BACKGROUND REPORT

AP-42 SECTION 12.2

COKE PRODUCTION

Prepared for

U.S. Environmental Protection Agency
OAQPS/TSD/EIB
Research Triangle Park, NC 27711

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Pacific Environmental Services, Inc.
5001 South Miami Boulevard, Suite 300
Post Office Box 12077
Research Triangle Park, NC 27709
919/941-0333

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AP-42 Background Report

TECHNICAL SUPPORT DIVISION

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards

Research Triangle Park, NC 27711

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1.0 INTRODUCTION

The document "Compilation of Air Pollutant Emission Factors" (AP-42) has been published by the U.S. Environmental Protection Agency (EPA) since 1972. Supplements to AP-42 have been routinely published to add new emission source categories and to update existing emission factors. AP-42 is routinely updated by the EPA to respond to new emission factor needs of the EPA, state and local air pollution control programs, and industry.

An emission factor relates the quantity (weight) of pollutants emitted to a unit of activity of the source. The uses for the emission factors reported in AP-42 include:

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

The purpose of this report is to provide background information obtained from test reports and the results of a literature search to support revision of the AP-42 section for metallurgical coke production.

Including the introduction (Chapter 1.0), this report contains four chapters. Chapter 2.0 provides statistics regarding the production of coke as a by-product of the iron and steel industry, as well as descriptions of the different manufacturing processes, emissions from these processes, and the techniques used to control these emissions.

Chapter 3.0 is a review of emissions data collection and analysis procedures. It describes the literature search conducted during this update of AP-42 Section 12.2, the screening of emission data, and the quality rating system for both emission data and emission factors. Chapter 4.0 details criteria and noncriteria pollutant emission factor development. It includes the review of specific data sets and the results of data analyses. Particle size determination and particle size data analysis methodology are also described.

2.0 INDUSTRY DESCRIPTION

2.1 General

Coke is a residue of impure carbon which is obtained through the heating of coal in the absence of air. This process is known as destructive distillation, or carbonization, of coal. Metallurgical coke is one of the raw materials used in blast furnaces in the iron and steel industry, along with iron oxides, limestone, and air, and serves as a reducing agent. Over 90 percent of the total metallurgical coke production is dedicated to blast furnace operations, but coke also serves as a reducing agent in sinter plants and iron and steel foundries. Coke intended for use in operations other than blast furnaces is known as foundry coke; this coke typically undergoes a longer carbonization period than furnace coke and is derived from raw materials with lower volatile matter content.

Although coals suitable for coke manufacture are plentiful in the U.S., domestic coke production is decreasing. This trend is attributable primarily to a reduced requirement for coke per ton of pig iron produced in blast furnaces and the fact that less steel is being produced.

Research that is being funded primarily by the U.S. Department of Energy is currently underway to develop direct steelmaking technology that would not require the use of coke as a raw material. This technology is expected to involve the feeding of carbon-containing iron oxides into the top of a reactor, and the feeding of combustion oxygen into the bottom, to refine the charge directly into crude liquid steel. This process would eliminate air pollution from the manufacture of metallurgical coke, as well as reducing emissions from steelmaking.

Coke production is closely linked with the iron and steel industry. Some domestic coke plants are co-located with these facilities. Tables 2.1-1 and 2.1-2 list the operator, type, number of ovens, and approximate capacity of each furnace and foundry coke oven battery in the U.S. in 1992, respectively.

Table 2.1-1
Furnace Coke Byproduct Recovery Plants: Coke Oven Battery Capacity[a]

Operator/Location	Type[b]	Battery No.	Battery Capacity	No. of Ovens
Acme Steel, Chicago, IL	GW	1	291	50
	GW	2	291	50
Armco Inc., Middletown, OH	CS	1	544	57
	CS	2	544	57
	W	4	343	76
Armco Inc., Ashland, KY	W	3	430	76
	W	4	631	70
Bethlehem Steel, Bethlehem, PA	O	A	808	80
	KB	2A	728	102
	KB	5	380	80
Bethlehem Steel, Burns Harbor, IN	O	1	880	82
	K	2	880	82
Bethlehem Steel, Lackawanna, NY	W	7	397	76
	W	8	397	76
Geneva Steel, Provo, UT	KB-u	1	290	63
	KB-u	2	290	63
	KB-u	3	290	63
	KB-u	4	290	63
Gulf States Steel, Gasden, AL	W	2	379	65
	W	3	379	65
LTV Steel, Warren, OH	K	4	540	85
LTV Steel, Cleveland, OH	KB	6	366	63
	KB	7	366	63
LTV Steel, So. Chicago, IL	O	2	596	60
LTV Steel, Pittsburg, PA	W	P1	340	59
	W	P2	340	59
	W	P3N	340	59
	W	P3S	340	59
	KB-u	P4	432	79
National Steel, Granite City, IL	O	A	314	45
	O	B	314	45
National Steel, Ecorse, MI	GW	4	345	78

