic[c,d]	Beryllium[c,d]	Cadmium[c,d]	Chromium[c,d]	Chromium VI[c,d]	Cobalt[d]
34	1	Subbituminous	PC, DB	69	10100222	FF	none	none	A	3	5.95e-06 DL/2	*5.70e-06	1.14e-06 DL/2	5.70e-06 DL/2	*3.59e-05	---	*1.23e-05
35	1	Bituminous	PC, DB	615	10100202	ESP	none	none	C	3	*6.14e-05	*9.07e-05	*1.82e-06	*2.20e-05	*1.95e-04	---	*1.64e-05
36	1	Bituminous	PC, DB	500	10100202	LNB/OFA	ESP	none	A	3	---	*2.92e-03	*8.24e-05	*9.57e-05	*5.58e-04	*1.44e-04	*1.73e-04
37	1	Bituminous	Cyclone	275	10100203	ESP	none	none	A	3	---	*5.42e-03	*9.86e-05	*8.88e-05	*2.47e-03	---	*6.41e-04
Average Factor											1.84e-05	4.08e-04	2.12e-05	5.08e-05	2.55e-04	7.95e-05	1.03e-04
Quality Rating											A	A	A	A	A	D	A

[a] PC = Pulverized Coal, DB = Dry Bottom, T = Tangential, O = Opposed, W = Wall, AFBC = Atmospheric Fluidized Bed Combustor, CB = Circulating Bed.

[b] ESP = Electrostatic Precipitator, FGD = Flue Gas Desulfurization, FIL = Furnace Injection of Limestone, FF = Fabric Filter, LNB = Low Nox Burners, OFA = Overfire Air, SDA = Spray Dryer Absorber, SNCR = Selective Non-catalytic Reduction, WLS = Wet Limestone Scrubber, VSST = Venturi Scrubber Spray Tower. These are the controls that were in place during the emissions tests.

[c] An asterisk before a factor indicates that the factor was used in calculating the overall average.

[d] A "DL/2" after a number indicates that the pollutant was not detected in any of the sampling runs used to develop the factor. The value shown here represents a factor based on one half of the detection limit.

Table 4. Data Used to Develop Controlled PAH Emission Factors for Section 1.7 of AP-42

Ref. No.	No. of Boilers	Type of Coal	Boiler Type	MW	SCC	Control Device 1[b]	Control Device 2[b]	Control Device 3[b]	Data Quality	No. of Test Runs[c]	Biphenyl[c,d]	Acenaphthene[c,d]	Acenaph-thylene[c,d]	Anthracene[c,d]	Benz(a)-anthracene[c,d]	Benzo(a)-pyrene[c,d]	Benzo(b,j,k)-fluoranthene[d]
29	1	Subbituminous	PC,DB,T	700	10100226	OFA	FGD-WLS	ESP	B	1	---	---	---	---	---	---	---
34	1	Bituminous	PC,DB,O	667	10100202	ESP	FGD-WLS	none	A	7	---	*4.72e-07	*1.97e-07	*2.60e-07	*3.41e-08	*4.72e-08	*1.73e-07
35	1	Subbituminous	PC,DB,O	700	10100222	ESP	none	none	A	3	---	*1.11e-07	*6.29e-08	*8.51e-08	*1.85e-08	*2.04e-08	*5.00e-08
37	1	Subbituminous	PC,DB	267	10100222	LNB	FGD-SD	FF	A	2	---	*1.60e-06	*6.01e-07	*4.01e-07	*1.80e-07	4.01e-08 DL/2	*2.40e-07
39	1	Bituminous	PC,DB	117	10100202	LNB/OFA	FF	none	B	3	---	---	---	---	---	---	---
41	1	Bituminous	Cyclone	108	10100203	ESP	none	none	A	3	*3.06e-06	*6.46e-07	*1.66e-07	*5.04e-07	*9.02e-08	2.92e-08 DL/2	*1.71e-07
42	1	Lignite	PC,DB,T	550	10100302	ESP	FGD-WLS	none	A	3	*2.87e-07	*2.16e-07	*1.31e-07	*1.83e-07	*2.62e-08	*1.12e-08	*5.61e-08
43	1	Bituminous	Cyclone	568	10100203	ESP	none	none	A	3	9.35e-06 DL/2	*6.70e-08 DL/2	*6.78e-07	*5.61e-08	*2.49e-08	5.80e-09 DL/2	*8.32e-08
44	1	Subbituminous	PC,DB	69	10100222	FF	none	none	A	3	1.57e-06 DL/2	*7.18e-07	*9.34e-08	*1.09e-07	*8.23e-08	*3.68e-09	*5.37e-08
45	1	Bituminous	PC,DB	615	10100202	ESP	none	none	C	3	---	---	---	---	---	---	---
46	1	Bituminous	PC,DB	500	10100202	LNB/OFA	ESP	none	A	3	---	*2.15e-07	*7.98e-08	*9.84e-08	*1.86e-07	*1.09e-07	*3.99e-08
Average Factor											1.67e-06	5.06e-07	2.51e-07	2.12e-07	8.03e-08	3.83e-08	1.08e-07
Quality Rating											D	B	B	B	B	D	B

a PC = Pulverized Coal, DB = Dry Bottom, T = Tangential, O = Opposed.
b ESP = Electrostatic Precipitator, FF = Fabric Filter, FGD = Flue Gas Desulfurization, LNB = Low Nox Burners, OFA = Overfire Air, SD = Spray Dryer, WLS = Wet Limestone Scrubber. These controls were in use during emissions tests.
c An asterisk before a factor indicates that the factor was used in calculating the overall average.
d A "DL/2" after a number indicates that the pollutant was not detected in any of the sampling runs used to develop the factor. The value shown here represents a factor based on one half of the detection limit.

Table 5. Data Used to Develop Organic Emission Factors for Section 1.7 of AP-42

Reference No.	No. of Boilers	Coal Type	Boiler Type[a]	MW	SCC	Control Device 1[b]	Control Device 2[b]	Control Device 3[b]	Data Quality	No. of Test Runs[c]	Acetaldehyde[c,d]	Acetophenone[c,d]	Acrolein[c,d]	Benzene[c,d]	Benzylchloride[c,d]	bis(2-ethyl-hexyl-phthalate[c,d]	Bromo-form[d]
23	4	Subbituminous	PC,DB	---	10100222	ESP	none	none	B	3	---	---	---	*5.45e-07 DL/2	---	---	---
24	1	Subbituminous	PC,DB	---	10100222	FF	none	none	B	3	---	---	---	*1.66e-02	---	---	---
24	1	Subbituminous	PC,DB	---	10100222	FF	none	none	B	3	---	---	---	6.30e-04 DL/2	---	---	---
28	1	Subbituminous	AFBC,CB	110	10100238	FGD-FIL	FF	none	A	1	---	---	---	*4.10e-05	---	*9.24e-05	---
29	1	Subbituminous	PC,DB,T	700	10100226	OFA	FGD-WLS	ESP	B	1	---	---	---	---	---	---	---
30	1	Bituminous	PC,DB,O	700	10100202	ESP	FGD-WLS	none	A	2	---	---	---	*1.82e-05	---	---	---
31	1	Bituminous	PC,DB,T	600	10100212	ESP	none	none	A	3	---	---	---	*2.08e-05	---	---	---
34	1	Bituminous	PC,DB,O	667	10100202	ESP	FGD-WLS	none	A	7	---	---	---	---	---	---	---
35	1	Subbituminous	PC,DB,O	700	10100222	ESP	none	none	A	3	---	---	---	---	---	---	---
36	1	Subbituminous	PC,DB,W	800	10100222	LNB	FF	FGD-WLS	A	2	---	---	---	*1.02e-05	---	---	---
37	1	Subbituminous	PC,DB	267	10100222	LNB	FGD-SD	FF	A	2	---	---	---	*4.23e-04	---	---	---
38	1	Bituminous	Cyclone	100	10100203	ESP	none	none	A	3	*6.07e-05	---	---	*5.37e-05	---	---	---
38	1	Bituminous	Cyclone	100	10100203	Reburn/OFA	ESP	none	A	3	*3.07e-05 DL/2	---	---	*2.46e-05	---	---	---
39	1	Bituminous	PC,DB	117	10100202	LNB/OFA	FF	none	B	3	---	---	---	*5.95e-05	---	---	---
41	1	Bituminous	Cyclone	108	10100203	ESP	none	none	A	3	*2.17e-03	*1.55e-05	*9.99e-04	*1.93e-04	1.44e-07 DL/2	---	5.85e-05
42	1	Lignite	PC,DB,T	550	10100302	ESP	FGD-WLS	none	A	3	*8.35e-04	*6.76e-06	*1.37e-05 DL/2	*5.11e-04	*7.10e-08	---	*3.86e-05
43	1	Bituminous	Cyclone	568	10100203	ESP	none	none	A	3	*2.91e-04	*2.62e-05	*7.55e-05	*2.57e-03	---	*9.78e-05	---
44	1	Subbituminous	PC,DB	69	10100222	FF	none	none	A	3	*9.60e-06 DL/2	*1.25e-05	*5.98e-05	*1.81e-03	---	*2.96e-05	---
45	1	Bituminous	PC,DB	615	10100202	ESP	none	none	C	3	---	---	---	*8.84e-05	*1.40e-03	---	---

(continued)

Table 5. Data Used to Develop Organic Emission Factors for Section 1.7 of AP-42 (Continued)

Reference No.	No. of Boilers	Coal Type	Boiler Type[a]	MW	SCC	Control Device 1[b]	Control Device 2[b]	Control Device 3[b]	Data Quality	No. of Test Runs[c]	Acetaldehyde[c,d]	Acetophenone[c,d]	Acrolein[c,d]	Benzene[c,d]	Benzylchloride[c,d]	bis(2-ethyl-hexyl-phthalate[c,d]	Bromo-form[d]
46	1	Bituminous	PC,DB	500	10100202	LNB/OFA	ESP	none	A	3	---	---	---	*1.36e-05	---	---	---
47	1	Bituminous	Cyclone	275	10100203	ESP	none	none	A	3	---	---	---	*1.92e-04	---	---	---
Average Factor											5.66e-04	1.52e-05	2.87e-04	1.33e-03	7.00e-04	7.33e-05	3.86e-05
Quality Rating											C	D	D	A	D	D	E

[a] PC = Pulverized Coal, DB = Dry Bottom, AFBC = Atmospheric Fluidized Bed Combustion, CB = Circulating Bed, T = Tangential, O = Opposed, W = Wall.
[b] Controls in use during emissions tests: ESP = Electrostatic Precipitator, FF = Fabric Filter, FGD = Flue Gas Desulfurization, FIL = Furnace Injection of Limestone, LNB = Low Nox Burners, SD = Spray Dryer, WLS = Wet Limestone Scrubber.
[c] An asterisk before a factor indicates that it was used in calculating the overall emission factor.
[d] A DL/2 after a factor indicates that the pollutant was not detected in any of the sampling runs used to develop the factor. The value shown here represents a factor based on one half the detection limit.

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4.0 REVISED SECTION 1.7

This section contains the revised Section 1.7 of AP-42, 5th Edition. The electronic version can be located on the EPA TTN at http://134.67.104.12/html/chief/fsnpub.htm.

5.0 EMISSION FACTOR DOCUMENT, APRIL 1993

This section contains the complete Emission Factor Document for Section 1.7, Lignite Combustion, dated April 1993. The electronic version can be located on the EPA TTN at http://134.67.104.12/html/chief/fbgdocs.htm. The zipped file on the TTN contains this (1996) background report as well as the 1993 Emission Factor Documentation.

Appendix A

REFERENCE 19 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: RESULTS OF THE MARCH 28, 1990 DIOXIN EMISSION PERFORMANCE TEST ON UNIT 3 AT THE NSP SHERCO PLANT IN BECKER, MINNESOTA

FACILITY: NSP SHERCO
UNIT NO.: 3
LOCATION: Becker, Minnesota
FILENAME SHERCO3.tbl

PROCESS DATA

	Run 1	Run 2	Run 3
Oxygen (% v/v)[a]	6.30	5.80	5.80
Vol. Flow Rate (dscf/m)[b]	1,971,603	1,939,776	1,952,851
Vol. Flow Rate (dscf/hr)	118,296,180	116,386,560	117,171,060
F-factor (dscf/MMBtu)[c]	9,780	9,780	9,780
Heat input (MMBtu/hr)	8,450	8,598	8,656
HHV Bituminous Coal (Btu/lb)[d]	8,547	8,547	8,547
HHV Bituminous Coal (Btu/ton)	17,094,000	17,094,000	17,094,000
Coal Feed (ton/hr)	494	503	506
Coal type[e]	Subbituminous		
Boiler configuration[e]	Pulverized, dry bottom		
Coal source[e]	Montana		
SCC	10100222		
Control device 1[e]	Flue Gas Desulfurization, Spray Dryer absorber		
Control device 2[e]	Baghouse		
Data Quality	C- Coal heating value and feed rate not provided.		
Process Parameters[e]	860 megawatts, on line in 1987.		
Test methods[f]	MM5		
Number of test runs[g]	3		

[a]Page 8.
[b]Page 9.
[c]40 CFR Pt 60, Appendix A, Meth. 19, Bituminous coal
[d]From report "Results of the May 29, 1990 Trace Metal Characterization Study on Units 1 and 2 at the Sherburne County Generating Station in Becker, Minnesota", page G-1. (Reference No. 25).
[e]Page 1. Assumed dry bottom.
[f]Page 1.
[g]Page 5.

DIOXIN/FURAN EMISSION FACTORS

EMISSION RATES (g/sec)[a]	Run 1	Run 2	Run 3	AVG
TCDD	4.0e-08	2.0e-08	1.4e-08	
PeCDD	7.8e-08	3.8e-08	1.7e-08	
HxCDD	3.2e-07	1.6e-07	8.6e-08	
HpCDD	1.19e-06	4.6e-07	2.4e-07	
OCDD	3.51e-06	1.16e-06	7.2e-07	
TCDF	3.2e-07	1.0e-07	4.8e-08	
PeCDF	5.7e-07	2.2e-07	1.2e-07	
HxCDF	1.43e-06	6.5e-07	3.2e-07	
HpCDF	5.12e-06	1.97e-06	1.18e-06	
OCDF	1.670e-05	5.12e-06	4.02e-06	

EMISSION RATES (lb/hr)[b]	Run 1	Run 2	Run 3	AVG
TCDD	3.18e-07	1.59e-07	1.11e-07	
PeCDD	6.19e-07	3.02e-07	1.35e-07	
HxCDD	2.54e-06	1.27e-06	6.83e-07	
HpCDD	9.45e-06	3.65e-06	1.91e-06	
OCDD	2.79e-05	9.21e-06	5.72e-06	
TCDF	2.54e-06	7.94e-07	3.81e-07	
PeCDF	4.52e-06	1.75e-06	9.53e-07	
HxCDF	1.14e-05	5.16e-06	2.54e-06	
HpCDF	4.06e-05	1.56e-05	9.37e-06	
OCDF	1.33e-04	4.06e-05	3.19e-05	

EMISSION FACTORS (lb/ton)[c]	Run 1	Run 2	Run 3	AVG
TCDD	6.42e-10	3.16e-10	2.19e-10	3.93e-10
PeCDD	1.25e-09	6.00e-10	2.67e-10	7.06e-10
HxCDD	5.14e-09	2.53e-09	1.35e-09	3.00e-09
HpCDD	1.91e-08	7.26e-09	3.76e-09	1.00e-08
OCDD	5.64e-08	1.83e-08	1.13e-08	2.87e-08
TCDF	5.14e-09	1.58e-09	7.52e-10	2.49e-09
PeCDF	9.15e-09	3.47e-09	1.88e-09	4.84e-09
HxCDF	2.30e-08	1.03e-08	5.02e-09	1.27e-08
HpCDF	8.22e-08	3.11e-08	1.85e-08	4.39e-08
OCDF	2.68e-07	8.08e-08	6.30e-08	1.37e-07

[a]Page 4
[b]Convert g/sec to lb/hr.
[c]Divide emission rate by coal feed rate.

REFERENCE 20 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 10 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: RESULTS OF THE SEPTEMBER 10 AND 11, 1991 MERCURY REMOVAL TESTS ON THE UNITS 1 & 2, AND UNIT 3 SCRUBBER SYSTEMS AT THE NSP SHERCO PLANT IN BECKER, MINNESOTA

FACILITY: NSP SHERCO
UNIT NO.: 3
LOCATION: Becker, Minnesota
FILENAME: SHRCO123.tbl

PROCESS DATA UNIT 3			
	Run 1	Run 2	Run 3
Vol. Flow Rate (dscf/m)[a]	1,909,745	1,908,275	1,850,934
Vol. Flow Rate (dscf/hr)	114,584,700	114,496,500	111,056,040
Coal Feed (ton/hr)[b]	490	494	503
Coal type[c]	Subbituminous		
Boiler configuration[c]	Pulverized, dry bottom		
Coal source[c]	Montana		
SCC	10100222		
Control device 1[c]	Flue Gas Desulfurization, Spray Dryer absorber		
Control device 2[c]	Baghouse		
Data Quality	A		
Process Parameters[c]	860 megawatts, on line in 1987.		
Test methods[c]	EPA 101A for mercury		
Number of test runs[d]	3		

[a]Page 18.
[b]Page 7.
[c]Page 1. Assumed to be dry bottom.
[d]Page 5.

MERCURY EMISSION FACTORS UNIT 3				
	Run 1	Run 2	Run 3	AVG
EMISSION RATES (lb/hr)[a]	0.038	0.043	0.044	
EMISSION FACTOR (lb/ton)[b]	7.76e-05	8.70e-05	8.75e-05	8.40e-05

[a]Page 5.
[b]Divide emission rate by coal feed rate.

REFERENCE 20 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 10 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

PROCESS DATA UNITS 1 & 2

	Run 1	Run 2	Run 3
Vol. Flow Rate (dscf/m)[a]	3,334,932	3,376,641	3,313,486
Vol. Flow Rate (dscf/hr)	200,095,920	202,598,460	198,809,160
Coal Feed (ton/hr)[b]	764	775	766
Coal type[c]	Subbituminous		
Boiler configuration[c]	Pulverized, assume dry bottom		
Coal source[c]	70% Wyoming/30% Montana		
SCC	10100222		
Control device 1[c]	Flue Gas Desulfurization, Venturi Scrubber Spray Tower		
Control device 2[c]			
Data Quality	A		
Process Parameters[c]	750 MW each, on line in 1976		
Test methods[c]	EPA 101A for mercury		
Number of test runs[d]	3		

[a]Page 16.
[b]Page 7.
[c]Page 1.
[d]Page 5.

MERCURY EMISSION FACTORS UNIT 1 & 2

	Run 1	Run 2	Run 3	AVG
EMISSION RATES (lb/hr)[a]	0.042	0.025	0.090	
EMISSION FACTOR (lb/ton)[b]	5.50e-05	3.23e-05	1.17e-04	6.82e-05

[a]Page 5.
[b]Divide emission rate by coal feed rate.

REFERENCE 21 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 11 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: RESULTS OF THE NOVEMBER 5, 1991 AIR TOXIC EMISSION STUDY ON THE NO. 1, 3 & 4 BOILERS AT THE NSP BLACK DOG PLANT

FACILITY: NSP BLACK DOG
UNIT NO.: 1, 3 & 4
LOCATION: Burnsville, Minnesota
FILENAME BLKDG134.tbl

PROCESS DATA	METALS			
	Run 1	Run 2	Run 3	
Oxygen (% v/v)[a]	7.10	6.80	6.60	
Vol. Flow Rate (dscf/m)[b]	836,298	842,891	824,638	
Vol. Flow Rate (dscf/hr)	50,177,880	50,573,460	49,478,280	
F-factor (dscf/MMBtu)[c]	9,780	9,780	9,780	
Heat input (MMBtu/hr)	3,388	3,489	3,462	
HHV Bituminous Coal (Btu/lb)[d]	8,707	8,707	8,707	
HHV Bituminous Coal (Btu/ton)	17,414,000	17,414,000	17,414,000	
Coal Feed (ton/hr)	195	200	199	
Coal type[e]	Subbituminous			
Boiler configuration[e]	Pulverized, dry bottom			
Coal source[e]	Antelope/North Antelope			
SCC	10100222			
Control device 1[e]	ESP			
Control device 2[e]	ESP			
Data Quality	B	Had to use F-factor and average HHV to get coal feed rate, ton/hr.		
Process Parameters[e]	Three watertube boilers at 720,000, 775,000 and 1,250,000 lb/hr steam.			
Test methods[f]	MM 5 metals			
Number of test runs[g]	3			

[a]Page 22.
[b]Page 29.
[c]Page 29.
[d]Section 4 Results of Fuel Analyses.
[e]Page 1. Assumed dry bottom.
[f]Page 1.
[g]Various pages.