Table 2.1-1
(Concluded)

Operator/Location	Type[b]	Battery No.	Battery Capacity	No. of Ovens
New Boston, Portsmouth, OH	K	1	364	70
Sharon Steel, Monessen, PA		1B	195	37
		2	100	19
U.S. Steel, Clairton, PA	W	1	285	64
	W	2	285	64
	W	3	285	64
	K	7	285	64
	K	8	285	64
	K	9	285	64
	CS	13	299	61
	CS	14	299	61
	CS	15	299	61
	KB-u	19	500	87
	KB-u	20	500	87
	CS	B	838	75
U.S. Steel, Gary, IN	CS	2	750	57
	CS	3	750	57
	CS	5	265	77
	CS	7	265	77
Wheeling-Pitt, E. Steubenville, WV	K	1	199	47
	K	2	199	47
	K	3	215	51
	KB-u	8	896	79

[a] References 1,2. Capacities in thousands of megagrams per year.

[b] Type refers to manufacturer:
GW = Gibbons-Wilputte
CS = Carl Still
W = Wilputte
O = Otto
KB = Koppers-Becker
KBu = Koppers-Becker underfired
K = Koppers

Table 2.1-2
Foundry Coke Byproduct Recovery Plants: Coke Oven Battery Capacity[a]

Operator/Location	Type[b]	Battery No.	Battery Capacity	No. of Ovens
ABC Coke, Tarrant, AL	W	A	353	78
	KB	5	113	25
	KB	6	117	29
Citizens Gas, Indianapolis, IN	W	E	93	47
	K	H	79	41
	CS	I	305	72
Empire Coke, Holt, AL	SS	1	107	20
	SS	2	54	40
Erie Coke, Erie, PA	K	A	82	23
	K	B	125	35
Koppers, Woodward, AL	K	1	252	60
	K	2A	161	38
	K	2B	128	40
	K	4	97	58
	K	5	55	30
Shenango, Pittsburgh, PA	KB	1	322	56
	KB-U	4	199	35
Sloss Industries, Birmingham, AL	K	3	100	30
	K	4	100	30
	K	5	197	60
Toledo Coke, Toledo, OH	W	C	157	57
Tonawanda, Buffalo, NY	W	1	299	60

[a] References 1,2. Capacities in thousands of megagrams per year.

[b] Type refers to manufacturer:
W = Wilputte
KB = Koppers-Becker
K = Koppers
CS = Carl Still
SS = Senet-Solvay
Kbu = Koppers-Becker underfired

2.2 Process Description

Most metallurgical coke is produced using the "byproduct" method, utilizing destructive distillation of coal in the absence of air. Ovens in which this process occurs must remain airtight under the cyclic stress of expansion and contraction. Each oven has three main parts: coking chambers, heating chambers, and regenerative chambers. All of the chambers are lined with silica refractory brick. The coking chamber has ports in the top for charging of the coal.

A coke oven battery is a series of 10 to 100 coke ovens operated together. Figure 2.1-1 illustrates a byproduct coke oven battery.

Each oven holds between 14 and 23 megagrams (15 and 25 tons) of coal. Offtake flues remove gases evolved from the destructive distillation process. Process heat comes from the combustion of gases between or beneath the coke chambers. Individual coke ovens operate intermittently, with run times of each oven coordinated to insure a consistent flow of collectible gas. Approximately 40 percent of cleaned oven gas (after the removal of economically valuable byproducts) is used to heat the coke ovens, with the remainder used in other operations related to steel production.

A schematic illustration of a typical byproduct coke manufacturing process is presented in Figure 2.1-2 . Coke manufacturing includes preparing, possibly preheating the coal, and charging; removing and cooling the coke product; and cooling, cleaning, and recycling the oven gas.

Coal is prepared for coking by pulverizing it so that 80 to 90 percent of the coal passes through a 3.2 mm (1/8 inch) screen. Several types of coal are blended to produce the desired properties, and to control the expansion of the coal mixture in the coke oven. Water or oil are sometimes added to the coal mixture to adjust the density, to control expansion, and to prevent damage to the oven.

Coke ovens may be charged with coal in either a dry or wet state. Flash-dried coal is transported directly to the ovens by steam in the pipeline used to charge coke ovens, by a Larry car that has a nitrogen blanket, or a Reddler conveyor system. A few domestic plants preheat the coal to about 260°C (500°F) before charging, using a flash drying column heated by the combustion of coke oven gas or natural gas. Prepared wet coal is finely crushed before charging to the oven. During charging of coke ovens, wall temperatures stay above 1100°C (2000°F).