METALS EMISSION FACTORS

EMISSION RATES (lb/hr)[a]	Run 1	Run 2	Run 3	AVG
Aluminum	8.8	9.7	10.9	
Antimony[b]	0.019	0.019	0.019	
Arsenic	0.0021	0.0021	0.0021	
Barium	0.67	0.51	0.22	
Beryllium	0.00036	0.00047	0.00055	
Boron	0.11	0.099	0.12	
Cadmium	0.0017	0.013	0.017	
Calcium	12.6	15.2	13.2	
Chromium	0.0071	0.013	0.009	
Copper	0.037	0.14	0.034	
Iron	3.1	3.8	4.1	
Lead	0.017	0.19	0.0084	
Magnesium	2.7	3.2	3.6	
Manganese	0.019	0.021	0.022	
Mercury	0.017	0.0087	0.022	
Molybdenum[b]	0.0063	0.0063	0.0063	
Nickel	0.012	0.052	0.0092	
Potassium	0.52	0.93	0.65	
Selenium	0.0042	0.0042	0.0042	
Silver	0.0038	0.0032	0.0078	
SO2	1490	1630	1460	
Sodium	1.5	2.5	1.9	
Strontium	0.23	0.23	0.19	
Vanadium	0.023	0.025	0.026	
Zinc	0.059	0.46	0.091	

EMISSION FACTORS (lb/ton)[c]	Run 1	Run 2	Run 3	AVG
Aluminum	4.52e-02	4.84e-02	5.48e-02	4.95e-02
Antimony[b]	9.77e-05	9.48e-05	9.56e-05	9.60e-05
Arsenic	1.08e-05	1.05e-05	1.06e-05	1.06e-05
Barium	3.44e-03	2.55e-03	1.11e-03	2.37e-03
Beryllium	1.85e-06	2.35e-06	2.77e-06	2.32e-06
Boron	5.65e-04	4.94e-04	6.04e-04	5.54e-04
Cadmium	8.74e-06	6.49e-05	8.55e-05	5.31e-05
Calcium	6.48e-02	7.59e-02	6.64e-02	6.90e-02
Chromium	3.65e-05	6.49e-05	4.53e-05	4.89e-05
Copper	1.90e-04	6.99e-04	1.71e-04	3.53e-04
Iron	1.59e-02	1.90e-02	2.06e-02	1.85e-02
Lead	8.74e-05	9.48e-04	4.23e-05	3.59e-04
Magnesium	1.39e-02	1.60e-02	1.81e-02	1.60e-02
Manganese	9.77e-05	1.05e-04	1.11e-04	1.04e-04
Mercury	8.74e-05	4.34e-05	1.11e-04	8.05e-05
Molybdenum[b]	3.24e-05	3.14e-05	3.17e-05	3.18e-05
Nickel	6.17e-05	2.60e-04	4.63e-05	1.23e-04
Potassium	2.67e-03	4.64e-03	3.27e-03	3.53e-03
Selenium	2.16e-05	2.10e-05	2.11e-05	2.12e-05
Silver	1.95e-05	1.60e-05	3.92e-05	2.49e-05
SO2	7.66e+00	8.14e+00	7.34e+00	7.71e+0
Sodium	7.71e-03	1.25e-02	9.56e-03	9.92e-03
Strontium	1.18e-03	1.15e-03	9.56e-04	1.10e-03
Vanadium	1.18e-04	1.25e-04	1.31e-04	1.25e-04
Zinc	3.03e-04	2.30e-03	4.58e-04	1.02e-03

[a]Table 3 (page 13?).

[b]Not detected in any of the sampling runs, emission factor is based on detection limits.

[c]Divide emission rate by coal feed rate.

REFERENCE 22 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 12 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: RESULTS OF THE JANUARY 1992 AIR TOXIC EMISSION STUDY ON THE NO. 2 BOILER AT THE NSP BLACK DOG PLANT

FACILITY: NSP BLACK DOG
UNIT NO.: 2
LOCATION: Burnsville, Minnesota
FILENAME BLKDOG2.tbl

PROCESS DATA	METALS		
	Run 1	Run 2	Run 3
Oxygen (% v/v)[a]	10.40	10.20	10.20
Vol. Flow Rate (dscf/m)[b]	354,118	351,097	354,635
Vol. Flow Rate (dscf/hr)	21,247,080	21,065,820	21,278,100
F-factor (dscf/MMBtu)[c]	9,780	9,780	9,780
Heat input (MMBtu/hr)	1,091	1,103	1,114
HHV Bituminous Coal (Btu/lb)[d]	8,553	8,553	8,553
HHV Bituminous Coal (Btu/ton)	17,106,000	17,106,000	17,106,000
Coal Feed (ton/hr)	64	64	65
Coal type[e]	Subbituminous		
Boiler configuration[e]	Atmospheric Fluidized bed Combustor (AFBC), circulating bed		
Coal source[e]	Antelope/North Antelope		
SCC	10100238		
Control Device 1[e]	Cyclone (mechanical dust collector)		
Control device 2[e]	ESP		
Control device 3[e]	ESP		
Data Quality	B	Had to use F-factor and average HHV to get coal feed rate (ton/hr).	
Process Parameters[e]	137 MW		
Test methods[f]	MM 5 metalS.		
Number of test runs[g]	2 for lead, 3 for all others		

[a]Page 20.
[b]Page 25.
[c]Page 25.
[d]Page 31
[e]Page 1. Coal from Antelope/Northern Antelope is subbituminous, according to another report.
[f]Page 1.
[g]Various pages.

REFERENCE 22 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 12 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

METALS EMISSION FACTORS				
EMISSION RATES (lb/hr)[a]	Run 1	Run 2	Run 3	AVG
Aluminum	1.05	1.29	1.33	
Antimony[b]	0.0006	0.0006	0.0006	
Arsenic	0.000584	0.000603	0.000559	
Barium	0.0541	0.0639	0.0691	
Beryllium[b]	0.00003	0.00003	0.00003	
Boron	0.0927	0.101	0.0847	
Cadmium	0.00403	0.0117	0.00575	
Calcium	4.05	4.59	4.76	
Chromium	0.00573	0.0112	0.00386	
Copper	0.0139	0.0177	0.0113	
Iron	0.969	1.04	1.15	
Lead	0.0496		0.0613	
Magnesium	0.704	0.812	0.835	
Manganese	0.00529	0.00615	0.00895	
Mercury	0.0029	0.00265	0.00297	
Molybdenum	0.0064	0.0135	0.0051	
Nickel	0.0376	0.0471	0.01	
Potassium	0.07	0.107	0.0901	
Selenium	0.000602	0.000299	0.000445	
Silver[b]	0.0006	0.0006	0.0006	
SO2	362	356	334	
Sodium	0.837	0.983	0.829	
Strontium	0.056	0.0651	0.0733	
Vanadium	0.00437	0.00434	0.00436	
Zinc	0.122	0.092	0.0479	

REFERENCE 22 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 12 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

EMISSION FACTORS (lb/ton)[c]	Run 1	Run 2	Run 3	AVG
Aluminum	1.65e-02	2.00e-02	2.04e-02	1.90e-02
Antimony[b]	9.40e-06	9.31e-06	9.21e-06	9.31e-06
Arsenic	9.15e-06	9.35e-06	8.58e-06	9.03e-06
Barium	8.48e-04	9.91e-04	1.06e-03	9.67e-04
Beryllium[b]	4.70e-07	4.65e-07	4.61e-07	4.65e-07
Boron	1.45e-03	1.57e-03	1.30e-03	1.44e-03
Cadmium	6.32e-05	1.81e-04	8.83e-05	1.11e-04
Calcium	6.35e-02	7.12e-02	7.31e-02	6.93e-02
Chromium	8.98e-05	1.74e-04	5.93e-05	1.08e-04
Copper	2.18e-04	2.75e-04	1.74e-04	2.22e-04
Iron	1.52e-02	1.61e-02	1.77e-02	1.63e-02
Lead	7.77e-04		9.41e-04	8.59e-04
Magnesium	1.10e-02	1.26e-02	1.28e-02	1.22e-02
Manganese	8.29e-05	9.54e-05	1.37e-04	1.05e-04
Mercury	4.55e-05	4.11e-05	4.56e-05	4.41e-05
Molybdenum	1.00e-04	2.09e-04	7.83e-05	1.29e-04
Nickel	5.89e-04	7.31e-04	1.54e-04	4.91e-04
Potassium	1.10e-03	1.66e-03	1.38e-03	1.38e-03
Selenium	9.43e-06	4.64e-06	6.83e-06	6.97e-06
Silver[b]	9.40e-06	9.31e-06	9.21e-06	9.31e-06
SO2	5.67e+00	5.52e+00	5.13e+00	5.44e+00
Sodium	1.31e-02	1.52e-02	1.27e-02	1.37e-02
Strontium	8.78e-04	1.01e-03	1.13e-03	1.00e-03
Vanadium	6.85e-05	6.73e-05	6.70e-05	6.76e-05
Zinc	1.91e-03	1.43e-03	7.36e-04	1.36e-03

[a]Page 11
[b]Pollutant was not detected in any of the sampling runs, detection limits used to develop rates.
[c]Divide emission rate by coal feed rate.

REFERENCE 23 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 13 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: RESULTS OF THE NOVEMBER 7, 1991 AIR TOXIC EMISSION STUDY ON THE NOS. 3, 4, 5 & 6 BOILERS AT THE NSP HIGH BRIDGE PLANT

FACILITY: NSP High Bridge
UNIT NO.: 3, 4, 5 & 6
LOCATION: St. Paul, Minnesota
FILENAME HIBRIDGE.tbl

PROCESS DATA	METALS			
	Run 1	Run 2	Run 3	
Oxygen (% v/v)[a]	7.70	7.60	7.80	
Vol. Flow Rate (dscf/m)[b]	804,786	788,668	815,076	
Vol. Flow Rate (dscf/hr)	48,287,160	47,320,080	48,904,560	
F-factor (dscf/MMBtu)[c]	9,780	9,780	9,780	
Heat input (MMBtu/hr)	3,118	3,079	3,134	
HHV Bituminous Coal (Btu/lb)[d]	8,498	8,498	8,498	
HHV Bituminous Coal (Btu/ton)	16,996,000	16,996,000	16,996,000	
Coal Feed (ton/hr)	183	181	184	
Coal type[e]	Subbituminous			
Boiler configuration[e]	Pulverized, dry bottom			
Coal source[e]	Rochelle			
SCC	10100222			
Control device 1[e]	ESPC			
Control device 2[e]	None			
Data Quality	B	Had to use F-factor and average HHV to get coal feed rate, ton/hr.		
Process Parameters[e]	Watertube boilers with economizers and air preheaters			
Test methods[f]	MM 5 metals, Method 18 for BTEX			
Number of test runs[g]	3			

[a]Page 29.
[b]Page 37.
[c]40 CFR Pt 60, App A, Meth. 19
[d]Page 42
[e]Page 1. Assumed dry bottom.
[f]Page 1 for metals, page 3 for BTEX.
[g]Various pages.

REFERENCE 23 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 13 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

METALS EMISSION FACTORS

EMISSION RATES (lb/hr)[a]	Run 1	Run 2	Run 3	AVG
Aluminum	4.17	3.24	4.63	
Antimony	0.00126	0.00456	0.00092	
Arsenic	0.00126	0.00091	0.00092	
Barium	0.406	0.350	0.433	
Beryllium	0.00018	0.00018	0.00037	
Boron	0.127	0.105	0.118	
Cadmium	0.0023	0.0018	0.002	
Calcium	5.25	4.12	6.45	
Chromium	0.023	0.018	0.024	
Copper	0.036	0.024	0.028	
Iron	1.66	1.42	1.55	
Lead	0.015	0.0091	0.0092	
Magnesium	1.03	0.82	1.14	
Manganese	0.033	0.015	0.028	
Mercury[b]	0.013	0.010	0.013	
Molybdenum	0.059	0.046	0.061	
Nickel	0.012	0.0091	0.011	
Potassium	0.54	0.38	0.49	
Selenium	0.0036	0.0018	0.0018	
Silver	0.072	0.051	0.037	
SO2	1,319	1,290	1,247	
Sodium	1.22	1.02	1.40	
Strontium	0.17	0.12	0.15	
Vanadium	0.0066	0.0067	0.0068	
Zinc	0.074	0.049	0.050	

EMISSION FACTORS (lb/ton)[c]	Run 1	Run 2	Run 3	AVG
Aluminum	2.27e-02	1.79e-02	2.51e-02	2.19e-02
Antimony	6.87e-06	2.52e-05	4.99e-06	1.23e-05
Arsenic	6.87e-06	5.02e-06	4.99e-06	5.63e-06
Barium	2.21e-03	1.93e-03	2.35e-03	2.16e-03
Beryllium	9.81e-07	9.94e-07	2.01e-06	1.33e-06
Boron	6.92e-04	5.80e-04	6.40e-04	6.37e-04
Cadmium	1.25e-05	9.94e-06	1.08e-05	1.11e-05
Calcium	2.86e-02	2.27e-02	3.50e-02	2.88e-02
Chromium	1.25e-04	9.94e-05	1.30e-04	1.18e-04
Copper	1.96e-04	1.32e-04	1.52e-04	1.60e-04
Iron	9.05e-03	7.84e-03	8.41e-03	8.43e-03
Lead	8.18e-05	5.02e-05	4.99e-05	6.06e-05
Magnesium	5.61e-03	4.53e-03	6.18e-03	5.44e-03
Manganese	1.80e-04	8.28e-05	1.52e-04	1.38e-04
Mercury[b]	7.09e-05	5.52e-05	7.05e-05	6.55e-05
Molybdenum	3.22e-04	2.54e-04	3.31e-04	3.02e-04
Nickel	6.54e-05	5.02e-05	5.96e-05	5.84e-05
Potassium	2.94e-03	2.10e-03	2.66e-03	2.57e-03
Selenium	1.96e-05	9.94e-06	9.76e-06	1.31e-05
Silver	3.92e-04	2.82e-04	2.01e-04	2.92e-04
SO2	7.19e+00	7.12e+00	6.76e+00	7.02e+00
Sodium	6.65e-03	5.63e-03	7.59e-03	6.62e-03
Strontium	9.27e-04	6.62e-04	8.13e-04	8.01e-04
Vanadium	3.60e-05	3.70e-05	3.69e-05	3.66e-05
Zinc	4.03e-04	2.70e-04	2.71e-04	3.15e-04

[a]Table 4, page 16.
[b]Pollutant not detected in any of the sampling runs, detection limit used to develop emission factor.
[c]Divide emission rate by coal feed rate.

REFERENCE 23 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 13 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

BTEX EMISSION FACTORS

EMISSION RATES (lb/hr)[a]	Run 1	Run 2	Run 3
Benzene[b]	0.2	0.2	0.2
Toluene[b]	0.2	0.2	0.2
Ethyl Benzene[b]	0.2	0.2	0.2
Xylene[b]	0.2	0.2	0.2

[a]page 22

EMISSION FACTORS (lb/ton)[c]	Run 1	Run 2	Run 3	AVG
Benzene[b]	1.09e-03	1.10e-03	1.08e-03	1.09e-03
Toluene[b]	1.09e-03	1.10e-03	1.08e-03	1.09e-03
Ethyl Benzene[b]	1.09e-03	1.10e-03	1.08e-03	1.09e-03
Xylene[b]	1.09e-03	1.10e-03	1.08e-03	1.09e-03

[a]page 22
[b]Pollutant was not detected in any of the sampling runs, detection limits used to develop emission factor.
[c]Divide emission rate by coal feed rate.

REFERENCE 24 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 14 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: RESULTS OF THE DECEMBER 1991 AIR TOXIC EMISSION STUDY ON UNITS 6 & 7 AT THE NSP RIVERSIDE PLANT

FACILITY: NSP Riverside
UNIT NO.: 6, 7
LOCATION: Minneapolis, Mn
FILENAME RIVERSID.tbl

PROCESS DATA		
Coal type[a]	Subbituminous	
Boiler configuration[a]	Pulverized, dry bottom	
Coal source[a]	Rochelle	
SCC	10100222	
Control device 1[b]	Baghouse	
Control device 2[b]	None	
Data Quality	B	Had to use F-factor and average HHV to get coal feed rate (ton/hr)
Process Parameters[a]	575,000 lb/hr steam each; equipped with economizers and air preheaters.	
Test methods[c]	MM5 for PM/Metals, Method 18 for BTEX.	
Number of test runs[d]	3	

FLOW RATES, COAL FEED RATES		Unit 6	
	Run 1	Run 2	Run 3
Volumentric flow rate (dscf/m)[e]	193,851	189,541	187,122
Volumentric flow rate (dscf/hr)	11,631,060	11,372,460	11,227,320
F-Factor (dscf/MMBtu)[f]	9,780	9,780	9,780
O2 %v/v[g]	6.00	6.00	6.60
Heat input (MMBtu/hr)	848	829	785
Coal HHV (Btu/lb)[h]	8,602	8,602	8,602
Coal HHV (Btu/ton)	17,204,000	17,204,000	17,204,000
Coal feed rate (ton/hr)	49.28	48.19	45.66

	Unit 7		
	Run 1	Run 2	Run 3
Volumentric flow rate (dscf/m)[e]	188,847	188,814	194,376
Volumentric flow rate (dscf/hr)	11,330,820	11,328,840	11,662,560
F-Factor (dscf/MMBtu)[f]	9,780	9,780	9,780
O2 %v/v[g]	6.30	6.20	6.30
Heat input (MMBtu/hr)	809	815	833
Coal HHV (Btu/lb)[h]	8,602	8,602	8,602
Coal HHV (Btu/ton)	17,204,000	17,204,000	17,204,000
Coal feed rate (ton/hr)	47.04	47.36	48.42

[a]Page 1. Assumed dry bottom.
[b]Page 2.
[c]Page 1, 3, 24.
[d]Various pages.
[e]Page 29 for Unit 6 metals, Page 30 for Unit 7 metals.
[f]Page 28.
[g]Page 23 for Unit 6 metals, Page 24 for Unit 7 metals.
[h]Page 36.