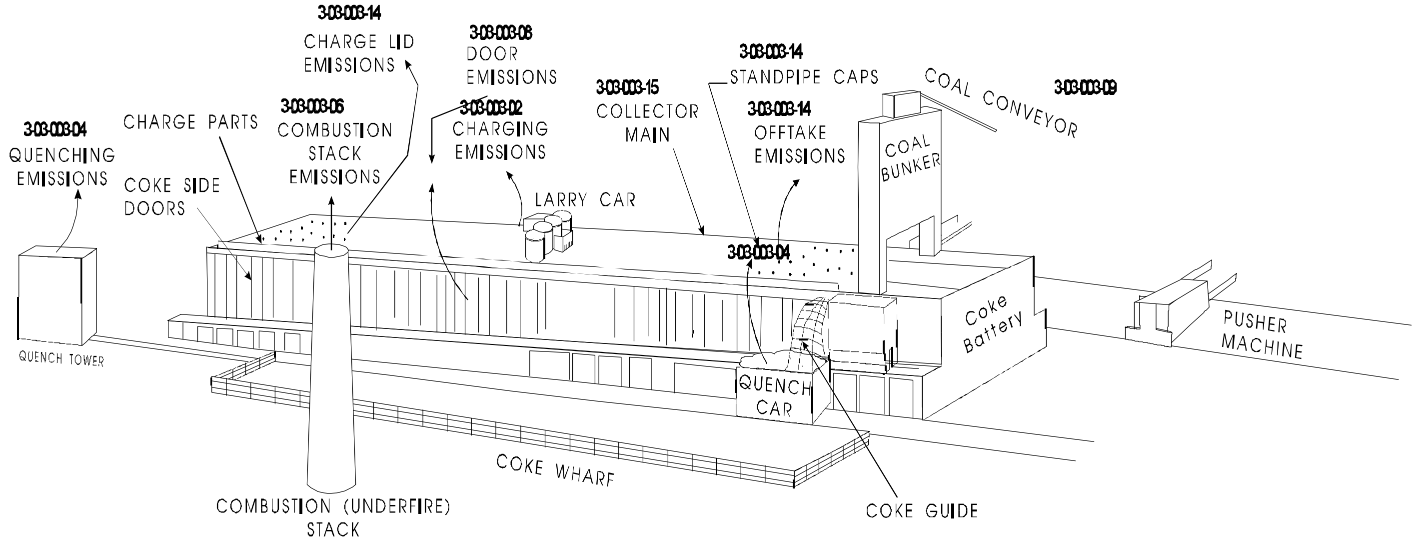

Figure 2.2-1 Byproduct coke oven battery showing major emission points

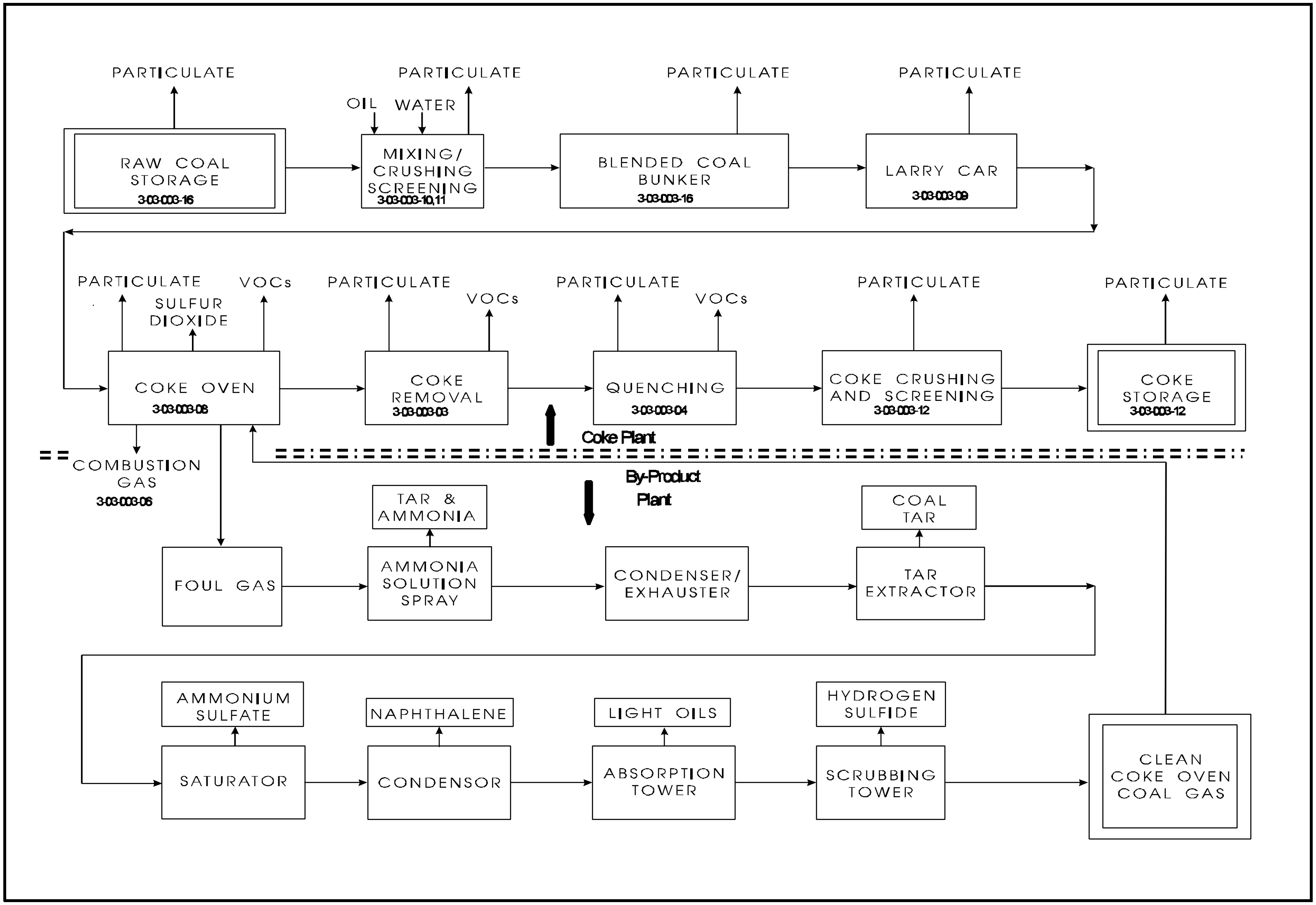

Figure 2.2-2 Process flow schematic for coke manufacturing

The blended coal mass is heated for 12 to 20 hours for metallurgical coke. Thermal energy from the walls of the coke chamber heats the coal mass by conduction from the sides to the middle of the coke chamber. During the coking process, the charge is in direct contact with the heated wall surfaces and develops into an aggregate "plastic zone." As thermal energy is absorbed, the plastic zone thickens and merges toward the middle of the charge. Volatile gases escape in front of the developing zone due to heat progression from the side walls. The maximum temperature attained at the center of the coke mass is usually 1100 to 1150°C (2000 to 2100°F). This evaporates all volatile matter from the coal mass and forms a high quality metallurgical coke.

After coking process is completed, the coke in the chamber is removed. Doors on both sides of the coking chamber are opened and a rail mounted ram is inserted into the chamber from one side. The coke is pushed out of the opposite side of the oven in less than one minute. It passes through the coke guide and into a quench car. After the coke chamber is emptied, the doors are cleaned and repositioned. The oven is then ready to receive another charge of coal.