METALS EMISSION FACTORS UNITS 6 & 7

EMISSION RATES (lb/hr)[a]	Run 1	Run 2	Run 3	AVG
Aluminum	13.9	16.7	15.5	
Antimony	0.00075	0.00067	0.00024	
Arsenic	0.00174	0.00183	0.00183	
Barium	0.073	0.005	0.002	
Beryllium	0.00073	0.0007	0.00088	
Boron	0.132	0.022	0.007	
Cadmium	0.115	0.0141	0.0101	
Calcium	23.4	27.7	19.0	
Chromium	0.0228	0.0209	0.0234	
Copper	0.060	0.065	0.053	
Iron	5.5	6.7	5.9	
Lead	0.0134	0.0100	0.0096	
Magnesium	4.9	5.9	5.3	
Manganese	0.0298	0.0400	0.0252	

METALS EMISSION FACTORS UNITS 6 & 7				
EMISSION RATES (lb/hr)[a]	Run 1	Run 2	Run 3	AVG
Mercury	0.013	0.006	0.005	
Molybdenum	0.00198	0.00409	0.00434	
Nickel	0.0285	0.113	0.0234	
Potassium	0.55	0.78	0.61	
Selenium	0.00706	0.00289	0.00193	
Silver	0.005	0.002	0.002	
SO2	875	788	762	
Sodium	2.03	2.85	2.49	
Strontium	0.328	0.372	0.256	
Vanadium	0.0289	0.0390	0.0347	
Zinc	0.071	0.278	0.006	
EMISSION FACTORS (lb/ton)[b]	Run 1	Run 2	Run 3	AVG
Aluminum	1.44e-01	1.75e-01	1.65e-01	1.61e-01
Antimony	7.79e-06	7.01e-06	2.55e-06	5.78e-06
Arsenic	1.81e-05	1.92e-05	1.95e-05	1.89e-05
Barium	7.58e-04	5.23e-05	2.13e-05	2.77e-04
Beryllium	7.58e-06	7.33e-06	9.35e-06	8.09e-06
Boron	1.37e-03	2.30e-04	7.44e-05	5.58e-04
Cadmium	1.19e-03	1.48e-04	1.07e-04	4.83e-04
Calcium	2.43e-01	2.90e-01	2.02e-01	2.45e-01
Chromium	2.37e-04	2.19e-04	2.49e-04	2.35e-04
Copper	6.23e-04	6.80e-04	5.63e-04	6.22e-04
Iron	5.71e-02	7.01e-02	6.27e-02	6.33e-02
Lead	1.39e-04	1.05e-04	1.02e-04	1.15e-04
Magnesium	5.09e-02	6.18e-02	5.63e-02	5.63e-02
Manganese	3.09e-04	4.19e-04	2.68e-04	3.32e-04
Mercury	1.35e-04	6.28e-05	5.31e-05	8.36e-05
Molybdenum	2.06e-05	4.28e-05	4.61e-05	3.65e-05
Nickel	2.96e-04	1.18e-03	2.49e-04	5.76e-04

EMISSION FACTORS (lb/ton)[b]	Run 1	Run 2	Run 3	AVG
Potassium	5.71e-03	8.16e-03	6.48e-03	6.79e-03
Selenium	7.33e-05	3.02e-05	2.05e-05	4.14e-05
Silver	5.19e-05	2.09e-05	2.13e-05	3.14e-05
SO2	9.08e+00	8.25e+00	8.10e+00	8.48e+00
Sodium	2.11e-02	2.98e-02	2.65e-02	2.58e-02
Strontium	3.41e-03	3.89e-03	2.72e-03	3.34e-03
Vanadium	3.00e-04	4.08e-04	3.69e-04	3.59e-04
Zinc	7.37e-04	2.91e-03	6.38e-05	1.24e-03

[a]Table 8, page 16.
[b]Divide emission rate by coal feed rate.

BTEX EMISSION FACTORS UNIT 6

Emission Rates (lb/hr)[a]	Run 1	Run 2	Run 3	
Benzene	1.02	1.05	0.33	
Toluene[b]	0.06	0.06	0.06	
Ethylbenzene[b]	0.06	0.06	0.06	
Xylene[b]	0.06	0.06	0.06	
Emission Factors (lb/ton)[c]				**avg**
Benzene	2.07e-02	2.18e-02	7.23e-03	1.66e-02
Toluene[b]	1.22e-03	1.25e-03	1.31e-03	1.26e-03
Ethylbenzene[b]	1.22e-03	1.25e-03	1.31e-03	1.26e-03
Xylene[b]	1.22e-03	1.25e-03	1.31e-03	1.26e-03

[a]page 19.
[b]Pollutant was not detected in any of the sampling runs. EF is based on detection limits.
[c]Divide emission rate by coal feed rate.

BTEX EMISSION FACTORS UNIT 7

Emission Rates (lb/hr)[a]	Run 1	Run 2	Run 3
Benzene[b]	0.06	0.06	0.06
Toluene[b]	0.06	0.06	0.06
Ethylbenzene[b]	0.06	0.06	0.06
Xylene[b]	0.06	0.06	0.06

REFERENCE 24 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 14 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

Emission Factors (lb/ton)[c]				
Benzene[b]	1.28e-03	1.27e-03	1.24e-03	1.26e-03
Toluene[b]	1.28e-03	1.27e-03	1.24e-03	1.26e-03
Ethylbenzene[b]	1.28e-03	1.27e-03	1.24e-03	1.26e-03
Xylene[b]	1.28e-03	1.27e-03	1.24e-03	1.26e-03

[a]page 19.
[b]Pollutant was not detected in any of the sampling runs. EF is based on detection limits.
[c]Divide emission rate by coal feed rate.

REFERENCE 25 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 15 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: RESULTS OF THE MAY 29, 1990 TRACE METAL CHARACTERIZATION STUDY ON UNITS 1 AND 2 AT THE SHERBURNE COUNTY GENERATING STATION IN BECKER, MINNESOTA

FACILITY: NSP Sherco
UNIT NO.: 1, 2
LOCATION: Becker, Minnesota
FILENAME SHERCO12.tbl

PROCESS DATA	PM/METALS		
	Run 1	Run 2	Run 3
Oxygen (% v/v)[a]	6.60	6.50	6.60
Vol. Flow Rate (dscf/m)[b]	3,305,953	3,340,203	3,106,503
Vol. Flow Rate (dscf/hr)	198,357,180	200,412,180	186,390,180
F-factor (dscf/MMBtu)[c]	9,780	9,780	9,780
Heat input (MMBtu/hr)	13,877	14,119	13,040
HHV Bituminous Coal (Btu/lb)[d]	8,547	8,547	8,547
HHV Bituminous Coal (Btu/ton)	17,094,000	17,094,000	17,094,000
Coal Feed (ton/hr)	812	826	763
Coal type[e]		Subbituminous	
Boiler configuration[e]		Pulverized, dry bottom	
Coal source[e]		80% Rochelle/20% Coalstrip	
SCC	10100222		
Control device 1[e]	Flue Gas Desulfurization, Venturi Scrubber Spray Tower		
Control device 2[e]	None		
Data Quality	B	Had to use F-factor and average HHV to get coal feed rate, ton/hr.	
Process Parameters[e]	750 MW each, on line in 1976.		
Test methods[f]	MM 5		
Number of test runs[g]	2 for nickel, 3 for all others		

[a]Page 7.
[b]Page 8.
[c]40 CFR Pt 60, App A.
[d]Page G-1.
[e]Page 1.
[f]Page 1.
[g]Various pages.

METALS EMISSION FACTORS				
EMISSION RATES (lb/hr)[a]	Run 1	Run 2	Run 3	AVG
Aluminum	8.9725	23.3877	7.7052	
Antimony	0.0084	0.0041	0.0092	
Arsenic	0.0304	0.0433	0.0326	
Barium	3.3101	6.4375	2.6330	
Beryllium	0.0033	0.0036	0.0035	
Boron	4.1097	86.2852	43.3077	
Cadmium	0.0205	0.0132	0.0097	
Calcium	67.2241	141.6439	72.3851	
Chromium	0.2046	0.1788	0.0881	
Copper	0.1302	0.1694	0.1321	
Iron	10.3672	13.7879	9.5545	
Lead	0.1116	0.0941	0.0969	
Magnesium	7.0757	18.5219	6.6221	
Manganese	0.3068	0.3294	0.6076	
Mercury	0.0093	0.0196	0.0141	
Molybdenum	0.0279	0.0471	0.0264	
Nickel	0.0186	----	0.0185	
Potassium	1.5806	2.0705	1.8493	
Selenium	0.0818	0.1129	0.1233	
Silver[b]	0.0112	0.0113	0.0114	
Sodium	4.7419	6.8704	5.4597	
Strontium	2.5197	4.5928	2.4657	
Vanadium	0.2603	0.3294	0.2906	
Zinc	0.2696	0.3106	0.2378	

[a]Page 5.
[b]Pollutant was not detected in any of the sampling runs. EF is based on detection limits.

EMISSION FACTORS (lb/ton)[c]	Run 1	Run 2	Run 3	AVG
Aluminum	1.11e-02	2.83e-02	1.01e-02	1.65e-02
Antimony	1.03e-05	4.96e-06	1.21e-05	9.12e-06
Arsenic	3.74e-05	5.24e-05	4.27e-05	4.42e-05
Barium	4.08e-03	7.79e-03	3.45e-03	5.11e-03
Beryllium	4.06e-06	4.36e-06	4.59e-06	4.34e-06
Boron	5.06e-03	1.04e-01	5.68e-02	5.54e-02
Cadmium	2.53e-05	1.60e-05	1.27e-05	1.80e-05
Calcium	8.28e-02	1.71e-01	9.49e-02	1.16e-01
Chromium	2.52e-04	2.16e-04	1.15e-04	1.95e-04
Copper	1.60e-04	2.05e-04	1.73e-04	1.80e-04
Iron	1.28e-02	1.67e-02	1.25e-02	1.40e-02
Lead	1.37e-04	1.14e-04	1.27e-04	1.26e-04
Magnesium	8.72e-03	2.24e-02	8.68e-03	1.33e-02
Manganese	3.78e-04	3.99e-04	7.97e-04	5.24e-04
Mercury	1.15e-05	2.37e-05	1.85e-05	1.79e-05
Molybdenum	3.44e-05	5.70e-05	3.46e-05	4.20e-05
Nickel	2.29e-05		2.43e-05	2.36e-05
Potassium	1.95e-03	2.51e-03	2.42e-03	2.29e-03
Selenium	1.01e-04	1.37e-04	1.62e-04	1.33e-04
Silver[b]	1.38e-05	1.37e-05	1.49e-05	1.41e-05
Sodium	5.84e-03	8.32e-03	7.16e-03	7.11e-03
Strontium	3.10e-03	5.56e-03	3.23e-03	3.97e-03
Vanadium	3.21e-04	3.99e-04	3.81e-04	3.67e-04
Zinc	3.32e-04	3.76e-04	3.12e-04	3.40e-04

[a]Page 5.
[b]Pollutant was not detected in any of the sampling runs. EF is based on detection limits.
[c]Divide emission rate by coal feed rate.

REFERENCE 26 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 16 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: RESULTS OF THE MAY 1, 1990 TRACE METAL CHARACTERIZATION STUDY ON UNITS 1 AND 2 AT THE SHERBURNE COUNTY GENERATING STATION

FACILITY: NSP Sherco
UNIT NO.: 1, 2
LOCATION: Becker, Minnesota
FILENAME SHRCO12A.TBL

PROCESS DATA	METALS		
	Run 1	Run 2	Run 3
Oxygen (% v/v)[a]	6.60	6.60	6.70
Vol. Flow Rate (dscf/m)[b]	3,284,153	3,326,471	3,347,367
Vol. Flow Rate (dscf/hr)	197,049,180	199,588,260	200,842,020
F-factor (dscf/MMBtu)[c]	9,780	9,780	9,780
Heat input (MMBtu/hr)	13,786	13,963	13,953
HHV Bituminous Coal (Btu/lb)[d]	8,547	8,547	8,547
HHV Bituminous Coal (Btu/ton)	17,094,000	17,094,000	17,094,000
Coal Feed (ton/hr)	806	817	816
Coal type[e]	Subbituminous		
Boiler configuration[e]	Pulverized, dry bottom		
Coal source	no data		
SCC	10100222		
Control device 1[e]	Flue Gas Desulfurization, Venturi Scrubber Spray Tower		
Control device 2[e]	None		
Data Quality	B	Had to use F-factor and average HHV to get coal feed rate, ton/hr.	
Process Parameters[e]	750 MW each, on line in 1976.		
Test methods[f]	MM 5 metals.		
Number of test runs[g]	2 for cadmium, nickel, copper and zinc; 3 for all others		

[a]Page 14.
[b]Page 19.
[c]40 CFR Pt 60, App A.
[d]From report "Results of the May 29, 1990 Trace Metal Characterization Study on Units 1 and 2 at the Sherburne County Generating Station in Becker, Minnesota", page G-1. (Reference No. 25)
[e]Page 1 of "Results of the September 10 and 11, 1991 Mercury Removal Tests on the Units 1 & 2, and Unit 3 Scrubber Systems at the NSP Sherco Plant in Becker, Minnesota" (Reference 19). Dry bottom assumed.
[f]Page 2.
[g]Various pages.

REFERENCE 26 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 16 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

METALS EMISSION FACTORS				
EMISSION RATES (lb/hr)[a]	Run 1	Run 2	Run 3	AVG
Aluminum	9.58	11.06	8.86	
Antimony	0.016	0.011	0.009	
Arsenic	0.035	0.039	0.030	
Barium	3.59	5.81	2.25	
Beryllium	0.0037	0.0042	0.0038	
Boron	98.0	18.1	38.1	
Cadmium	---	0.029	0.049	
Calcium	126	141	129	
Chromium	0.133	0.101	0.092	
Copper	---	0.200	0.227	
Iron	14.6	14.6	12.9	
Lead	0.127	0.118	0.100	
Magnesium	5.36	7.65	5.91	
Manganese	0.281	0.401	0.273	
Mercury	0.092	0.078	0.063	
Molybdenum [b]	0.027	0.027	0.027	
Nickel	---	0.071	0.052	
Potassium	2.00	1.88	1.74	
Selenium	0.109	0.137	0.118	
Silver	0.009	0.010	0.030	
Sodium	7.67	6.42	5.13	
Strontium	3.26	3.82	3.09	
Vanadium	0.300	0.291	0.282	
Zinc	---	0.70	0.45	

EMISSION FACTORS (lb/ton)[c]	Run 1	Run 2	Run 3	AVG
Aluminum	1.19e-02	1.35e-02	1.09e-02	1.21e-02
Antimony	1.98e-05	1.35e-05	1.10e-05	1.48e-05
Arsenic	4.34e-05	4.77e-05	3.68e-05	4.26e-05
Barium	4.45e-03	7.11e-03	2.76e-03	4.77e-03
Beryllium	4.59e-06	5.14e-06	4.66e-06	4.80e-06
Boron	1.22e-01	2.22e-02	4.67e-02	6.35e-02
Cadmium		3.55e-05	6.00e-05	4.78e-05
Calcium	1.56e-01	1.73e-01	1.58e-01	1.62e-01
Chromium	1.65e-04	1.24e-04	1.13e-04	1.34e-04
Copper		2.45e-04	2.78e-04	2.61e-04
Iron	1.81e-02	1.79e-02	1.58e-02	1.73e-02
Lead	1.57e-04	1.44e-04	1.23e-04	1.41e-04
Magnesium	6.65e-03	9.37e-03	7.24e-03	7.75e-03
Manganese	3.48e-04	4.91e-04	3.34e-04	3.91e-04
Mercury	1.14e-04	9.55e-05	7.72e-05	9.56e-05
Molybdenum[b]	3.35e-05	3.31e-05	3.31e-05	3.32e-05
Nickel		8.69e-05	6.37e-05	7.53e-05
Potassium	2.48e-03	2.30e-03	2.13e-03	2.30e-03
Selenium	1.35e-04	1.68e-04	1.45e-04	1.49e-04
Silver	1.12e-05	1.22e-05	3.68e-05	2.01e-05
Sodium	9.51e-03	7.86e-03	6.28e-03	7.89e-03
Strontium	4.04e-03	4.68e-03	3.79e-03	4.17e-03
Vanadium	3.72e-04	3.56e-04	3.45e-04	3.58e-04
Zinc		8.57e-04	5.51e-04	7.04e-04

[a]Pages 5 and 7.
[b]Pollutant was not detected in any of the sampling runs. EF is based on detection limits.
[c]Divide emission rate by coal feed rate.

REFERENCE 27 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 17 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: RESULTS OF THE MARCH 1990 TRACE METAL CHARACTERIZATION STUDY ON UNIT 3 AT THE SHERBURNE COUNTY GENERATING STATION

FACILITY: NSP SHERCO
UNIT NO.: 3
LOCATION: Becker, Minnesota
FILENAME SHERCO3A.tbl

PROCESS DATA	METALS		
	Run 1	Run 2	Run 3
Oxygen (% v/v)[a]	6.50	6.20	6.10
Vol. Flow Rate (dscf/m)[b]	1,950,168	1,965,867	1,962,255
Vol. Flow Rate (dscf/hr)	117,010,080	117,952,020	117,735,300
F-factor (dscf/MMBtu)[c]	9,780	9,780	9,780
Heat input (MMBtu/hr)	8,243	8,483	8,525
HHV Bituminous Coal (Btu/lb)[d]	8,547	8,547	8,547
HHV Bituminous Coal (Btu/ton)	17,094,000	17,094,000	17,094,000
Coal Feed (ton/hr)	482	496	499
	CHROME VI		
	Run 1	Run 2	Run 3
Oxygen (% v/v)[a]	6.10	6.10	6.00
Vol. Flow Rate (dscf/m)[b]	1,957,528	1,950,487	1,944,863
Vol. Flow Rate (dscf/hr)	117,029,220	116,691,780	
F-factor (dscf/MMBtu)[c]	9,780	9,780	9,780
Heat input (MMBtu/hr)	8,504	8,474	8,506
HHV Bituminous Coal (Btu/lb)[d]	8,547	8,547	8,547
HHV Bituminous Coal (Btu/ton)	17,094,000	17,094,000	17,094,000
Coal Feed (ton/hr)	497	496	498
Coal type[e]	Subbituminous		
Boiler configuration[e]	Pulverized, dry bottom		
Coal source[e]	Montana		
SCC	10100222		
Control device 1[e]	Flue Gas Desulfurization, Spray Dryer absorber		
Control device 2[e]	Baghouse		

REFERENCE 27 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 17 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

Data Quality	B	Had to use F-factor and average HHV to get coal feed rate (ton/hr)
Process Parameters[e]	860 megawatts, on line in 1987.	
Test methods[f]	MM5 for metals, MM13 for chrome VI.	
Number of test runs[g]	2 for calcium, nickel, sodium and zinc. 3 for all others.	

[a]Page 12 for metals runs; page 13 for chrome VI runs.
[b]Page 16 for metals runs, page 18 for chrome VI runs.
[c]40 CFR Pt 60, App A, Meth. 19, Bituminous coal.
[d]From report "Results of the May 29, 1990 Trace Metal Characterization Study on Units 1 and 2 at the Sherburne County Generating Station in Becker, Minnesota", page G-1. (Reference No. 25).
[e]Page 1. Assumed dry bottom.
[f]Page 1 for MM5, page 2 for MM 13.
[g]Various pages.