The quench car carries the hot coke on the battery tracks to a quench tower where approximately 1100 liters of water per megagram of coke (270 gallons of water per ton) are sprayed onto the coke mass to cool it from about 1100 to 80°C (2000 to 180°F) and to prevent it from igniting. The quench car may rely on a movable hood to collect particulate emissions, a scrubber car attached, or it may not have any particulate control. The car discharges the coke onto a wharf to drain and cool. Gates on the wharf open, dropping coke onto a conveyor to the crushing and screening station. After sizing, coke is sent to the blast furnace or to storage.

The recovery of valuable chemicals from the coke oven off gas is an economic necessity, accounting for approximately 25 percent of the mass and 35 percent of the value of the coal. The off gas is condensed and separated into liquid and gaseous fractions, known as coal tar and coal gas, respectively. The coal tar is distilled into several fractions of hydrocarbons. The coal gas contains hydrogen and methane, ammonia, carbon monoxide, carbon dioxide, ethane, ethylene, benzene, oxygen and nitrogen, hydrogen sulfide, water vapor, cyclopentadiene, toluene, naphthalene, hydrogen cyanide, cyanogen, and nitric oxide.

During the coking cycle, volatile matter driven from the coal mass passes upward through cast iron "goosenecks" into a common horizontal steel pipe, called the collecting main, which connects all the ovens in series. Coke oven gas is initially cleaned with a weak ammonia spray, which condenses some tar and ammonia from the gas. The liquid condensate flows down the collecting main until it reaches a settling tank. Some of the collected ammonia is used as make-up in the weak ammonia spray, while the excess is pumped to an ammonia still. Collected coal tar is pumped to a storage tank and is either sold to tar distillers or used as fuel.

The coke oven gas is cooled in a condenser and then is compressed by an exhauster. Remaining coal tar is removed by a tar extractor, either by impingement against a metal surface or collection by an electrostatic precipitator. The gas still contains 75 percent of the original ammonia and 95 percent of the original light oils. Ammonia is removed by passing the gas through a saturator containing a 5 to 10 percent solution of sulfuric acid. In the saturator, ammonia reacts with sulfuric acid to form ammonium sulfate. Ammonium sulfate is crystallized and removed. The gas is further cooled, resulting in the condensation of naphthalene. The light oils are removed in an absorption tower containing water mixed with "straw oil" (a heavy fraction of petroleum). Straw oil acts as an absorbent for the light oils. In another process the used straw oil is heated to release the light oils for recovery and refinement. Hydrogen sulfide can be removed from the gas using several methods. The cleaned coal gas is either used as fuel for the coke ovens or for steam generation, or is sold.

2.3 Emissions and Controls

Emissions of particulate matter, organic compounds, carbon monoxide, and other pollutants originate from several byproduct coking operations: 1) coal preparation, 2) coal preheating (if used), 3) coal charging, 4) oven leakage during the coking period, 5) coke removal (coke pushing), 6) hot coke quenching, and 7) underfire combustion stacks. Coal preparations produced particulate emissions that can be controlled using wet ESP's or wet scrubbers. In operations where the coal is preheated before charging, the air stream that conveys coal can be passed through conventional wet scrubbers or wet ESP's for particulate removal before discharging to the atmosphere.

Oven charging can produce significant emissions of particulate matter and organic compounds if not properly controlled. Proper charging techniques normally allow most charging emissions to be captured by the battery collecting main. Leaks can occur from charge lids and oven doors during pipeline charging due to positive pressure during charging.

During the coking cycle, uncontrolled organic compound emissions from the thermal distillation process may occur through poorly sealed doors, charge lids, offtake caps, collecting main, and through cracks that may develop in oven brickwork. Door leaks may be controlled by diligent cleaning and maintenance, rebuilding, and, in some plants, by manual application of luting material to the door seal. Charge lid and offtake leaks may be controlled by an effective patching and luting program.

Pushing coke out of coke ovens and into a quench car is a major source of particulate emissions. If the coke mass is not fully coked (green coke), gaseous pollutants will also be emitted. Some facilities minimize pushing emissions through the use of mobile scrubber cars with hoods, shed enclosures evacuated to a gas cleaning device, or traveling hoods with a fixed duct leading to a stationary gas cleaner. Quencing hot coke with cold water creates thermally shock, releasing particulate from hot coke. Water vapor from water heated during contact with hot coke rises from quenced coke and entrains particulate matter from the coke mass. In addition, dissolved solids from the quench water may also become entrained in the steam plume rising from the tower.

Combustion of gas used to heat coke ovens produce emissions. Sulfur dioxide emissions may be present if coke oven gas is not completely desulfurized. If oven wall brickwork is damaged, coal fines and coking decomposition products may leak from the coke oven into combustion exhaust gases. Conventional gas cleaning equipment, including electrostatic precipitators and fabric filters, have been installed on battery combustion stacks. However, where combustion gas has been desulfurized and coke oven walls are well maintained, uncontrolled air emissions from combustion stacks have been found to equal controlled air emissions from combustion stacks at other coke batteries.

Fugitive particulate emissions are associated with material handling operations. These operations consist of unloading, storing, grinding and sizing of coal, and screening, crushing, storing, and unloading of coke. In addition, various operations for recovery of ammonia, coke oven gas, tar, phenol, light oils (benzene, toluene, xylene), and pyridine gaseous effluent collected from the ovens during the coking process are sources of VOC emissions.

Coke oven emissions contain over 10,000 compounds as gases, condensable vapors, and particulates. The primary public health concern is benzene and other known or suspected carcinogens. These carcinogens belong to a class of compounds termed polycyclic organic matter (POM). POMs condense as fine particulate at ambient temperatures. There are thousands of

POM compounds with two or more fused rings. These pollutants are sometimes reported as benzene soluble organics (BSO) or by the quantity of a specific surrogate compound, such as benzo (a) pyrene (BaP).

A Practical method of determining mass emission measurements has not been developed. There are many changes in process variables taking place during coking operations that affect the mass emission rate. Regulatory agencies and coke oven operators have devised a visible emission method to estimate coke oven emission control. This method, Method 303, is a formal EPA procedure used to estimate emissions from coke oven doors, lids, and offtakes. Emissions are characterized by percent of leaking doors (PLD), percent of leaking lids (PLL), and percent of leaking offtakes (PLO). Charging emissions are characterized by the total time that visible emissions occur during charging of the oven.

Method 303 requires an inspector to walk at a steady pace observing each cove oven door for up to 3 seconds. A coke oven door is reported as leaking if it is observed to be leaking from one or more points on the door. A similar inspection process is followed when counting the number of leaking lids and offtakes. The percent leaking can be calculated by dividing the number of leaking doors, lids, and offtakes by the total number of each on the battery's operating ovens.