METALS EMISSION FACTORS

EMISSION RATES (lb/hr)[a]	Run 1	Run 2	Run 3	AVG
Aluminum	1.91	0.493	0.742	
Antimony	7.09e-03	1.62e-03	1.6e-03	
Arsenic[b]	---	4.12e-04	4.12e-04	
Barium[b]	0.048	0.049	0.050	
Beryllium	1.61e-05	4.93e-05	9.92e-05	
Boron	19.1	3.28	13.9	
Calcium	---	1.91	1.85	
Chromium	0.114	0.0682	0.0520	
Copper	0.789	0.384	0.188	
Iron	1.04	0.759	0.248	
Lead	0.123	0.0394	0.033	
Magnesium	0.294	0.123	0.215	
Manganese	0.0565	0.382	0.0379	
Mercury	0.0411	0.0172	0.0338	
Molybdenum[b]	0.032	0.033	0.033	
Nickel	---	0.0736	0.0264	
Potassium	1.83	0.624	0.602	
Selenium[b]	0.0199	0.0205	0.0207	
Silver[b]	2.41e-03	2.43e-03	2.50e-03	

METALS EMISSION FACTORS				
EMISSION RATES (lb/hr)[a]	Run 1	Run 2	Run 3	AVG
Sodium	---	4.62	4.80	
Strontium	0.0119	0.0411	0.0412	
Vanadium[b]	8.04e-04	8.10e-04	8.09e-04	
Zinc	---	0.262	0.172	
EMISSION FACTORS (lb/ton)[c]	Run 1	Run 2	Run 3	AVG
Aluminum	3.96e-03	9.93e-04	1.49e-03	2.15e-03
Antimony	1.47e-05	3.26e-06	3.21e-06	7.06e-06
Arsenic[b]		8.30e-07	8.26e-07	8.28e-07
Barium[b]	9.95e-05	9.87e-05	1.00e-04	9.95e-05
Beryllium	3.34e-08	9.93e-08	1.99e-07	1.11e-07
Boron	3.96e-02	6.61e-03	2.79e-02	2.47e-02
Calcium		3.85e-03	3.71e-03	3.78e-03
Chromium	2.36e-04	1.37e-04	1.04e-04	1.59e-04
Copper	1.64e-03	7.74e-04	3.77e-04	9.29e-04
Iron	2.16e-03	1.53e-03	4.97e-04	1.39e-03
Lead	2.55e-04	7.94e-05	6.62e-05	1.34e-04
Magnesium	6.10e-04	2.48e-04	4.31e-04	4.30e-04
Manganese	1.17e-04	7.70e-04	7.60e-05	3.21e-04
Mercury	8.52e-05	3.47e-05	6.78e-05	6.26e-05
Molybdenum[b]	6.64e-05	6.65e-05	6.62e-05	6.63e-05
Nickel		1.48e-04	5.29e-05	1.01e-04
Potassium	3.79e-03	1.26e-03	1.21e-03	2.09e-03
Selenium[b]	4.13e-05	4.13e-05	4.15e-05	4.14e-05
Silver[b]	5.00e-06	4.90e-06	5.01e-06	4.97e-06
Sodium		9.31e-03	9.63e-03	9.47e-03
Strontium	2.47e-05	8.28e-05	8.26e-05	6.34e-05
Vanadium[b]	1.67e-06	1.63e-06	1.62e-06	1.64e-06
Zinc		5.28e-04	3.45e-04	4.36e-04

[a]Pages 5 and 7.
[b]Pollutant was not detected in any of the sampling runs. EF is based on detection limits.
[c]Divide emission rate by coal feed rate.

CHROME VI EMISSION FACTORS

	Run 1	Run 2	Run 3	AVG
Emission Rates (lb/hr)[a]	0.0095	0.0028	0.0100	
Emission Factors (lb/ton)[b]	1.91e-05	5.65e-06	2.01e-05	1.49e-05

[a]Page 8.
[b]Divide emission rate by coal feed rate.

REFERENCE 28 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 18 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: FIELD CHEMICAL EMISSIONS MONITORING PROJECT: SITE 10 EMISSIONS MONITORING. RADIAN CORPORATION, AUSTIN, TEXAS. OCTOBER, 1992.

FACILITY: EPRI SITE 10
FILENAME SITE10.tbl

PROCESS DATA			
Coal feed rate, dry (lb/hr)[a]	108,626	Coal HHV, dry (Btu/lb)[b]	11,000
Coal moisture percent by weight[b]	7.3%	Coal HHV, as received (Btu/lb)	10,252
Coal feed rate, as received (lb/hr)	117,180	Coal HHV, as received (MMBtu/lb)	0.01
Coal feed rate, as received (ton/hr)	58.59	Coal HHV, as received (MMBtu/ton)	20.50
Stack gas flow rate (dscf/hr)[a]	15,500,000		
Coal type[c]	Subbituminous		
Boiler configuration[d]	Circulating Fluidized Bed Combustor (CFBC)		
Coal source[c]	Salt River		
SCC	10100238		
Control device 1[e]	Flue gas desulfurization by limestone injection into the combustion chamber (FGD-FIL)		
Control device 2[e]	Fabric Filter		
Data Quality	A		
Process Parameters[d]	110 megawatts		
Test methods[f]	EPA, or EPA-approved, test methods		
Number of test runs[g]	5 for benzene, 1 for all others.		

[a]Page C-3
[b]Page B-3
[c]Appendix B of EPRI Synthesis Report, page B-3.
[d]Appendix B of EPRI Synthesis Report, page B-6.
[e]Page 1-1
[f]Pages A-3 through A-13
[g]Page 3-1 and B-15 for benzene, page 3-1 for others.

METALS, VOC EMISSION FACTORS[a]

Pollutant	(lb/10^12 Btu)	(lb/MMBtu)	(lb/ton)[c]
Arsenic[b]	1	1.00e-06	2.05e-05
Barium	12.1	1.21e-05	2.48e-04
Beryllium[b]	0.2	2.00e-07	4.10e-06
Cadmium[b]	0.4	4.00e-07	8.20e-06
Chloride	958	9.58e-04	1.96e-02
Chromium	1.6	1.60e-06	3.28e-05
Cobalt[b]	0.8	8.00e-07	1.64e-05
Copper[b]	2	2.00e-06	4.10e-05
Fluoride[b]	18	1.80e-05	3.69e-04
Lead	0.6	6.00e-07	1.23e-05
Manganese	31	3.10e-05	6.36e-04
Molybdenum[b]	4	4.00e-06	8.20e-05
Nickel[b]	2	2.00e-06	4.10e-05
Phosphorous[b]	24	2.40e-05	4.92e-04
Selenium[b]	16	1.60e-05	3.28e-04
Vanadium[b]	2	2.00e-06	4.10e-05
Formaldehyde[b]	15	1.50e-05	3.08e-04
Benzene	2	2.00e-06	4.10e-05

[a]Page 3-12
[b]Emission factor is based only on detection limits.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

MISC. EMISSION FACTORS

Pollutant	Stack Gas Conc. (ug/Nm3)[a]	Stack Gas Conc. (ug/dscm)[b]	Stack Gas Conc. (lb/dscf)[c]	Emission Rate (lb/hr)[d]	Emission Factor (lb/ton)[e]
Dibutyl Phthalate	3.1	2.89	1.80e-10	2.80e-03	4.77e-05
bis(2-Ethylhexyl) phthalate	6.0	5.59	3.49e-10	5.41e-03	9.24e-05
N-Nitrosodiethylamine	15	13.98	8.73e-10	1.35e-02	2.31e-04

[a]Page 3-14
[b]Convert Normal meter to standard meter, i.e., multiply by 273/293.
[c]Convert ug/dscm to lb/dscf.
[d]Multiply concentration by stack gas flow rate.
[e]Divide emission rate by coal feed rate.

REFERENCE 29 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 19 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: FIELD CHEMICAL EMISSIONS MONITORING PROJECT: SITE 11 EMISSIONS MONITORING. RADIAN CORPORATION, AUSTIN, TEXAS. OCTOBER, 1992.

FACILITY: EPRI SITE 11
FILENAME SITE11.tbl

PROCESS DATA	
Coal type[a]	Subbituminous
Boiler configuration[b]	Pulverized, dry, tangential
Coal source[a]	Powder River Basin
SCC	10100226
Control device 1[a]	Over Fire Air
Control device 2[a]	ESP
Control device 3[a]	Flue Gas Desulfurization, Wet Limestone Scrubber (Absorber)
Data Quality	B
Process Parameters[a]	700 MW
Test methods[c]	EPA, or EPA-approved, test methods
Number of test runs[d]	1
Stack gas flow rate (dscf/m)[e]	1,598,400
Stack gas flow rate (dscf/hr)	95,904,000
Stack Gas O2 %[e]	6.9
F-factor (dscf/MMBtu)[f]	9,780
Heat input (MMBtu/hr)	6568.7
Coal HHV, as received (Btu/lb)[a]	8,300
Coal HHV, as received (MMBtu/lb)	0.008
Coal HHV, as received (MMBtu/ton)	16.60
Coal feed rate as received (ton/hr)	395.70

[a]Page 2-1.
[b]Page 2-1. Assumed dry bottom.
[c]Appendix A.
[d]Page 3-18.
[e]Page D-7.
[f]40 CFR Pt 60, App. A, Meth. 19, bituminous coal.

METALS, VOC EMISSION FACTORS

Pollutant	Particulate Phase (ug/Nm3)[a]	Vapor Phase (ug/Nm3)[a]	Total (ug/Nm3)	Total (ug/dscm)	Total (lb/dscf)	Emission Rate (lb/hr)[c]	Emission Factor (lb/ton)[d]
Arsenic	1.0	NR(3)	1.0	0.93	5.82e-11	5.58e-03	1.41e-05
Barium	97	NR(6)	97.0	90.38	5.64e-09	5.41e-01	1.37e-03
Beryllium[b]	NR(0.2)	NR(1)	0.20	0.19	1.16e-11	1.12e-03	2.82e-06
Cadmium		1.3	1.3	1.21	7.56e-11	7.25e-03	1.83e-05
Chlorine		2200	2,200	2049.83	1.28e-07	1.23e+01	3.10e-02
Chromium	7.0	NR(6)	7.0	6.52	4.07e-10	3.91e-02	9.87e-05
Cobalt	1.7	NR(6)	1.7	1.58	9.89e-11	9.49e-03	2.40e-05
Copper	2.1	NR(10)	2.1	1.96	1.22e-10	1.17e-02	2.96e-05
Fluorine		130	130.00	121.13	7.56e-09	7.25e-01	1.83e-03
Lead		14	14.00	13.04	8.15e-10	7.81e-02	1.97e-04
Manganese	3.9	110	113.90	106.13	6.63e-09	6.36e-01	1.61e-03
Mercury	0.016	3.7	3.72	3.46	2.16e-10	2.07e-02	5.24e-05
Molybdenum[b]	NR(5)	NR(30)	5	4.66	2.91e-10	2.79e-02	7.05e-05
Nickel	4.7	NR(10)	4.7	4.38	2.73e-10	2.62e-02	6.63e-05
Phosphorous[b]		NR(20)	20	18.63	1.16e-09	1.12e-01	2.82e-04

METALS, VOC EMISSION FACTORS

Pollutant	Particulate Phase (ug/Nm3)[a]	Vapor Phase (ug/Nm3)[a]	Total (ug/Nm3)	Total (ug/dscm)	Total (lb/dscf)	Emission Rate (lb/hr)[c]	Emission Factor (lb/ton)[d]
Selenium[b]		NR(3)	3	2.80	1.75e-10	1.67e-02	4.23e-05
Vanadium	2.6	NR(10)	2.6	2.42	1.51e-10	1.45e-02	3.67e-05
Formaldehyde[b]		NR(10)	10	9.32	5.82e-10	5.58e-02	1.41e-04
Naphthalene[b]	NR(4)		4	3.73	2.33e-10	2.23e-02	5.64e-05

[a]Page 3-18, Run 2 data only (other runs invalid).
[b]Page 3-18. Detection limit value for one run used in calculating EF.
[c]Multiply concentration by stack gas flow rate.
[d]Divide emission rate by coal feed rate.

REFERENCE 30 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 20 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: FIELD CHEMICAL EMISSIONS MONITORING PROJECT: SITE 12 EMISSIONS MONITORING. RADIAN CORPORATION, AUSTIN, TEXAS. NOVEMBER, 1992.

FACILITY: EPRI SITE 12
FILENAME SITE12.tbl

PROCESS DATA	
Coal type[a]	Bituminous
Boiler configuration[b]	Pulverized, dry, opposed
Coal source[a]	West Pa.
SCC	10100202
Control device 1[c]	ESP
Control device 2[c]	Flue Gas Desulfurization, Wet Limestone Scrubber (Absorber)
Control device 3	None
Data Quality	A
Process Parameters[c]	700 MW
Test methods[d]	EPA, or EPA-approved, test methods
Number of test runs[e]	2 for Metals, 3 for VOCs.
Coal HHV, dry (Btu/lb)[f]	13,733
Coal moisture %[f]	4.12%
Coal HHV, as received (Btu/lb)	13,190
Coal HHV, as received (Btu/ton)	26,379,178
Coal HHV, as received (MMBtu/ton)	26.4

[a]Page 3-5.
[b]Page 2-1. Assumed dry bottom.
[c]Page 2-1.
[d]Appendix A.
[e]Page 3-11 for PM/metals, Page 3-14 for VOC.
[f]Page 3-6.

REFERENCE 30 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 20 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

METALS, VOC EMISSION FACTORS[a]

Pollutant	Emission Factor (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor (lb/ton)[c]
Arsenic	0.45	4.50e-07	1.19e-05
Barium	6.3	6.30e-06	1.66e-04
Beryllium[b]	0.16	1.60e-07	4.22e-06
Cadmium	1.2	1.20e-06	3.17e-05
Chloride	2500	2.50e-03	6.59e-02
Chromium	3.5	3.50e-06	9.23e-05
Cobalt[b]	1.0	1.00e-06	2.64e-05
Copper	4.4	4.40e-06	1.16e-04
Fluoride	27	2.70e-05	7.12e-04
Lead	5.7	5.70e-06	1.50e-04
Manganese	1.6	1.60e-06	4.22e-05
Mercury	0.16	1.60e-07	4.22e-06
Molybdenum	4	4.00e-06	1.06e-04
Nickel	4.4	4.40e-06	1.16e-04
Selenium	13	1.30e-05	3.43e-04
Vanadium[b]	1.6	1.60e-06	4.22e-05
Formaldehyde[b]	8.4	8.40e-06	2.22e-04
Bromomethane[b]	0.43	4.30e-07	1.13e-05
1,1,1-trichloroethane	0.75	7.50e-07	1.98e-05
Benzene	0.69	6.90e-07	1.82e-05
Toluene	1.04	1.04e-06	2.74e-05
m,p-xylene	0.72	7.20e-07	1.90e-05

[a]Page 3-12 for metals, page 3-14 for VOC. See page 3-11 for number of non-detect runs for pm/metals.
[b]Detection limit value for two runs used in calculating EF.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 31 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 21 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: FIELD CHEMICAL EMISSIONS MONITORING PROJECT: SITE 15 EMISSIONS MONITORING. RADIAN CORPORATION, AUSTIN, TEXAS. OCTOBER, 1992.

FACILITY: EPRI SITE 15
FILENAME SITE15.tbl

PROCESS DATA	
Coal type[a]	Bituminous
Boiler configuration[b]	Pulverized, dry, tangential
Coal source[a]	Eastern US
SCC	10100212
Control device 1[a]	ESP cold side
Control device 2	None
Control device 3	None
Data Quality	A
Process Parameters[a]	600 MW
Test methods[c]	EPA, or EPA-approved, test methods
Number of test runs[d]	2 for lead, 3 for all others
Coal HHV, dry (Btu/lb)[e]	13,000
Coal HHV, as received (Btu/ton)	26,000,000
Coal HHV, as received (MMBtu/ton)	26.0

[a]Page 2-1.
[b]Page 2-1. Assumed dry bottom.
[c]Appendix A.
[d]Page 3-9.
[e]Page 3-4, assumed to be as fired.

REFERENCE 31 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 21 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

EMISSION FACTORS[a]

Pollutant	Emission Factor (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor (lb/ton)[c]
Arsenic	13	1.30e-05	3.38e-04
Barium	34	3.40e-05	8.84e-04
Beryllium	0.4	4.00e-07	1.04e-05
Cadmium	3.1	3.10e-06	8.06e-05
Chloride	46,700	4.67e-02	1.21e+00
Chromium	12	1.20e-05	3.12e-04
Cobalt	2.0	2.00e-06	5.20e-05
Copper	5.5	5.50e-06	1.43e-04
Fluoride	3,850	3.85e-03	1.00e-01
Lead	4.3	4.30e-06	1.12e-04
Manganese	8.6	8.60e-06	2.24e-04
Molybdenum	5.3	5.30e-06	1.38e-04
Nickel	5.9	5.90e-06	1.53e-04
Selenium	77	7.70e-05	2.00e-03
Vanadium	14	1.40e-05	3.64e-04
Benzene	0.8	8.00e-07	2.08e-05
Formaldehyde[b]	5	5.00e-06	1.30e-04
Toluene	5.2	5.20e-06	1.35e-04

[a]Page 3-10.
[b]Emission factors is based only on detection limits.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 32 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 22 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: FIELD CHEMICAL EMISSIONS MONITORING PROJECT: SITE 19 EMISSIONS MONITORING. RADIAN CORPORATION, AUSTIN, TEXAS. NOVEMBER, 1992.

FACILITY: EPRI SITE 19
FILENAME SITE19.tbl

PROCESS DATA			
Coal type[a]	Bituminous	Coal HHV, dry (Btu/lb)[g]	13,467
Boiler configuration[b]	Pulverized, dry, opposed	Coal moisture %[g]	6.1%
Coal source	Virginia, Kentucky	Coal HHV, as received (Btu/lb)	12,693
SCC	10100202	Coal HHV, as received (Btu/ton)	25,385,485
Control device 1[c]	ESP cold side	Coal HHV, as received (MMBtu/ton)	25.4
Control device 2	None	Coal feed rate, dry (lb/hr)[h]	694,000
Control device 3	None	Coal moisture percent by weight[g]	6.1%
Data Quality	A	Coal feed rate, as received (lb/hr)	739,084
Process Parameters[d]	1160 MW	Coal feed rate, as received (ton/hr)	369.54
Test methods[e]	EPA, or EPA-approved, test methods	Stack gas flow rate (Nm3/hr)[h]	4,000,000
Number of test runs[f]	3		

[a]Page 2-1.
[b]Page 2-1. Assumed dry bottom.
[c]Page 2-1.
[d]Page 2-2.
[e]Appendix A.
[f]Page 3-7.
[g]Page 3-5.
[h]Page 3-8.

METALS

Pollutant	Emission Factor[a] ($lb/10^{12}$ Btu)	Emission Factor (lb/MMBtu)	Emission Factor (lb/ton)[b]
Arsenic	7.9	7.90e-06	2.01e-04
Cadmium	0.13	1.30e-07	3.30e-06
Chloride	75,000	7.50e-02	1.90e+0
Chromium	13	1.30e-05	3.30e-04
Copper	12	1.20e-05	3.05e-04
Fluoride	5,800	5.80e-03	1.47e-01
Manganese	5.4	5.40e-06	1.37e-04
Mercury	6.2	6.20e-06	1.57e-04
Nickel	7.9	7.90e-06	2.01e-04
Selenium	260	2.60e-04	6.60e-03

[a]Page 3-8.
[b]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

MISCELLANEOUS EMISSION FACTORS

Pollutant Concentration (ug/Nm3)[a]	Solid Phase Conc.			Vapor Phase Conc.			Total conc.			
	Run 2	Run 3	Run 4	Run 2	Run 3	Run 4	Run 2	Run 3	Run 4	avg
Antimony	0.47	0.39	0.35	0.76	1.9	1.7	0.47	2.29	2.05	1.60
Beryllium	1.1	1.0	0.72	0.49	0.55	0.50	1.1	1.55	1.22	1.29
Cobalt	4.3	4.2	2.8	2.5	2.8	2.5	4.3	7	5.3	5.53

Pollutant emissions	emission rate (ug/hr)[b]	emission rate (lb/hr)	emission factor (lb/ton)[c]
Antimony	6,413,333	1.41e-02	3.83e-05
Beryllium	5,160,000	1.14e-02	3.08e-05
Cobalt	22,133,333	4.88e-02	1.32e-04

[a]Page 3-9.
[b]Multiply concentration by stack gas flow rate.
[d]Divide emission rate by coal feed rate.

REFERENCE 33 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 23 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: FIELD CHEMICAL EMISSIONS MONITORING PROJECT: SITE 20 EMISSIONS MONITORING RADIAN CORPORATION, AUSTIN, TEXAS. MARCH, 1994.

FACILITY: EPRI SITE 20
FILENAME SITE20.tbl

PROCESS DATA	
Coal type[a]	Lignite
Boiler configuration[b]	Pulverized
Coal source[f]	Wilcox, Texas
SCC	10100301
Control device 1[a]	ESP cold side
Control device 2[a]	Flue Gas Desulfurization- Wet Limestone Scrubber (absorber)
Control device 3	None
Data Quality	A
Process Parameters[a]	680 MW
Test methods[c]	EPA, or EPA-approved, test methods
Number of test runs[d]	4
Coal HHV, as received (Btu/lb)[e]	6,760
Coal HHV, as received (Btu/ton)	13,520,000
Coal HHV, as received (MMBtu/ton)	13.5

[a]Page 2-1.
[b]Page 2-5.
[c]Appendix A.
[d]Page 3-9.
[e]Page 2-2.
[f]Appendix B of EPRI Synthesis Report, page B-3.

REFERENCE 33 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 23 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

EMISSION FACTORS	Emission Factor[a]	Emission Factor	Emission Factor
Pollutant	(lb/10^12 Btu)	(lb/MMBtu)	(lb/ton)[b]
Arsenic	0.63	6.30e-07	8.52e-06
Barium	42	4.20e-05	5.68e-04
Beryllium	0.35	3.50e-07	4.73e-06
Cadmium	0.70	7.00e-07	9.46e-06
Chloride	390	3.90e-04	5.27e-03
Chromium	2.8	2.80e-06	3.79e-05

REFERENCE 33 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 23 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

EMISSION FACTORS	Emission Factor[a]	Emission Factor	Emission Factor
Pollutant	(lb/10^12 Btu)	(lb/MMBtu)	(lb/ton)[b]
Cobalt	0.69	6.90e-07	9.33e-06
Fluoride	430	4.30e-04	5.81e-03
Lead	3.8	3.80e-06	5.14e-05
Manganese	8.5	8.50e-06	1.15e-04
Mercury	12	1.20e-05	1.62e-04
Nickel	4.3	4.30e-06	5.81e-05
Phosphorous	21	2.10e-05	2.84e-04
Selenium	160	1.60e-04	2.16e-03
Vanadium	3.08	3.08e-06	4.16e-05

[a]Page 3-11, Stack data.
[b]Multiply emission factor,lb/MMBtu, by coal HHV, MMBtu/ton.

Antimony EMISSION FACTOR: Note that antimony was not detected in any of the sampling runs.

	Run 1	Run 2	Run 3	Run 4
Coal feed rate (lb/hr, dry)[a]	630,000	614,000	619,000	618,000
Coal moisture (%)[a]	33.5%	34.2%	33.6%	34.4%
Coal feed rate (lb/hr, wet) (as fired)	947,368	933,131	932,229	942,073
Coal feed rate (ton/hr)	474	467	466	471
Stack gas flow rate (Nm3/hr)[b]	3,100,000	3,140,000	3,100,000	3,040,000
Antimony concentration (ug/Nm3)[b,c]	1.31	1.07	1.13	1.29
Antimony emission rate (ug/hr)[d]	4,061,000	3,359,800	3,503,000	3,921,600
Antimony emission rate (lb/hr)[e]	8.95e-03	7.41e-03	7.72e-03	8.65e-03
Antimony emission factor (lb/ton)[f]	1.89e-05	1.59e-05	1.66e-05	1.84e-05
				avg
				1.74e-05

[a]Page 3-6.
[b]Page 3-9.
[c]Pollutant was not detected in any sampling runs. EF based on detection limits.
[d]Multiply concentration by stack gas flow rate.
[e]Convert ug/hr to lb/hr.
[f]Divide emission rate by coal feed rate.

REFERENCE 34 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 24 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: FIELD CHEMICAL EMISSIONS MONITORING PROJECT: SITE 21 EMISSIONS MONITORING. RADIAN CORPORATION, AUSTIN, TEXAS. AUGUST, 1993.

FACILITY: EPRI SITE 21
FILENAME SITE21.tbl

PROCESS DATA	
Coal type[a]	Bituminous
Boiler configuration[b]	Pulverized, dry, opposed
Coal source[a]	Pa., W. Va.
SCC	10100202
Control device 1[c]	ESP
Control device 2[c]	Flue Gas Desulfurization, Wet Limestone Scrubber (Absorber)
Control device 3	None
Data Quality	A
Process Parameters[c]	667 MW
Test methods[d]	EPA, or EPA-approved, test methods
Number of test runs[e]	8 for PM/metals, 7 for semi-volatiles
Coal HHV, dry (Btu/lb)[f]	14,032
Coal moisture %[g]	7%
Coal HHV, as received (Btu/lb)	13,114
Coal HHV, as received (Btu/ton)	26,228,037
Coal HHV, as received (MMBtu/ton)	26.2

[a]Page 3-6.
[b]Assumed to be pulverized, dry bottom.
[c]Page 2-3.
[d]Appendix A.
[e]Page 3-10 for metals, page 3-14 for semi-volatiles.
[f]Page 3-5.
[g]Page 7-2.

EMISSION FACTORS	Emission Factor[a]	Emission Factor	Emission Factor[b]
Pollutant	(lb/10^12 Btu)	(lb/MMBtu)	(lb/ton)
Acenapthene	0.018	1.80e-08	4.72e-07
Acenapthylene	0.0075	7.50e-09	1.97e-07
Anthracene	0.0099	9.90e-09	2.60e-07
Arsenic	6.17	6.17e-06	1.62e-04

REFERENCE 34 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 24 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

EMISSION FACTORS	Emission Factor[a]	Emission Factor	Emission Factor[b]
Pollutant	(lb/10^12 Btu)	(lb/MMBtu)	(lb/ton)
Barium	3.21	3.21e-06	8.42e-05
Benz(a)anthracene	0.0013	1.30e-09	3.41e-08
Benzo(a)pyrene	0.0018	1.80e-09	4.72e-08
Benzo(b,j,k)fluoranthenes	0.0066	6.60e-09	1.73e-07
Benzo(g,h,i)perylene	0.0012	1.20e-09	3.15e-08
Beryllium	0.13	1.30e-07	3.41e-06
Cadmium	0.57	5.70e-07	1.49e-05
Chloride	1,980	1.98e-03	5.19e-02
Chromium	2.74	2.74e-06	7.19e-05
Chrysene	0.0069	6.90e-09	1.81e-07
Cobalt	4.1	4.10e-06	1.08e-04
Copper	1.57	1.57e-06	4.12e-05
Fluoranthene	0.053	5.30e-08	1.39e-06
Fluorene	0.064	6.40e-08	1.68e-06
Fluoride	31.9	3.19e-05	8.37e-04
Indeno(1,2,3-cd)pyrene	0.0015	1.50e-09	3.93e-08
Lead	6.32	6.32e-06	1.66e-04
Manganese	15	1.50e-05	3.93e-04
Mercury	0.84	8.40e-07	2.20e-05
Molybdenum	0.61	6.10e-07	1.60e-05
Nickel	1.68	1.68e-06	4.41e-05
Phenanthrene	0.21	2.10e-07	5.51e-06
Pyrene	0.024	2.40e-08	6.29e-07
Selenium	9.9	9.90e-06	2.60e-04
Vanadium	5.50	5.50e-06	1.44e-04
5-Methyl Chrysene	0.0015	1.50e-09	3.93e-08

[a]Page 3-15.
[b]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 35 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 25 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: FIELD CHEMICAL EMISSIONS MONITORING PROJECT: SITE 22 EMISSIONS REPORT. RADIAN CORPORATION, AUSTIN, TEXAS. FEBRUARY, 1994.

FACILITY: EPRI SITE 22
FILENAME SITE22.tbl

PROCESS DATA	
Coal type[a]	Subbituminous
Boiler configuration[b]	Pulverized, dry, opposed
Coal source[a]	Powder River
SCC	10100222
Control device 1[a]	ESP Cold Side
Control device 2	None
Control device 3	None
Data Quality	A
Process Parameters[c]	700 MW
Test methods[d]	EPA, or EPA-approved, test methods
Number of test runs[e]	3
Coal HHV, dry (Btu/lb)[f]	11,981
Coal moisture %[f]	29.5%
Coal HHV, as received (Btu/lb)	9,252
Coal HHV, as received (Btu/ton)	18,503,475
Coal HHV, as received (MMBtu/ton)	18.5

[a]Page 2-1
[b]Assumed pulverized, dry bottom.
[c]Page 2-2.
[d]Appendix A
[e]Pages 3-7 through 3-11
[f]Page 3-6

METALS, ORGANIC EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Arsenic	0.087	8.70e-08	1.61e-06
Barium	16	1.60e-05	2.96e-04
Beryllium[b]	0.031	3.10e-08	5.74e-07
Cadmium	0.16	1.60e-07	2.96e-06
Chloride	726	7.26e-04	1.34e-02
Chromium	0.53	5.30e-07	9.81e-06
Cobalt[b]	0.70	7.00e-07	1.30e-05
Copper	1.0	1.00e-06	1.85e-05
Fluoride	855	8.55e-04	1.58e-02
Lead	0.11	1.10e-07	2.04e-06
Manganese	1.1	1.10e-06	2.04e-05
Mercury	3.8	3.80e-06	7.03e-05
Molybdenum	1.9	1.90e-06	3.52e-05
Nickel	0.64	6.40e-07	1.18e-05
Phosphorous	11	1.10e-05	2.04e-04
Selenium	0.053	5.30e-08	9.81e-07
Vanadium	0.78	7.80e-07	1.44e-05
Aluminum	136	1.36e-04	2.52e-03
Antimony[b]	3.8	3.80e-06	7.03e-05
Calcium	325	3.25e-04	6.01e-03
Iron	52	5.20e-05	9.62e-04
Magnesium	47	4.70e-05	8.70e-04
Potassium[b]	82	8.20e-05	1.52e-03
Sodium	86	8.60e-05	1.59e-03
Titanium	12	1.20e-05	2.22e-04

[a] Page 3-12.
[b] Emission factor is based only on detection limits.
[c] Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 35 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 25 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

PAH EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Acenaphthalene	0.0034	3.40e-09	6.29e-08
Acenaphthene	0.0060	6.00e-09	1.11e-07
Anthracene	0.0046	4.60e-09	8.51e-08
Benzo(a)pyrene	0.0011	1.10e-09	2.04e-08
Benzo(b,j,k)fluoranthenes	0.0027	2.70e-09	5.00e-08
Benzo(g,h,i)perylene	0.0022	2.20e-09	4.07e-08
Benz(a)anthracene	0.0010	1.00e-09	1.85e-08
Chrysene	0.0025	2.50e-09	4.63e-08
Fluoranthene	0.024	2.40e-08	4.44e-07
Fluorene	0.012	1.20e-08	2.22e-07
Indeno(1,2,3-cd)pyrene	0.0086	8.60e-09	1.59e-07
5-Methyl Chrysene[b]	0.00047	4.70e-10	8.70e-09
Phenanthrene	0.069	6.90e-08	1.28e-06
Pyrene	0.016	1.60e-08	2.96e-07

[a]Page 3-14..
[b]Emission factor is based only on detection limits.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu, ton.

DIOXIN/FURAN EMISSION FACTORS

Pollutant	Emission Factor (lb/10^12 Btu)[a]	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
2,3,7,8-TCDD[b]	3.3e-06	3.3e-12	6.1e-11
Total TCDD	4.7e-06	4.7e-12	8.7e-11
Total PeCDD	ND	ND	ND
Total HxCDD	ND	ND	ND
Total HpCDD	9.8e-06	9.8e-12	1.8e-10
OCDD	5.2e-05	5.2e-11	9.6e-10

REFERENCE 35 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 25 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

DIOXIN/FURAN EMISSION FACTORS

Pollutant	Emission Factor (lb/10^12 Btu)[a]	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
2,3,7,8-TCDF[b]	3.6e-06	3.6e-12	6.7e-11
Total TCDF	6.2e-06	6.2e-12	1.1e-10
Total PeCDF	7.3e-06	7.3e-12	1.4e-10
Total HxCDF	3.5e-06	3.5e-12	6.5e-11
Total HpCDF	2.2e-06	2.2e-12	4.1e-11
OCDF	4.2e-06	4.2e-12	7.8e-11

[a]Page 3-15.
[b]Emission factor is based only on detection limits.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu, ton.

REFERENCE 36 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 26 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: FIELD CHEMICAL EMISSIONS MONITORING PROJECT: SITE 101 EMISSIONS REPORT. RADIAN CORPORATION, AUSTIN, TEXAS. OCTOBER, 1994.

FACILITY: EPRI SITE 101
FILENAME SITE101.tbl

PROCESS DATA	
Coal type[a]	Subbituminous
Boiler configuration[b]	Pulverized, dry, wall-fired
Coal source[c]	New Mexico
SCC	10100222
Control device 1[a]	Low Nox Burners (LNB)
Control device 2[a]	Fabric Filter
Control device 3[a]	Flue Gas Desulfurization- Wet Limestone Scrubber
Data Quality	A
Process Parameters[a]	800 MW
Test methods[d]	EPA, or EPA-approved, test methods
Number of test runs[e]	3 for benzene, toluene, chloride and fluoride; 2 for all others.
Coal HHV, dry (Btu/lb)[f]	10,190
Coal moisture %[f]	14%
Coal HHV, as received (Btu/lb)	8,939
Coal HHV, as received (Btu/ton)	17,877,193
Coal HHV, as received (MMBtu/ton)	17.9

[a]Page 2-1.
[b]Page 2-1, assumed dry bottom.
[c]Appendix B of the EPRI Synthesis Report, page B-3.
[d]Appendix A.
[e]Page 3-10 for benzene and toluene, page 3-6 for others.
[f]Page 3-5.

METALS, ORGANIC EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[b] (lb/ton)
Arsenic	0.34	3.40e-07	6.08e-06
Barium	18	1.80e-05	3.22e-04
Beryllium	0.036	3.60e-08	6.44e-07
Cadmium	0.40	4.00e-07	7.15e-06
Chloride	2,500	2.50e-03	4.47e-02
Chromium	2.2	2.20e-06	3.93e-05
Cobalt	0.13	1.30e-07	2.32e-06
Copper	2.2	2.20e-06	3.93e-05
Fluoride	3,600	3.60e-03	6.44e-02
Lead	0.72	7.20e-07	1.29e-05
Manganese	10	1.00e-05	1.79e-04
Mercury	1.9	1.90e-06	3.40e-05
Molybdenum	2.6	2.60e-06	4.65e-05
Nickel	2.8	2.80e-06	5.01e-05
Phosphorous	9.2	9.20e-06	1.64e-04
Selenium	1.4	1.40e-06	2.50e-05
Vanadium	0.93	9.30e-07	1.66e-05
Benzene	0.57	5.70e-07	1.02e-05
Toluene	0.57	5.70e-07	1.02e-05

[a]Page 3-13.
[b]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 37 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 27 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: FIELD CHEMICAL EMISSIONS MONITORING PROJECT: SITE 111 EMISSIONS REPORT. RADIAN CORPORATION, AUSTIN, TEXAS. MAY, 1993.

FACILITY: EPRI SITE 111
FILENAME SITE111.tbl

PROCESS DATA	
Coal type[a]	Subbituminous
Boiler configuration[b]	Pulverized, dry bottom
Coal source[c]	Western
SCC	10100222
Control device 1[c]	Low Nox Burners (LNB)
Control device 2[c]	Flue Gas Desulfurization- Spray Dryer (FGD-SD)
Control device 3[c]	Fabric Filter (FF)
Data Quality	A
Process Parameters[c]	267 MW
Test methods[d]	EPA, or EPA-approved, test methods
Number of test runs[e]	2
Coal HHV, as fired (received) (Btu/lb)[f]	10,020
Coal HHV, as fired (received) (Btu/ton)	20,040,000
Coal HHV, as fired (received) (MMBtu/ton)	20.0

[a]Page 2-2.
[b]Assumed dry bottom.
[c]Page 2-1.
d Page 1-4.
e Page 3-12.
f Page 2-2.

REFERENCE 37 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 27 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor (lb/ton)[c]
Arsenic[b]	0.21	2.10e-07	4.21e-06
Cadmium[b]	2.1	2.10e-06	4.21e-05
Chromium[b]	4.3	4.30e-06	8.62e-05
Mercury[b]	67	6.70e-05	1.34e-03
Nickel	5.3	5.30e-06	1.06e-04
Chloride	1,250	1.25e-03	2.51e-02
Benzene	21.1	2.11e-05	4.23e-04
Naphthalene	0.76	7.60e-07	1.52e-05
Acenaphthalene	0.03	3.00e-08	6.01e-07
Acenaphthene	0.08	8.00e-08	1.60e-06
Fluorene	0.18	1.80e-07	3.61e-06
Phenanthrene	0.13	1.30e-07	2.61e-06
Anthracene	0.02	2.00e-08	4.01e-07
Fluoranthene	0.03	3.00e-08	6.01e-07
Pyrene	0.01	1.00e-08	2.00e-07
Chrysene[b]	0.004	4.00e-09	8.02e-08
Benz(a)anthracene	0.009	9.00e-09	1.80e-07
Benzo(b)fluoranthene	0.008	8.00e-09	1.60e-07
Benzo(k)fluoranthene	0.004	4.00e-09	8.02e-08
Benzo(a)pyrene[b]	0.004	4.00e-09	8.02e-08
Indeno(1,2,3-cd)pyrene	0.004	4.00e-09	8.02e-08
Benzo(g,h,i)perylene	0.004	4.00e-09	8.02e-08

[a]Page 3-15.
[b]Emission factor is based only on detection limits.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 38 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 28 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: FIELD CHEMICAL EMISSIONS MONITORING PROJECT: SITE 114 REPORT. RADIAN CORPORATION, AUSTIN, TEXAS. MAY, 1994.

FACILITY: EPRI SITE 114
FILENAME SITE114.tbl

PROCESS DATA		
Coal type[a]	Bituminous	
Boiler configuration[a]	Cyclone	
Coal source[a]	Indiana Lamar	
SCC	10100203	
Control device 1[a]	ESP for baseline condition, Reburn/Overfire Air for condition two	
Control device 2[a]	None for baseline, ESP for condition two	
Control device 3	none	
Data Quality	A	
Process Parameters[a]	100 MW	
Test methods[b]	EPA, or EPA-approved, test methods	
Number of test runs[c]	3	
	Baseline	Reburn
Coal HHV, dry (Btu/lb)[d]	13,490	13,280
Coal moisture %[d]	15.6%	12.5%
Coal HHV, as received (Btu/lb)	11,670	11,804
Coal HHV, as received (Btu/ton)	23,339,100	23,608,889
Coal HHV, as received (MMBtu/ton)	23.3	23.6

[a]Page 2-1.
[b]Page 1-4.
[c]Pages 3-8 and 3-9.
[d]Pages 3-4 & 3-5.

EMISSION FACTORS- BASELINE CONDITION

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Arsenic	7	7.00e-06	1.63e-04
Beryllium	2.4	2.40e-06	5.60e-05
Cadmium	1.8	1.80e-06	4.20e-05
Chromium	14	1.40e-05	3.27e-04
Manganese	20	2.00e-05	4.67e-04
Nickel	78	7.80e-05	1.82e-03
Lead	86	8.60e-05	2.01e-03
Selenium	240	2.40e-04	5.60e-03
Mercury	4.5	4.50e-06	1.05e-04
Chloride	4,310	4.31e-03	1.01e-01
Fluoride	64	6.40e-05	1.49e-03
Benzene	2.3	2.30e-06	5.37e-05
Toluene	1.02	1.02e-06	2.38e-05
PAHs[b]	ND	ND	ND
Formaldehyde	2.6	2.60e-06	6.07e-05
Acetaldehyde	2.6	2.60e-06	6.07e-05

[a]Page 3-10.
[b]ND = not detected in three runs, no EF calculated. See page 3-8.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

EMISSION FACTORS- REBURN CONDITION

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor (lb/ton)[d]
Arsenic	8.0	8.00e-06	1.89e-04
Beryllium	0.8	8.00e-07	1.89e-05
Cadmium	0.4	4.00e-07	9.44e-06
Chromium	4.6	4.60e-06	1.09e-04
Manganese	15	1.50e-05	3.54e-04
Nickel	34	3.40e-05	8.03e-04
Lead	57	5.70e-05	1.35e-03
Selenium	150	1.50e-04	3.54e-03
Mercury	3.8	3.80e-06	8.97e-05
Chloride	6,000	6.00e-03	1.42e-01
Fluoride	89.9	8.99e-05	2.12e-03
Benzene	1.04	1.04e-06	2.46e-05
Toluene	0.70	7.00e-07	1.65e-05
PAHs[b]	ND	ND	ND
Formaldehyde[c]	2.6	2.60e-06	6.14e-05
Acetaldehyde[c]	2.6	2.60e-06	6.14e-05

[a]Page 3-9.
[b]ND = not detected in three runs, no EF calculated. See page 3-9.
[c]Emission factors based completely on detection limits.
[d]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 39 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 29 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: FIELD CHEMICAL EMISSIONS MONITORING PROJECT: SITE 115 EMISSIONS REPORT. RADIAN CORPORATION, AUSTIN, TEXAS. NOVEMBER, 1994.