Visible emissions from charging operations is quantified by recording the total time emissions are seen being generated. A stopwatch is operated by an observer only when visible emissions occur from the Larry car and charging ports of an oven.

There are poorly-controlled and well-controlled coke batteries. A poorly-controlled coke battery can be identified by uncontrolled charging emissions lasting 3 to 5 minutes for each charge, 30-70 percent of oven doors are observed to be leaking, and lid and offtake leaks are found to be 20 to 40 percent. Table 2.2-1 can be used to make emission estimates for a specific battery.

Table 2.2-1
BSO Emission Factors for Poorly Controlled Coke Oven Sources[a]

Source	BSO kg/Mg of coal (lbs/ton of coal)	BSO emission rate Kg per hour (lbs per hour)
Charging[b]	0.05[9] to 0.55[10,11]	0.2 to 1.5 kg/min of emissions
	(0.10 to 1.1)	(0.4 to 3)
Doors[c]	0.13 to 0.25[10, 11, 12]	0.2 to 0.7 kg/hr per leaking door[10,12]
	(0.26 to 0.5)	(0.4 to 1.4)
Lids[d]	0.002 to 0.03	0.0033 to 0.021 kg/hr per leaking lid[13]
	(0.004 to 0.06)	(0.0066 to 0.042)
Offtakes[d]	0.002 to 0.02	0.0033 to 0.021 kg/hr per leaking offtake[13]
	(0.004 to 0.04)	(0.0066 to 0.042)

[a] Coke Oven Emissions from Wet-Coal Charged By-Product Oven Batteries - Background Information for Proposed Standards, EPA 450/3-85-028a.
[b] For 3 to 5 minutes of uncontrolled emissions.
[c] For 30 to 75 percent leaking doors.
[d] For 20 to 40 percent leaking lids or offtakes.

<u>EXAMPLE</u>

A sample calculation is given below for a battery of 62 ovens with 30 percent of the doors leaking at an average rate of 0.2 kilogram of BSO per hour per leaking door. This facility normally charges each oven with 16.3 Mg of coal and cycles the ovens every 18 hours. The coke battery operates 8,760 hours per year.

<u>Sample calculation</u>:

$$Number\ of\ leaking\ doors = 62\ ovens\ x\ \frac{2\ doors}{oven}\ x\ 0.3\ (fraction\ leaking\ )$$
$$= 37\ doors$$

$$kg\ of\ BSO\ per\ year = 37\ doors\ x\ 0.2kg\text{—}hour/door\ x\ \frac{8{,}760hr}{year} = 64{,}800\ Kg$$

For 16.3 Mg of coal per oven and an 18-hour cycle time, the coal usage would be:

$$of\ coal\ per\ year = \frac{16.3\ Mg\ of\ coal}{oven}\ x\ \frac{62\ ovens}{18\ hr}\ x\ \frac{8{,}760\ hr}{year} = 492{,}000\ Mg/y$$

$$Emissionfactor = 64{,}800\ Kg/yr\ \div 492{,}000\ Mg/yr = 0.13 kg\ of\ BSO/Mg\ of\ coal$$

Another method to estimate door leak emissions uses exponential equations to describe both minimum and maximum emission rates per leak. Both equations were developed from actual measurement of simulated emissions on doors. The maximum emission measurements were taken from a shed built around a coke battery.

TABLE 2.2-2
Door Leak Limits and Estimated Emission Rates

Average Percentage of Doors Leaking (PDL)	BSO/hr per leak (kg)	
	Minimum[a]	Maximum[b]
70	0.19	2.18
60	0.15	1.73
50	0.11	1.31
40	0.08	0.94
30	0.05	0.61

[a] Minimum = $(\text{average PLD}/70)^{1.5}$ x 0.19
[b] Maximum = $(\text{average PLD}/29)^{1.5}$ x 0.58

2.4 Review of Specific References

The following sources were contacted in order to obtain the most up-to-date information on industrial processes, emission stream characterization, and control technology concerning the manufacture of metallurgical coke:

1) Alabama Department of Environmental Management
Montgomery, Alabama

2) Indiana Department of Environmental Management
Indianapolis, Indiana

3) Michigan Department of Natural Resources
Lansing, Michigan

4) Ohio Environmental Protection Agency
Columbus, Ohio

5) Pennsylvania Department of Environmental Regulation
Harrisburg, Pennsylvania

6) U.S. Department of Energy
Washington, DC

7) Coke and Chemical Association
Washington, DC

8) American Iron and Steel Institute
Washington, DC

9) U.S. Environmental Protection Agency
Region III
Philadelphia, Pennsylvania

A response relating to metallurgical coke manufacture was received only from source #8, the American Iron and Steel Institute (AISI), and source #9, EPA Region III. AISI provided a list (Reference 1) of byproduct coke oven batteries currently operating in the U.S. The information provided, including types of ovens and their locations and capacities, is presented in Section 2.1 of this background report and is incorporated generally into the industry description presented in the revised version of AP-42 Section 12.2. The emission test files maintained by the EPA Region III office in Philadelphia were examined in an effort to obtain useful data for developing AP-42 emission factors for metallurgical coke production. Although seven of the domestic coke production facilities are located within Region III, only four test reports were found in these files. All of these reports pertain to facilities operated by US Steel, but only one was suitable for use in emission factor development. This report is discussed in more detail in Sections 4.1 and 4.3 of this background report.