FACILITY: EPRI SITE 115
FILENAME SITE115.tbl

PROCESS DATA		
Coal type[a]	Bituminous	
Boiler configuration[b]	Pulverized, Dry bottom	
Coal source[a]	Western	
SCC	10100202	
	PHASE I	PHASE II
Control device 1[c]	LNB/OFA	LNB/OFA
Control device 2[c]	Fabric Filter	SNCR
Control device 3[c]	none	Fabric Filter
Data Quality	B	(coal moisture percent not provided)
Process Parameters[a]	117 MW	
Test methods[d]	EPA, or EPA-approved, test methods	
Number of test runs[e]	2 for nickel during Phase I, 3 for all others	
	PHASE I	PHASE II
Coal HHV, dry (Btu/lb)[f]	12,565	12,638
Coal moisture %[g]	9.8%	9.8%
Coal HHV, as received (Btu/lb)	11,444	11,510
Coal HHV, as received (Btu/ton)	22,887,067	23,020,036
Coal HHV, as received (MMBtu/ton)	22.9	23.0

[a]Page 6.
[b]Page 6. Assumed dry bottom.
[c]Page 6. LNB= Low Nox Burners; OFA = Overfire Air; SNCR = Selective non-catalytic reduction.
[d]Appendix A, Table A-1.
[e]Page 26 for Phase I, page 35 for Phase II. Also, see footnote to nickel EF in Table 3-4.
[f]Page 20 for Phase I; Page 32 for Phase II.
[g]The test report does not provide a moisture content for the coal. EPRI Site 111 (Reference 19) also uses a "western bituminous" coal and the value used here is from that reference.

REFERENCE 39 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 29 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION

EMISSION FACTORS- PHASE I

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[d] (lb/ton)
Arsenic	0.75	7.50e-07	1.72e-05
Barium	1.1	1.10e-06	2.52e-05
Beryllium[c]	0.02	2.00e-08	4.58e-07
Cadmium	0.12	1.20e-07	2.75e-06
Chromium	0.66	6.60e-07	1.51e-05
Cobalt[c]	0.22	2.20e-07	5.04e-06
Copper	1.1	1.10e-06	2.52e-05
Lead	0.44	4.40e-07	1.01e-05
Manganese	1.0	1.00e-06	2.29e-05
Mercury[c]	0.35	3.50e-07	8.01e-06
Molybdenum	0.17	1.70e-07	3.89e-06
Nickel[b]	1.5	1.50e-06	3.43e-05
Phosphorus	6.7	6.70e-06	1.53e-04
Selenium	0.36	3.60e-07	8.24e-06
Vanadium	0.24	2.40e-07	5.49e-06
Chloride	630	6.30e-04	1.44e-02
Fluoride	4,300	4.30e-03	9.84e-02
Benzene	2.6	2.60e-06	5.95e-05
Toluene	105	1.05e-04	2.40e-03
Formaldehyde	16.5	1.65e-05	3.78e-04
Cyanide	8	8.00e-06	1.83e-04
Naphthalene	0.26	2.60e-07	5.95e-06

[a]page 28, 29. ND = not detected in 3 runs, no EF developed. See page 26 for run data.
[b]One run invalid, data from two runs used to develop EF.
[c]Emission factor is based only on detection limits.
[d]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

EMISSION FACTORS- PHASE II

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Arsenic	0.15	1.50e-07	3.45e-06
Barium	1.1	1.10e-06	2.53e-05
Beryllium[b]	0.02	2.00e-08	4.60e-07
Cadmium[b]	0.07	7.00e-08	1.61e-06
Chromium	0.30	3.00e-07	6.91e-06
Cobalt[b]	0.23	2.30e-07	5.29e-06
Copper	1.3	1.30e-06	2.99e-05
Lead	0.40	4.00e-07	9.21e-06
Manganese	0.89	8.90e-07	2.05e-05
Mercury	0.41	4.10e-07	9.44e-06
Molybdenum	0.27	2.70e-07	6.22e-06
Nickel	0.45	4.50e-07	1.04e-05
Phosphorus	4.6	4.60e-06	1.06e-04
Selenium[b]	0.06	6.00e-08	1.38e-06
Vanadium	0.29	2.90e-07	6.68e-06
Chloride	720	7.20e-04	1.66e-02
Fluoride	4,800	4.80e-03	1.10e-01
Cyanide	9	9.00e-06	2.07e-04

[a]Page 37.
[b]Emission factor is based only on detection limits.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 40 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 30 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: CHARACTERIZING TOXIC EMISSIONS FROM A COAL-FIRED POWER PLANT DEMONSTRATING THE AFGD ICCT PROJECT AND A PLANT UTILIZING A DRY SCRUBBER/BAGHOUSE SYSTEM. SPRINGERVILLE GENERATING STATION UNIT NO. 2. SOUTHERN RESEARCH INSTITUTE, BIRMINGHAM, AL. DECEMBER, 1993.

FACILITY: Springerville, Arizona
FILENAME DOE7.tbl

PROCESS DATA	
Coal type[a]	Subbituminous
Boiler configuration[b]	Pulverized, dry bottom, tangential
Coal source[a]	New Mexico
SCC	10100226
Control device 1[a]	Low Nox Burners- Overfire Air (LNB/OFA)
Control device 2[a]	Flue Gas Desulfurization- Spray Dryer (FGD-SD)
Control device 3[a]	Baghouse
Data Quality	A
Process Parameters[a]	422 MW
Test methods[c]	EPA, or EPA-approved, test methods
Number of test runs[d]	2 for selenium, cadmium and manganese, 3 for others.
Coal HHV, as received (Btu/lb)[e]	9,446
Coal HHV, as received (Btu/ton)	18,892,000
Coal HHV, as received (MMBtu/ton)	18.9

[a]Page 3-1.
[b]"Pulverized" from page 3-1, assumed dry bottom,
"Tangential" from Appendix B of EPRI Synthesis Report. Page B-7.
[c]Page 4-2.
[d]Pages 6-53, 6-54, and 6-55.
[e]Page 6-2, average for conveyor.

EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Antimony	0.041	4.10e-08	7.75e-07
Arsenic	0.15	1.50e-07	2.83e-06
Barium	14.1	1.41e-05	2.66e-04
Beryllium[b]	0.04	4.00e-08	7.56e-07
Boron	609	6.09e-04	1.15e-02
Cadmium	0.026	2.60e-08	4.91e-07
Chromium	0.10	1.00e-07	1.89e-06
Cobalt[b]	0.3	3.00e-07	5.67e-06
Copper	0.98	9.80e-07	1.85e-05
Lead	0.70	7.00e-07	1.32e-05
Manganese	11.36	1.14e-05	2.15e-04
Mercury	4.18	4.18e-06	7.90e-05
Molybdenum	1.4	1.40e-06	2.64e-05
Nickel[b]	0.3	3.00e-07	5.67e-06
Selenium[b]	0.038	3.80e-08	7.18e-07
Vanadium	1.0	1.00e-06	1.89e-05

[a]Page 1-11.
[b]Emission factor is based only on detection limits.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 41 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 31 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: A STUDY OF TOXIC EMISSIONS FROM A COAL-FIRED POWER PLANT- NILES STATION BOILER NO. 2. BATTELLE, COLUMBUS, OHIO. DECEMBER 29, 1993.

FACILITY: Niles, Ohio
FILENAME DOE2.tbl

PROCESS DATA	
Coal type[a]	Bituminous
Boiler configuration[a]	Cyclone
Coal source[a]	Ohio/W. Pa.
SCC	10100203
Control device 1[a]	ESP
Control device 2	None
Control device 3	None
Data Quality	A
Process Parameters[a]	108 MW
Test methods	Assumed EPA, or EPA-approved, test methods
Number of test runs[b]	3
Coal HHV, as received (Btu/lb)[c]	12,184
Coal HHV, as received (Btu/ton)	24,368,000
Coal HHV, as received (MMBtu/ton)	24.4

[a]Page 2-1.
[b]Pages 6-24, 6-26, 6-27, 6-28, 6-30, 6-32, 6-33, 6-35.
[c]Page 2-18. Average of 11964, 12504, 12397, 12139, 12031, and 12068 Btu/lb.

METALS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Aluminum	1114	1.11e-03	2.71e-02
Antimony[b]	0.18	1.80e-07	4.39e-06
Arsenic	42	4.20e-05	1.02e-03
Barium	5.4	5.40e-06	1.32e-04
Beryllium	0.19	1.90e-07	4.63e-06
Cadmium	0.07	7.00e-08	1.71e-06

METALS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Chromium	3.0	3.00e-06	7.31e-05
Cobalt[b]	0.06	6.00e-08	1.46e-06
Copper	4.0	4.00e-06	9.75e-05
Lead	1.6	1.60e-06	3.90e-05
Manganese	3.4	3.40e-06	8.29e-05
Mercury	14	1.40e-05	3.41e-04
Molybdenum	2.3	2.30e-06	5.60e-05
Nickel	0.55	5.50e-07	1.34e-05
Potassium	705	7.05e-04	1.72e-02
Selenium	62.0	6.20e-05	1.51e-03
Sodium	1767	1.77e-03	4.31e-02
Titanium	23	2.30e-05	5.60e-04
Vanadium	2.5	2.50e-06	6.09e-05

[a]Page 6-24, "Average" values.
[b]Pollutant was not detected in any of the sampling runs. EF is based on detection limits (1/2).
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

AMMONIA/CYANIDE EMISSION FACTORS

Pollutant	Emission Factor (lb/10^12 Btu)[a]	Emission Factor (lb/MMBtu)	Emission Factor (lb/ton)[c]
Ammonia[b]	70	7.00e-05	1.71e-03
Cyanide	180	1.80e-04	4.39e-03

[a]Page 6-26, Table 6-8, "Average" values.
[b]Detection limit values (1/2) for two runs used in developing EF.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

HCl, HFl EMISSION FACTORS

Pollutant	Emission Factor (lb/10^12 Btu)[a]	Emission Factor (lb/MMBtu)	Emission Factor (lb/ton)[b]
Hydrogen Chloride	132,049	1.32e-01	3.22e+00
Hydrogen Fluoride	8,921	8.92e-03	2.17e-01

[a]Page 6-27, Table 6-10, "Average" values.
[b]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 41 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 31 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

ORGANIC EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Chloromethane (Methyl Chloride)	4.9	4.90e-06	1.19e-04
Bromomethane (Methyl Bromide)[b]	3.2	3.20e-06	7.80e-05
Vinyl Chloride[b]	2.5	2.50e-06	6.09e-05
Chloroethane (Ethyl Chloride)[b]	2.5	2.50e-06	6.09e-05
Carbon Disulfide	5.9	5.90e-06	1.44e-04
1,1-Dichloroethane (Ethylidene Dichloride)[b]	2.5	2.50e-06	6.09e-05
Chloroform [b]	2.5	2.50e-06	6.09e-05
1,2-Dichloroethane (Ethylene Dichloride)[b]	2.5	2.50e-06	6.09e-05
2-Butanone (Methyl Ethyl Ketone)	5.1	5.10e-06	1.24e-04
1,1,1-Trichloroethane[b]	2.5	2.50e-06	6.09e-05
Carbon Tetrachloride[b]	2.5	2.50e-06	6.09e-05
Vinyl Acetate[b]	2.5	2.50e-06	6.09e-05
1,2-Dichloropropane (Propylene Dichloride)[b]	2.5	2.50e-06	6.09e-05
Trichloroethene[b]	2.5	2.50e-06	6.09e-05
1,1,2-Trichloroethane[b]	2.4	2.40e-06	5.85e-05
Benzene	7.9	7.90e-06	1.93e-04
1,3-Dichloropropylene[b]	2.5	2.50e-06	6.09e-05
Bromoform[b]	2.4	2.40e-06	5.85e-05
Tetrachloroethene	3.1	3.10e-06	7.55e-05
1,1,2,2-Tetrachloroethane[b]	2.5	2.50e-06	6.09e-05
Toluene	3.5	3.50e-06	8.53e-05
Chlorobenzene[b]	2.5	2.50e-06	6.09e-05
Ethylbenzene[b]	2.5	2.50e-06	6.09e-05
Styrene[b]	2.5	2.50e-06	6.09e-05
Xylenes[b]	2.5	2.50e-06	6.09e-05

[a]Page 6-28 (189 HAPs, only).
[b]Pollutant not detected in any sampling runs. EF is based on detection limits (1/2).
c Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

PAH/ORGANIC EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Benzyl chloride[b]	0.0059	5.90e-09	1.44e-07
Acetophenone	0.6360	6.36e-07	1.55e-05
Hexachloroethane[b]	0.0059	5.90e-09	1.44e-07
Naphthalene	0.2153	2.15e-07	5.25e-06
Hexachlorobutadiene[b]	0.0059	5.90e-09	1.44e-07
2-Chloroacetophenone	0.2879	2.88e-07	7.02e-06
Biphenyl	0.1257	1.26e-07	3.06e-06
Acenaphthylene	0.0068	6.80e-09	1.66e-07
Acenaphthene	0.0265	2.65e-08	6.46e-07
Dibenzofurans	0.0654	6.54e-08	1.59e-06
2,4-Dinitrotoluene	0.0197	1.97e-08	4.80e-07
Fluorene	0.0313	3.13e-08	7.63e-07
Hexachlorobenzene[b]	0.0059	5.90e-09	1.44e-07
Phenanthrene	0.0776	7.76e-08	1.89e-06
Anthracene	0.0207	2.07e-08	5.04e-07
Fluoranthene	0.0270	2.70e-08	6.58e-07
Pyrene	0.0139	1.39e-08	3.39e-07
Benz(a)anthracene	0.0037	3.70e-09	9.02e-08
Chrysene	0.0089	8.90e-09	2.17e-07
Benzo(b,k)fluoranthene	0.0070	7.00e-09	1.71e-07
Benzo(a)pyrene[b]	0.0012	1.20e-09	2.92e-08
Indeno(1,2,3-c,d)pyrene[b]	0.0012	1.20e-09	2.92e-08
Benzo(g,h,i)perylene[b]	0.0012	1.20e-09	2.92e-08

[a]Page 6-30 (most common PAHs, 189 HAPs).
[b]Pollutant not detected in any sampling runs. EF is based on detection limits (1/2).
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

DIOXINS/FURANS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
2,3,7,8-TCDD[b]	1.05e-06	1.05e-12	2.56e-11
OCDD	1.89e-05	1.89e-11	4.61e-10
2,3,7,8-TCDF	4.76e-06	4.76e-12	1.16e-10
OCDF	1.95e-05	1.95e-11	4.75e-10

[a]Page 6-32.
[b]Pollutant not detected in any sampling runs. EF is based on detection limits (1/2).
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

ALDEHYDES EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[b] (lb/ton)
Formaldehyde	3.9	3.90e-06	9.50e-05
Acetaldehyde	89	8.90e-05	2.17e-03
Acrolein	41	4.10e-05	9.99e-04
Propionaldehyde	25	2.50e-05	6.09e-04

[a]Page 6-33.
[b]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 42 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 32 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: A STUDY OF TOXIC EMISSIONS FROM A COAL-FIRED POWER PLANT UTILIZING AN ESP/WET FGD SYSTEM. BATTELLE, COLUMBUS, OHIO. DECEMBER 29, 1993.

FACILITY: Underwood, North Dakota
FILENAME DOE6.tbl

PROCESS DATA	
Coal type[a]	Lignite
Boiler configuration[a]	Pulverized, Dry bottom, tangential
Coal source[a]	North Dakota
SCC	10100302
Control device 1[a]	ESP
Control device 2[b]	Flue Gas Desulfurization- Wet Limestone Scrubber (FGD-WLS)
Control device 3	None
Data Quality	A
Process Parameters[c]	550 MW
Test methods[d]	Assumed EPA, or EPA-approved, test methods
Number of test runs[e]	2,3
Coal HHV, as received (Btu/lb)[f]	6,230
Coal HHV, as received (Btu/ton)	12,460,000
Coal HHV, as received (MMBtu/ton)	12.5

[a]Page 2-1.
[b]Pages 2-1, 2-4, and 2-5.
[c]Page 2-1. 2 identical units @ 1,100 MW- one unit = 550 MW.
[d]Page 3-26.
[e]See pages referenced below by groups of EFs.
[f]Page 2-33, average of "As received" values.

METALS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[d] (lb/ton)
Aluminum	578	5.78e-04	7.20e-03
Antimony	0.18	1.80e-07	2.24e-06
Arsenic	1.2	1.20e-06	1.50e-05
Barium	162	1.62e-04	2.02e-03
Beryllium[b]	0.85	8.50e-07	1.06e-05
Boron	19	1.90e-05	2.37e-04
Cadmium[b]	1.6	1.60e-06	1.99e-05
Calcium	1308	1.31e-03	1.63e-02
Chromium[c]	10.0	1.00e-05	1.25e-04
Cobalt	1.5	1.50e-06	1.87e-05
Copper	4.9	4.90e-06	6.11e-05
Lead	0.69	6.90e-07	8.60e-06
Manganese	30	3.00e-05	3.74e-04
Mercury	9.5	9.50e-06	1.18e-04
Molybdenum[c]	0.51	5.10e-07	6.35e-06
Nickel[c]	5.1	5.10e-06	6.35e-05
Potassium	109	1.09e-04	1.36e-03
Selenium	8.3	8.30e-06	1.03e-04
Sodium	218	2.18e-04	2.72e-03
Titanium	42	4.20e-05	5.23e-04
Vanadium	4.4	4.40e-06	5.48e-05

[a]Page 6-76, "Average" values.
[b]Pollutant was not detected in any of the sampling runs. EF is based on detection limits (1/2).
[c]Data from one run not used, EF based on data from two runs.
[d]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 42 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 32 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

AMMONIA/CYANIDE EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Ammonia[b]	1.9	1.90e-06	2.37e-05
Cyanide	51	5.10e-05	6.35e-04

[a]Page 6-78.
[b]Pollutant was not detected in any sampling runs. EF is based on detection limits (1/2).
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

HCl, HFl EMISSION FACTORS

Pollutant	Emission Factor (lb/10^12 Btu)[a]	Emission Factor (lb/MMBtu)	Emission Factor (lb/ton)[b]
Hydrogen Chloride	1,339	1.34e-03	1.67e-02
Hydrogen Fluoride	3,976	3.98e-03	4.95e-02

[a]Page 6-80.
[b]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

ORGANIC EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Chloromethane (Methyl Chloride)	106	1.06e-04	1.32e-03
Bromomethane (Methyl Bromide)	4.3	4.30e-06	5.36e-05
Vinyl Chloride[b]	3.2	3.20e-06	3.99e-05
Chloroethane (Ethyl Chloride)[b]	3.2	3.20e-06	3.99e-05
Carbon Disulfide	3.4	3.40e-06	4.24e-05
1,1-Dichloroethane (Ethylidene Dichloride)[b]	3.2	3.20e-06	3.99e-05
Chloroform [b]	3.2	3.20e-06	3.99e-05
1,2-Dichloroethane (Ethylene Dichloride)	3.2	3.20e-06	3.99e-05
2-Butanone (Methyl Ethyl Ketone)	9.8	9.80e-06	1.22e-04
1,1,1-Trichloroethane[b]	3.2	3.20e-06	3.99e-05
Carbon Tetrachloride[b]	3.2	3.20e-06	3.99e-05
Vinyl Acetate[b]	3.2	3.20e-06	3.99e-05

REFERENCE 42 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 32 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

ORGANIC EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
1,2-Dichloropropane (Propylene Dichloride)[b]	3.2	3.20e-06	3.99e-05
Trichloroethene[b]	3.2	3.20e-06	3.99e-05
1,1,2-Trichloroethane[b]	3.2	3.20e-06	3.99e-05
Benzene	41	4.10e-05	5.11e-04
1,3-Dichloropropylene[b]	3.2	3.20e-06	3.99e-05
Bromoform	3.1	3.10e-06	3.86e-05
Tetrachloroethene[b]	3.2	3.20e-06	3.99e-05
1,1,2,2-Tetrachloroethane[b]	3.2	3.20e-06	3.99e-05
Toluene	24	2.40e-05	2.99e-04
Chlorobenzene	3.3	3.30e-06	4.11e-05
Ethylbenzene[b]	3.2	3.20e-06	3.99e-05
Styrene	3.3	3.30e-06	4.11e-05
Xylenes	3.5	3.50e-06	4.36e-05

[a]Page 6-82 (only 189 HAPs).
[b]Pollutant was not detected in any sampling runs. EF is based on detection limits (1/2).
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

PAH/SVOC EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Naphthalene	0.2549	2.55e-07	3.18e-06
Acenaphthene	0.0173	1.73e-08	2.16e-07
Dibenzofurans	0.0516	5.16e-08	6.43e-07
2,4-Dinitrotoluene	0.0065	6.50e-09	8.10e-08
Fluorene	0.0415	4.15e-08	5.17e-07
Hexachlorobenzene[b]	0.0009	9.00e-10	1.12e-08
Phenanthrene	0.3142	3.14e-07	3.91e-06
Anthracene	0.0147	1.47e-08	1.83e-07
Fluoranthene	0.0422	4.22e-08	5.26e-07

PAH/SVOC EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Pyrene	0.0162	1.62e-08	2.02e-07
Benz(a)anthracene	0.0021	2.10e-09	2.62e-08
Chrysene	0.0053	5.30e-09	6.60e-08
Benzo(b,k)fluoranthene	0.0045	4.50e-09	5.61e-08
Benzo(a)pyrene	0.0009	9.00e-10	1.12e-08
Indeno(1,2,3-c,d)pyrene	0.0006	6.00e-10	7.48e-09
Benzo(g,h,i)perylene	0.0006	6.00e-10	7.48e-09
Biphenyl	0.0230	2.30e-08	2.87e-07
Acetophenone	0.5425	5.43e-07	6.76e-06
Acenaphthylene	0.0105	1.05e-08	1.31e-07
Benzyl Chloride	0.0057	5.70e-09	7.10e-08

[a]Page 6-84 (most common PAHs, 189 HAPs).
[b]Pollutant was not detected in any sampling runs. EF is based on detection limits (1/2).
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

DIOXINS/FURANS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor (lb/ton)[c]
2,3,7,8-TCDD[b]	9.90e-07	9.90e-13	1.23e-11
OCDD	1.51e-05	1.51e-11	1.88e-10
2,3,7,8-TCDF	9.89e-06	9.89e-12	1.23e-10
OCDF	6.29e-06	6.29e-12	7.84e-11

[a]Page 6-86.
[b]Pollutant was not detected in any sampling runs. EF is based on detection limits (1/2).
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 42 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 32 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

ALDEHYDES EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Formaldehyde[b]	1.8	1.80e-06	2.24e-05
Acetaldehyde	67	6.70e-05	8.35e-04
Acrolein	1.1	1.10e-06	1.37e-05
Propionaldehyde	12	1.20e-05	1.50e-04

[a]Page 6-88.
[b]Pollutant was not detected in any sampling runs. EF is based on detection limits (1/2).
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 43 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 33 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: TOXICS ASSESSMENT REPORT. ILLINOIS POWER COMPANY. BALDWIN POWER STATION-UNIT 2. VOLUMES I THROUGH IV. ROY F. WESTON, INC. DECEMBER, 1993

FACILITY: Baldwin, Illinois
FILENAME DOE3.tbl

PROCESS DATA

Coal type[a]	Bituminous
Boiler configuration[a]	Cyclone
Coal source[a]	Illinois
SCC	10100203
Control device 1[b]	ESP
Control device 2	None
Control device 3	None
Data Quality	A
Process Parameters[a]	568 MW
Test methods[c]	EPA, or EPA-approved, test methods
Number of test runs[d]	6 for filterable PM, 3 for other pollutants
Coal HHV, as received (Btu/lb)[e]	10,633
Coal HHV, as received (Btu/ton)	21,266,000
Coal HHV, as received (MMBtu/ton)	21.3

[a]Page 2-1.
[b]Page 2-4.
[c]Page 1-12.
[d]See pages referenced below by groups of EFs.
[e]Page 2-23. Average of 10765, 10681, 10722, 10412, 10426 and 10794 Btu/lb, as received, non-soot blowing periods.

METALS EMISSION FACTORS

Pollutant	Emission Factor (lb/10^12 Btu)[a]	Emission Factor (lb/MMBtu)	Emission Factor (lb/ton)[b]
Aluminum	5.55e+03	5.55e-03	1.18e-01
Antimony	1.52e+00	1.52e-06	3.23e-05
Arsenic	1.34e+01	1.34e-05	2.85e-04
Barium	5.32e+00	5.32e-06	1.13e-04
Beryllium	1.41e+00	1.41e-06	3.00e-05

REFERENCE 43 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 33 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

METALS EMISSION FACTORS

Pollutant	Emission Factor (lb/10^12 Btu)[a]	Emission Factor (lb/MMBtu)	Emission Factor (lb/ton)[b]
Boron	7.67e+03	7.67e-03	1.63e-01
Cadmium	3.02e+00	3.02e-06	6.42e-05
Calcium	3.25e+02	3.25e-04	6.91e-03
Chromium	5.06e+01	5.06e-05	1.08e-03
Cobalt	6.80e+00	6.80e-06	1.45e-04
Copper	1.89e+01	1.89e-05	4.02e-04
Iron	8.39e+03	8.39e-03	1.78e-01
Lead	2.86e+01	2.86e-05	6.08e-04
Magnesium	2.90e+02	2.90e-04	6.17e-03
Manganese	2.23e+01	2.23e-05	4.74e-04
Mercury	3.83e+00	3.83e-06	8.14e-05
Molybdenum	3.37e+01	3.37e-05	7.17e-04
Nickel	2.21e+01	2.21e-05	4.70e-04
Potassium	9.33e+02	9.33e-04	1.98e-02
Phosphorous	1.98e+02	1.98e-04	4.21e-03
Selenium	1.30e+02	1.30e-04	2.76e-03
Sodium	1.17e+03	1.17e-03	2.49e-02
Titanium	3.82e+02	3.82e-04	8.12e-03
Vanadium	1.00e+02	1.00e-04	2.13e-03

[a]Page 4-18, "Average" values.
[b]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 43 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 33 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

ORGANICS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Phenol	1.15e+00	1.15e-06	2.45e-05
Acetophenone	1.23e+00	1.23e-06	2.62e-05
Isophorone	2.62e+01	2.62e-05	5.57e-04
Biphenyl[b]	8.78e-01	8.78e-07	1.87e-05
Di-n-butylphthalate	3.00e+00	3.00e-06	6.38e-05
bis(2-Ethylhexyl)phthalate	4.60e+00	4.60e-06	9.78e-05

[a]Page 4-74.
[b]Emission factor based on only non-detects.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

PAH EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor [c] (lb/ton)
Naphthalene	3.94e-01	3.94e-07	8.38e-06
Acenaphthylene	3.19e-02	3.19e-08	6.78e-07
Acenaphthene[b]	6.32e-03	6.32e-09	1.34e-07
Fluorene	4.87e-03	4.87e-09	1.04e-07
Phenanthrene	5.69e-02	5.69e-08	1.21e-06
Anthracene	2.64e-03	2.64e-09	5.61e-08
Fluoranthene	1.74e-02	1.74e-08	3.70e-07
Pyrene	2.82e-03	2.82e-09	6.00e-08
Benz(a)anthracene[b]	1.17e-03	1.17e-09	2.49e-08
Benzo(b,k)fluoranthene	3.91e-03	3.91e-09	8.32e-08
Benzo(a)pyrene[b]	5.44e-04	5.44e-10	1.16e-08
Indeno(1,2,3-c,d)pyrene[b]	1.11e-03	1.11e-09	2.36e-08
Benzo(g,h,i)perylene[b]	1.13e-03	1.13e-09	2.40e-08

[a]Page 4-74.
[b]Pollutant not detected in any sampling runs. EF is based on detection limits.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

DIOXINS/FURANS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
2,3,7,8-TCDD[b]	2.54e-06	2.54e-12	5.40e-11
Total TCDD	1.34e-06	1.34e-12	2.85e-11
Total PeCDD[b]	7.37e-07	7.37e-13	1.57e-11
Total HxCDD	9.59e-07	9.59e-13	2.04e-11
Total HpCDD	2.53e-06	2.53e-12	5.38e-11
Total OCDD[b]	8.91e-06	8.91e-12	1.89e-10
2,3,7,8-TCDF[b]	1.27e-06	1.27e-12	2.70e-11
Total TCDF[b]	3.82e-06	3.82e-12	8.12e-11
Total PeCDF	3.99e-06	3.99e-12	8.49e-11
Total HxCDF	5.57e-06	5.57e-12	1.18e-10
Total HpCDF	3.17e-06	3.17e-12	6.74e-11
Total OCDF	4.15e-06	4.15e-12	8.83e-11

[a]Page 4-76.
[b]Pollutant not detected in any sampling runs.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

ALDEHYDES/KETONES EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Formaldehyde	1.68e+00	1.68e-06	3.57e-05
Acetaldehyde	1.37e+01	1.37e-05	2.91e-04
Acrolein	3.55e+00	3.55e-06	7.55e-05
Methyl Ethyl Ketone	3.70e+00	3.70e-06	7.87e-05

[a]Page 4-78, ESP Outlet data, only 189 HAPs.
[b]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

ORGANICS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Bromomethane (Methyl Bromide)	9.70e-01	9.70e-07	2.06e-05
Carbon Disulfide	1.37e-01	1.37e-07	2.91e-06
Methylene Chloride[b]	1.83e+01	1.83e-05	3.89e-04
Hexane	1.64e-01	1.64e-07	3.49e-06
Benzene	1.21e+02	1.21e-04	2.57e-03
Toluene[b]	2.00e+00	2.00e-06	4.25e-05
Ethylbenzene	1.26e-01	1.26e-07	2.68e-06
Xylenes(m/p + o)	1.87e+00	1.87e-06	3.97e-05
Styrene	1.99e-01	1.99e-07	4.23e-06

[a]Page 4-80.
[b]Results suspected to be biased by lab solvents, do not use.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 44 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 34 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: TOXICS ASSESSMENT REPORT. MINNESOTA POWER COMPANY BOSWELL ENERGY CENTER UNIT 2. COHASSET, MINNESOTA. VOLUME 1- MAIN REPORT. ROY F. WESTON, INC. WEST CHESTER, PENNSYLVANIA. DECEMBER, 1993.

FACILITY: Cohasset, Minnesota
FILENAME DOE8.tbl

PROCESS DATA			
Coal type[a]	Subbituminous		
Boiler configuration[b]	Pulverized, Dry bottom		
Coal source[a]	Montana/Wyoming		
SCC	10100222		
Control device 1[c]	Baghouse		
Control device 2	None		
Control device 3	None		
Data Quality	A		
Process Parameters[a]	69 MW		
Test methods[d]	EPA, or EPA-approved, test methods		
Number of test runs[e]	3		8,692
			8,749
Coal HHV, as received (Btu/lb)[f]	8,798		8,839
Coal HHV, as received (Btu/ton)	17,596,000		8,815
Coal HHV, as received (MMBtu/ton)	17.6		8,871
			8,820
			---------------------
		avg	8,798

[a]Page 2-1.
[b]Page 2-1 for "pulverized", assumed dry bottom.
[c]Page 2-4.
[d]Page 1-12.
[e]See pages listing emission factors.
[f]Page 2-23, average of 8692, 8749, 8839, 8815, 8871, 8820 Btu/lb.

METALS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Aluminum	1.93e+03	1.93e-03	3.40e-02
Antimony[b]	6.77e-01	6.77e-07	1.19e-05
Arsenic	3.24e-01	3.24e-07	5.70e-06
Barium	8.16e+01	8.16e-05	1.44e-03
Beryllium[b]	1.29e-01	1.29e-07	2.27e-06
Boron	6.09e+02	6.09e-04	1.07e-02
Cadmium[b]	6.48e-01	6.48e-07	1.14e-05
Calcium	4.76e+02	4.76e-04	8.38e-03
Chromium	2.04e+00	2.04e-06	3.59e-05
Cobalt	7.01e-01	7.01e-07	1.23e-05
Copper	2.40e+00	2.40e-06	4.22e-05
Iron	4.12e+02	4.12e-04	7.25e-03
Lead	2.44e+00	2.44e-06	4.29e-05
Magnesium	2.05e+02	2.05e-04	3.61e-03
Manganese	1.84e+01	1.84e-05	3.24e-04
Mercury	1.93e+00	1.93e-06	3.40e-05
Molybdenum	1.29e+00	1.29e-06	2.27e-05
Nickel	1.97e+00	1.97e-06	3.47e-05
Potassium	5.71e+01	5.71e-05	1.00e-03
Phosphorous	2.67e+01	2.67e-05	4.70e-04
Selenium	3.23e+00	3.23e-06	5.68e-05
Sodium	1.97e+02	1.97e-04	3.47e-03
Titanium	5.78e+01	5.78e-05	1.02e-03
Vanadium	1.53e+00	1.53e-06	2.69e-05

[a] Page 4-14, "Average" values.
[b] Pollutant not detected in any sampling runs. EF is based on detection limits.
[c] Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

ORGANICS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
n-Nitrosodimethylamine[b]	8.87e-01	8.87e-07	1.56e-05
Phenol	4.29e-01	4.29e-07	7.55e-06
Acetophenone	7.13e-01	7.13e-07	1.25e-05
Biphenyl[b]	1.78e-01	1.78e-07	3.13e-06
Di-n-butylphthalate[b]	1.94e+00	1.94e-06	3.41e-05
bis(2-Ethylhexyl)phthalate	1.68e+00	1.68e-06	2.96e-05

[a]Page 4-43.
[b]Pollutant not detected in any sampling runs. EF is based on detection limits.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

PAH EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Naphthalene	2.53e-01	2.53e-07	4.45e-06
Acenaphthylene	5.31e-03	5.31e-09	9.34e-08
Acenaphthene	4.08e-02	4.08e-08	7.18e-07
Fluorene	8.84e-03	8.84e-09	1.56e-07
Phenanthrene	2.10e-01	2.10e-07	3.70e-06
Anthracene	6.17e-03	6.17e-09	1.09e-07
Fluoranthene	8.25e-02	8.25e-08	1.45e-06
Pyrene	3.73e-02	3.73e-08	6.56e-07
Benz(a)anthracene	4.68e-03	4.68e-09	8.23e-08
Benzo(b,j,k)fluoranthene	3.05e-03	3.05e-09	5.37e-08
Benzo(a)pyrene	2.09e-04	2.09e-10	3.68e-09
Indeno(1,2,3-c,d)pyrene	3.45e-04	3.45e-10	6.07e-09
Benzo(g,h,i)perylene[b]	5.19e-04	5.19e-10	9.13e-09

[a]Page 4-43.
[b]Pollutant not detected in any sampling runs. EF is based on detection limits.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

DIOXINS/FURANS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
2,3,7,8-TCDD	8.14e-07	8.14e-13	1.43e-11
Total TCDD	9.29e-06	9.29e-12	1.63e-10
Total PeCDD	4.64e-06	4.64e-12	8.16e-11
Total HxCDD	2.10e-06	2.10e-12	3.70e-11
Total HpCDD[b]	1.86e-06	1.86e-12	3.27e-11
Total OCDD	1.10e-05	1.10e-11	1.94e-10
2,3,7,8-TCDF	6.03e-06	6.03e-12	1.06e-10
Total TCDF	6.04e-05	6.04e-11	1.06e-09
Total PeCDF	4.74e-05	4.74e-11	8.34e-10
Total HxCDF	2.23e-05	2.23e-11	3.92e-10
Total HpCDF	6.95e-06	6.95e-12	1.22e-10
Total OCDF	1.86e-06	1.86e-12	3.27e-11

[a]Page 4-45.
[b]Pollutant not detected in any sampling runs. EF is based on detection limits.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

ALDEHYDES/KETONES EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Formaldehyde[b]	1.70e+00	1.70e-06	2.99e-05
Acetaldehyde[b]	1.09e+00	1.09e-06	1.92e-05
Acrolein	3.40e+00	3.40e-06	5.98e-05
Methyl Ethyl Ketone[b]	4.99e+00	4.99e-06	8.78e-05

[a]Page 4-47, ESP Outlet data, only 189 HAPs.
[b]Pollutant not detected in any sampling runs. EF is based on detection limits.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

VOC EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Chloroethane (ethyl chloride)	2.50e+00	2.50e-06	4.40e-05
Carbon Disulfide	1.77e+01	1.77e-05	3.11e-04
Methylene Chloride	1.07e+01	1.07e-05	1.88e-04
Hexane	1.54e+00	1.54e-06	2.71e-05
Vinyl acetate[b]	4.29e-01	4.29e-07	7.55e-06
2-Butanone (Methyl Ethyl Ketone)	1.64e+01	1.64e-05	2.89e-04
Benzene	1.03e-02	1.03e-08	1.81e-07
Methyl Methacrylate	1.14e+00	1.14e-06	2.01e-05
Ethylene Dibromide[c]	6.56e-02	6.56e-08	1.15e-06
Toluene	5.45e+00	5.45e-06	9.59e-05
Tetrachloroethene (PCE)	5.61e-01	5.61e-07	9.87e-06
Chlorobenzene	1.63e-01	1.63e-07	2.87e-06
Ethylbenzene	4.27e-01	4.27e-07	7.51e-06
Xylenes(m/p + o)	2.43e+00	2.43e-06	4.27e-05
Styrene	1.75e+00	1.75e-06	3.08e-05
Cumene	3.02e-01	3.02e-07	5.31e-06

[a]Page 4-49.
[b]Pollutant not detected in any sampling runs. EF is based on detection limits.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 45 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 35 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: ASSESSMENT OF TOXIC EMISSIONS FROM A COAL FIRED POWER PLANT UTILIZING AN ESP. FINAL REPORT-REVISION 1. ENERGY AND ENVIRONMENTAL RESEARCH CORPORATION. IRVINE, CALIFORNIA. DECEMBER 23, 1993.

FACILITY: Brilliant, Ohio, Cardinal Unit 1
FILENAME DOE5.tbl

PROCESS DATA	
Coal type[a]	Bituminous
Boiler configuration[b]	Pulverized, Dry bottom
Coal source[a]	Pennsylvania
SCC	10100202
Control device 1[a]	ESP
Control device 2	None
Control device 3	None
Data Quality	C (no HHV for the coal, had to use average from AP-42)
Process Parameters[a]	615
Test methods[c]	EPA, or EPA-approved, test methods
Number of test runs[d]	3
Coal HHV (Btu/lb)[e]	13,000
Coal HHV (Btu/ton)	26,000,000
Coal HHV (MMBtu/ton)	26.0

[a]Page 1-1.
[b]Page 1-1 for "pulverized", assumed dry bottom.
[c]Page 1-4.
[d]Page 1-5.
[e]Appendix A of AP-42, "Typical Parameters of Various Fuels".