Reference 2, Benzene Emissions from Coke Byproduct Recovery Plants, Benzene Storage Vessels, Equipment Leaks, and Ethylbenzene/Styrene Process Vents: Background Information and Responses to Technical Comments for 1989 Final Decisions, also was the source of some of the general industry information incorporated into the revised version of AP-42 Section 12.2. In 1984, the EPA proposed national emission standards for benzene from byproduct coke manufacture in the Federal Register, took comments, and then withdrew the standards. In response to legal action, revisions were made to these standards and they were proposed again in 1988. This reference presents the industry operating status as of January 1989, and discusses the comments received in response to the revised proposed standards.

Reference 3, "Iron and Steel" in the Minerals Yearbook published by the Bureau of Mines, examines the iron and steel industry from a primarily commercial standpoint. Some of this information, particularly that concerning trends and developments affecting coke manufacture, has been incorporated into the revised version of AP-42 Section 12.2.

References 4 and 5, Shreve's Chemical Process Industries and Marks' Standard Handbook for Mechanical Engineers, respectively, are readily available reference literature from which general information concerning the manufacture of metallurgical coke and the structure and operation of coke oven batteries was taken. This information was incorporated into the narrative process description in the revised AP-42 Section 12.2.

Reference 6, Locating and Estimating Air Emissions from Sources of Benzene and Reference 7, Metallurgical Coke Industry Particulate Emissions: Source Category Report, both contain specific process information, emission stream characterization, and control technique information for metallurgical coke production. This information has been incorporated into the revised version of AP-42 Section 12.2, along with data contained in each of these documents, which is discussed in detail in Chapter 4.0 of this background report.

2.5 References for Chapter 2.0

1. Facsimile transmission from B. Steiner, American Iron and Steel Institute, Washington, DC, to C.M. Campbell, Pacific Environmental Services, Inc., Research Triangle Park, NC, December 11, 1992.

2. Benzene Emissions from Coke Byproduct Recovery Plants, Benzene Storage Vessels, Equipment Leaks, and Ethylbenzene/Styrene Process Vents: Background Information and Responses to Technical Comments for 1989 Final Decisions, EPA-450/3-89-031, U.S. Environmental Protection Agency, Washington, DC, August 1989.

3. A.T. Peters, "Iron and Steel," Minerals Yearbook 1989, U.S. Department of the Interior, Bureau of Mines, Washington, DC, 1990.

4. Shreve's Chemical Process Industries, McGraw-Hill Book Company, Fifth Edition, 1984.

5. Mark's Standard Handbook for Mechanical Engineers, McGraw-Hill Book Company, Eighth Edition, 1978.

6. Locating and Estimating Air Emissions From Sources of Benzene, EPA-450/4-84-007, U.S. Environmental Protection Agency, Washington, DC, March 1988.

7. Metallurgical Coke Industry Particulate Emissions: Source Category Report, EPA-600/7-86-050, U.S. Environmental Protection Agency, Washington, DC, December 1986.

3.0 GENERAL EMISSION DATA REVIEW AND ANALYSIS PROCEDURES

3.1 Literature Search and Screening

The first step of this investigation involved a search of available literature relating to criteria and noncriteria pollutant emissions associated with coke production. This search included, but was not limited to, the following references:

1) AP-42 background files maintained by the Emission Factor and Methodologies Section. These files, including the background files for Section 12.5, were reviewed for coke related emission tests.
2) "PM_{10} Emission Factor Listing Developed by Technology Transfer (EPA-450/4-89-022). Reviewed but not used due to uncertain quality of data.
5) Information in the *Air Facility Subsystems* (AFS) of the EPA *Aerometric Information Retrieval System* (AIRS). PES was unable to retrieve any useful information for this application.
6) Handbook of Emission Factors, Parts I and II, Ministry of Health and Environmental Protection, The Netherlands, 1980/1983. No actual emission test data available.
7) The EPA *Clearinghouse for Inventories and Emission Factors* (CHIEF). CHIEF referenced emission source data as coming from AP-42. No new information was available.
8) The EPA databases, including *Speciation Database Management System* (SPECIATE), the *Crosswalk/Air Toxic Emission Factor Data Base Management System* (XATEF) and *Test Method Storage and Retrieval System* (TSAR) have been reviewed. SPECIATE used profile number 0000 to identify both volatile organics and particulate found in coke. A check of references for profile number 0000 revealed that it is an arithmetic average of 93 profiles developed for SPECIATE. XATEF contains no information concerning coke manufacturing. Both of these database systems were reviewed without tangible benefits. However, TSAR did provide 12 air emissions tests that were reviewed. Six of the tests are discussed in this document.
9) A literature search was conducted in the Duke University library, including a computer network search of the University of North Carolina and North Carolina

State University. No air tests were located at the Universities. The EPA Environmental Research Center library did contain primary emission tests for coke production facilities.