METALS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[b] (lb/ton)
Aluminum	235	2.35e-04	6.11e-03
Calcium	283	2.83e-04	7.36e-03
Iron	568	5.68e-04	1.48e-02
Magnesium	16.4	1.64e-05	4.26e-04

METALS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[b] (lb/ton)
Phosphorous	141	1.41e-04	3.67e-03
Potassium	88.7	8.87e-05	2.31e-03
Silicon	60.9	6.09e-05	1.58e-03
Sodium	249	2.49e-04	6.47e-03
Titanium	16.6	1.66e-05	4.32e-04
Zinc	18.3	1.83e-05	4.76e-04
Antimony	2.36	2.36e-06	6.14e-05
Arsenic	3.49	3.49e-06	9.07e-05
Barium	0.872	8.72e-07	2.27e-05
Beryllium	0.070	7.00e-08	1.82e-06
Boron	1,912	1.91e-03	4.97e-02
Cadmium	0.846	8.46e-07	2.20e-05
Chromium	7.51	7.51e-06	1.95e-04
Cobalt	0.631	6.31e-07	1.64e-05
Copper	1.39	1.39e-06	3.61e-05
Lead	3.83	3.83e-06	9.96e-05
Manganese	15.0	1.50e-05	3.90e-04
Mercury	0.448	4.48e-07	1.16e-05
Molybdenum	0.567	5.67e-07	1.47e-05
Nickel	4.72	4.72e-06	1.23e-04
Selenium	92.8	9.28e-05	2.41e-03
Silver	0.200	2.00e-07	5.20e-06
Vanadium	1.57	1.57e-06	4.08e-05

[a]Page 1-11.
[b]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

DIOXINS/FURANS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[b] (lb/ton)
Total TCDD	5.15e-05	5.15e-11	1.34e-09
Total HxCDD	2.23e-05	2.23e-11	5.80e-10
Total HpCDD	7.61e-06	7.61e-12	1.98e-10
Total OCDD	2.03e-05	2.03e-11	5.28e-10
2,3,7,8-TCDF	6.58e-07	6.58e-13	1.71e-11
Total PeCDF	2.79e-06	2.79e-12	7.25e-11
Total HxCDF	2.51e-05	2.51e-11	6.53e-10
Total HpCDF	2.68e-06	2.68e-12	6.97e-11
Total OCDF	1.07e-05	1.07e-11	2.78e-10

[a]Page 1-11.
[b]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

SEMIVOLATILE ORGANICS EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[b] (lb/ton)
Benzyl Chloride	53.9	5.39e-05	1.40e-03
Isophorone	23.3	2.33e-05	6.06e-04
Dimethyl Sulfate	1.83	1.83e-06	4.76e-05
Naphthalene	1.94	1.94e-06	5.04e-05

[a]Page 1-11.
[b]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

ORGANIC EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[b] (lb/ton)
2-Butanone (Methyl Ethyl Ketone)	48.1	4.81e-05	1.25e-03
Formaldehyde	60.0	6.00e-05	1.56e-03
Benzene	3.40	3.40e-06	8.84e-05
Bromomethane (Methyl Bromide)	15.1	1.51e-05	3.93e-04
Chloroform	2.92	2.92e-06	7.59e-05
Chloromethane (Methyl Chloride)	6.38	6.38e-06	1.66e-04

REFERENCE 45 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 35 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

ORGANIC EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[b] (lb/ton)
Hexane	6.53	6.53e-06	1.70e-04
m,p-Xylene	2.98	2.98e-06	7.75e-05
Methyl Hydrazine	6.57	6.57e-06	1.71e-04
Methyl Tert Butyl Ether	1.36	1.36e-06	3.54e-05
Toluene	5.16	5.16e-06	1.34e-04

[a]Page 1-13.
[b]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

OTHER EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[b] (lb/ton)
Ammonia	40.7	4.07e-05	1.06e-03
Chlorine	1,547	1.55e-03	4.02e-02
Hydrogen Chloride	22,915	2.29e-02	5.96e-01
Hydrogen Cyanide	0.591	5.91e-07	1.54e-05
Hydrogen Fluoride	1,869	1.87e-03	4.86e-02
CO	753	7.53e-04	1.96e-02
THC	365	3.65e-04	9.49e-03
NOX		1.22e+00	3.17e+01
SOX		4.41e+00	1.15e+02

[a]Page 1-14. Note that SOx and NOx units are lb/MMBtu.
[b]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 46 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 36 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: 500-MW DEMONSTRATION OF ADVANCED WALL-FIRED COMBUSTION TECHNIQUES FOR THE REDUCTION OF NITROGEN OXIDE (NOX) EMISSIONS FROM COAL-FIRED BOILERS. RADIAN, CORPORATION, AUSTIN, TEXAS.

FACILITY: EPRI SITE 16
FILENAME SITE16.tbl

PROCESS DATA	
Coal type[a]	Bituminous
Boiler configuration[b]	Pulverized, dry bottom
Coal source[f]	Virginia/Kentucky
SCC	10100202
Control device 1[a]	Low Nox Burners/Overfire Air (LNB/OFA)
Control device 2[a]	ESP
Control device 3	none
Data Quality	A
Process Parameters[a]	500 MW
Test methods[c]	EPA, or EPA-approved, test methods
Number of test runs[d]	3
Coal HHV, dry (Btu/lb)[e]	13,800
Coal moisture percent by weight[e]	3.8%
Coal HHV, as received (Btu/lb)	13,295
Coal HHV, as received (MMBtu/lb)	0.013
Coal HHV, as received (MMBtu/ton)	26.59
Coal feed rate (lb/hr,dry)[e]	315,000
Coal feed rate, as received, (lb/hr)	327,443
Coal feed rate, as received, (ton/hr)	164

[a]Page 2-1
[b]Conversation with Greg Behrens, Radian, Austin, Texas.
[c]Page 3-1
[d]Page 3-21, 3-22, 3-23
[e]Page 3-7
[f]Appendix B of EPRI Synthesis Report, page B-2

STACK EMISSION FACTORS

Pollutant	(lb/10^12 Btu)[a]	(lb/MMBtu)	(lb/ton)
Arsenic	110	1.10e-04	2.92e-03
Barium	140	1.40e-04	3.72e-03
Beryllium	3.1	3.10e-06	8.24e-05
Cadmium	3.6	3.60e-06	9.57e-05
Chloride	15,000	1.50e-02	3.99e-01
Chromium	21	2.10e-05	5.58e-04
Chrome VI	5.4	5.40e-06	1.44e-04
Cobalt	6.5	6.50e-06	1.73e-04
Copper	30	3.00e-05	7.98e-04
Fluoride	5,100	5.10e-03	1.36e-01
Lead	11	1.10e-05	2.92e-04
Manganese	21	2.10e-05	5.58e-04
Mercury	4.8	4.80e-06	1.28e-04
Molybdenum	12	1.20e-05	3.19e-04
Nickel	17	1.70e-05	4.52e-04
Phosphorous	180	1.80e-04	4.79e-03
Selenium	140	1.40e-04	3.72e-03
Vanadium	41	4.10e-05	1.09e-03
Benzene[c]	0.51	5.10e-07	1.36e-05
Toluene	0.7	7.00e-07	1.86e-05
Formaldehyde	1.3	1.30e-06	3.46e-05
Acenaphthene	0.0081	8.10e-09	2.15e-07
Acenaphthylene	0.0030	3.00e-09	7.98e-08
Anthracene	0.0037	3.70e-09	9.84e-08
Benzo(a)pyrene[c]	0.0041	4.10e-09	1.09e-07
Benzo(b,j,k)fluoranthenes	0.0015	1.50e-09	3.99e-08
Benzo(g,h,i)perylene[c]	0.0031	3.10e-09	8.24e-08
Benz(a)anthracene	0.0070	7.00e-09	1.86e-07
Chrysene	0.0018	1.80e-09	4.79e-08

STACK EMISSION FACTORS			
Pollutant	(lb/10^12 Btu)[a]	(lb/MMBtu)	(lb/ton)
Fluoranthene	0.010	1.00e-08	2.66e-07
Fluorene	0.0099	9.90e-09	2.63e-07
Indeno(1,2,3-c,d)pyrene[b]	0.0027	2.70e-09	7.18e-08
Phenanthrene	0.044	4.40e-08	1.17e-06
Pyrene	0.011	1.10e-08	2.92e-07

[a]Pages 3-24, 3-25. Individual run data on pages 3-21, 3-22, 3-23.

REFERENCE 47 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 37 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TEST REPORT TITLE: FIELD CHEMICAL EMISSIONS MONITORING REPORT: SITE 122. SOUTHERN RESEARCH INSTITUTE, BIRMINGHAM, ALABAMA. MAY, 1995.

FACILITY: EPRI SITE 122
FILENAME SITE122.tbl

PROCESS DATA	
Coal type[a]	Bituminous
Boiler configuration[a]	Cyclone
Coal source[a]	Illinois
SCC	10100203
Control device 1[a]	Electrostatic Precipitator, Cold side
Control device 2[a]	none
Control device 3[a]	none
Data Quality	A
Process Parameters[a]	275 MW
Test methods[b]	EPA, or EPA-approved, test methods
Number of test runs[c]	2 for manganese, 3 for all others
Coal HHV, as fired (Btu/lb)[d]	12,327
Coal HHV, as fired (Btu/ton)	24,654,000
Coal HHV, as fired (MMBtu/ton)	24.7

[a]Page 2-1.
[b]Page 1-3.
[c]Pages 3-17, 3-20 and 3-22.
[d]Page 3-4.

METALS, NONMETALS AND ORGANIC EMISSION FACTORS

Pollutant	Emission Factor[a] (lb/10^12 Btu)	Emission Factor (lb/MMBtu)	Emission Factor[c] (lb/ton)
Arsenic	220	2.20e-04	5.42e-03
Barium	69	6.90e-05	1.70e-03
Beryllium	4.0	4.00e-06	9.86e-05
Cadmium	3.6	3.60e-06	8.88e-05
Chromium	100	1.00e-04	2.47e-03
Cobalt	26	2.60e-05	6.41e-04
Lead	180	1.80e-04	4.44e-03
Manganese[b]	205	2.05e-04	5.05e-03
Mercury	8.2	8.20e-06	2.02e-04
Nickel	71	7.10e-05	1.75e-03
Selenium	67	6.70e-05	1.65e-03
Vanadium	148	1.48e-04	3.65e-03
Fluorine	3.8e+03	3.80e-03	9.37e-02
Chlorine	2.3e+05	2.30e-01	5.67e+00
Sulfur (sulfur dioxide)	1.5e+06	1.50e+00	3.70e+01
Formaldehyde	0.7	7.00e-07	1.73e-05
Benzene	7.8	7.80e-06	1.92e-04
Toluene	1.9	1.90e-06	4.68e-05

[a]Page 3-30.
[b]EF developed from two sampling runs. See footnote c to Table 3.10, page 3-17.
[c]Multiply emission factor, lb/MMBtu, by coal HHV, MMBtu/ton.

REFERENCE 48 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 38 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

TITLE: Hydrogen Chloride and Hydrogen Fluoride Emission Factors for the NAPAP Emission Inventory. EPA-600/7-85-041. October, 1985.

Filename: NAPAP.tbl

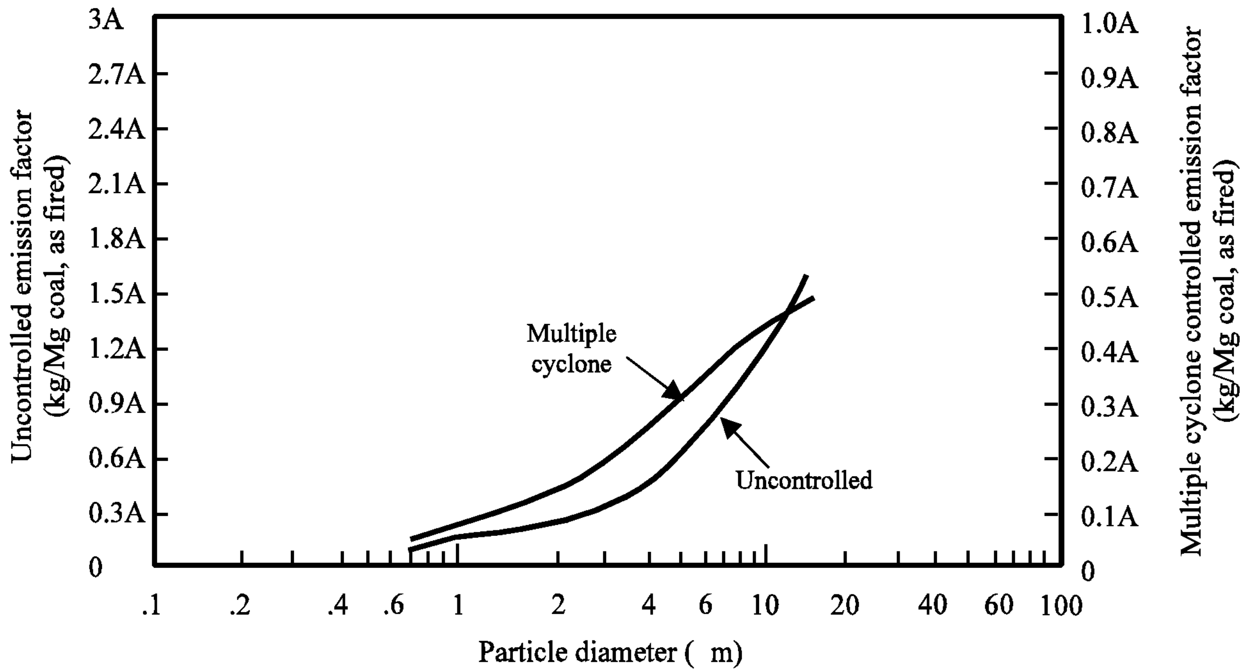
BOILER SCC DESCRIPTIONS	Source Classification Codes		Hydrogen Chloride (lb/ton)[a,b]		Hydrogen Fluoride (lb/ton)[a,b]
Commercial/Industrial Boilers					
Bituminous and Subbituminous Coal					
Firing Types					
Pulverized Coal Wet Bottom	1-03-002-05/21	*	1.48	*	0.17
Pulverized Coal Dry Bottom	1-03-002-06/22				
Overfeed Stoker	1-03-002-07				
Underfeed Stoker	1-03-002-08				
Spreader Stoker	1-03-002-09/24				
Hand-fired	1-03-002-14				
Pulverized Coal Dry Bottom Tangential	1-03-002-16/26				
Atmospheric Fluidized Bed Combustor	1-03-002-17/18				
Cyclone Furnace	1-03-002-23				
Traveling Grate Overfeed Stoker	1-03-002-25				
Electric Generation & Industrial Boilers					
Bituminous and Subbituminous Coal					
Firing Types					
Pulverized Coal Wet Bottom	1-01-002-01/21	*	1.9	*	0.23
	1-02-002-01/21				
Pulverized Coal Dry Bottom	1-01-002-02/22				
	1-02-002-02/22				
Cyclone Furnace	1-01-002-03/23				
	1-02-002-03/23				
Spreader Stoker	1-01-002-04/24				
	1-02-002-04/24				

BOILER SCC DESCRIPTIONS	Source Classification Codes	Hydrogen Chloride (lb/ton)[a,b]	Hydrogen Fluoride (lb/ton)[a,b]
Traveling Grate Overfeed Stoker	1-01-002-05/25		
	1-02-002-25		
Overfeed Stoker	1-02-002-05		
Pulverized Coal Dry Bottom,	1-01-002-12/26		
Tangential Firing	1-02-002-12		
Atmospheric Fluidized Bed	1-01-002-17		
	1-01-002-18		
	1-02-002-17		
	1-02-002-18		
Underfeed Stoker	1-02-002-06		
Commercial/Industrial Boilers			
Lignite			
Firing Types			
Pulverized Coal	1-03-003-05	* 0.351	* 0.063
Pulverized Coal Tangential Firing	1-03-003-06		
Traveling Grate Overfeed Stoker	1-03-003-07		
Spreader Stoker	1-03-003-09		
Electric Generation & Industrial Boilers			
Lignite			
Firing Types			
Pulverized Coal	1-01-003-01	0.01	0.01
	1-02-003-01		
Pulverized Coal Tangential Firing	1-01-003-02		
	1-02-003-02		
Cyclone Furnace	1-01-003-03		
	1-02-003-03		

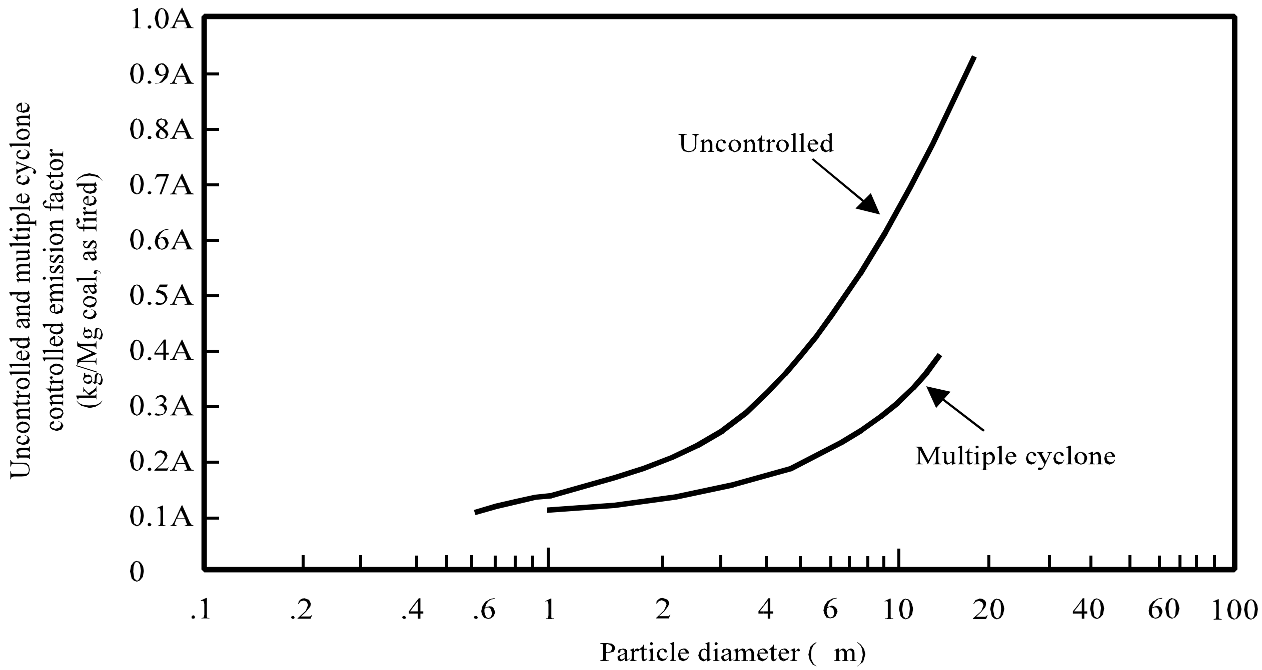
REFERENCE 48 OF AP-42 SECTION 1.1 BACKGROUND DOCUMENTATION
REFERENCE 38 OF AP-42 SECTION 1.7 BACKGROUND DOCUMENTATION

BOILER SCC DESCRIPTIONS	Source Classification Codes	Hydrogen Chloride (lb/ton)[a,b]	Hydrogen Fluoride (lb/ton)[a,b]
Traveling Grate Overfeed Stoker	1-01-003-04		
	1-02-003-04		
Spreader Stoker	1-01-003-06		
	1-02-003-06		
	Overall Average	1.2	0.15
	Quality Rating	B	B

[a]Pages 29, 30, 31. Factors are for both uncontrolled and controlled boilers.
[b]An asterisk to the left of a factor indicates that it was used in calculating the overall emission factor.



Uncontrolled emission factor
(kg/Mg coal, as fired)
3A
2.7A
2.4A
2.1A
1.8A
1.5A
1.2A
0.9A
0.6A
0.3A
0
Multiple
cyclone
Uncontrolled
.1
.2
.4
.6
1
2
4
6
10
20
40
60
100
Particle diameter (m)
1.0A
0.9A
0.8A
0.7A
0.6A
0.5A
0.4A
0.3A
0.2A
0.1A
0
Multiple cyclone controlled emission factor
(kg/Mg coal, as fired)



Uncontrolled and multiple cyclone controlled emission factor (kg/Mg coal, as fired)
1.0A
0.9A
0.8A
0.7A
0.6A
0.5A
0.4A
0.3A
0.2A
0.1A
0
Uncontrolled
Multiple cyclone
.1
.2
.4
.6
1
2
4
6
10
20
40
60
100
Particle diameter (m)