To reduce the amount of literature collected to a final group of references pertinent to this report, the following general criteria were used:

1. Emissions data must be from a primary reference; i.e., the document must constitute the original source of test data. For example, a technical paper was not included if the original study was contained in the previous document.
2. The referenced study must contain test results based on more than one test run.
3. The report must contain sufficient data to evaluate the testing procedures and source operating conditions (e.g., one-page reports were generally rejected).

If no primary data were found and the previous update utilized secondary data, these secondary data were still used, and the Emission Factor Rating lowered. A final set of reference materials was compiled after a thorough review of the pertinent reports, documents, and information according to these criteria. The final set of reference materials is given in Chapter 4.0.

3.2 Emission Data Quality Rating System

The quantity and quality of the information contained in the final set of reference documents were evaluated. The following data were excluded from consideration.

1. Test series averages reported in units that cannot be converted to the selected reporting units;
2. Test series representing incompatible test methods (e.g., comparison of the EPA Method 5 front-half with the EPA Method 5 front- and back-half);
3. Test series of controlled emissions for which the control device is not specified;
4. Test 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 by OAQPS for the preparation of AP-42 sections. 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 do not necessarily conform to the methodology specified in the EPA Reference Methods, although these methods were certainly used as a guide for the methodology actually used.

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. Source operation. 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. Sampling procedures. The sampling procedures conformed to a 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 to which 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 are suspect and were 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 the 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.

3.3 Emission Factor Quality Rating System

The quality of the emission factors developed from analysis of the test data was rated utilizing the following general criteria:

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 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 industry. 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 emission 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 always noted.

The use of these criteria is somewhat subjective and depends to an extent on the individual reviewer.

3.4 References for Chapter 3.0

1. Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections. U.S. Environmental Protection Agency, Research Triangle Park, NC, 27711, April 1992.
   [Note: this document is currently being revised at the time of this printing.]

2. Compilation of Air Pollutant Emission Factors, Supplement A, Appendix C.2, "Generalized Particle Size Distributions." U.S. Environmental Protection Agency, October 1986.

4.0 POLLUTANT EMISSION FACTOR DEVELOPMENT

No changes have been made to the emission factors presented in the previous (1986) version of AP-42 Section 12.2. Nonetheless, emission data obtained from several different sources, some of which are the basis for the emission factors presented, are discussed in this chapter.

4.1 Criteria Pollutant Emission Data

Particulate Matter.

Emissions of particulate matter can be divided into three categories: filterable, organic condensible, and inorganic condensible. Filterable particulate matter is that which collects on the filter and in the sampling probe assembly of a particulate sampling train. When emissions testing is performed in accordance with Method 5, the filter and probe are maintained at approximately 120°C (248°F); materials that condense at a temperature lower than this will pass through the filter. Many emissions tests also quantify emissions of condensible particulate matter, typically that which condenses at or above 20°C (68°F). This condensible particulate matter is collected by passing the sample gas through ice water-cooled impingers such that the gas exiting the last impinger is at a temperature less than 20°C. The preferred method for quantification of emissions of condensible particulate matter is EPA Reference Method 202. This method entails extraction of the organic portion of the condensible, or back-half, catch with methylene chloride, evaporation of the extract at room temperature, desiccation, and weighing. The inorganic portion of the back-half catch is evaporated at 105°C (221°F), desiccated, and weighed.

Because of environmental regulations imposed upon coke manufacturing facilities by state and local air pollution control agencies, and the short time Method 202 has existed, the data reviewed for this update do not follow the organic condensible particulate matter recovery procedures outlined above. The procedure used to quantify the condensible particulate matter emissions in these tests is equivalent to the inorganic condensible fraction measurement procedure in Method 202.

For pollution studies, the most common types of particle sizing instruments are cyclones, rotoclones, and cascade impactors. Traditionally, cyclones and rotoclones have been used as a preseparator ahead of a cascade impactor to remove the larger particles. These devices are of the standard reverse-flow design whereby the flue gas enters the cyclone through a tangential inlet and forms a vortex flow pattern. Particles move outward toward the cyclone wall with a velocity that is determined by the geometry and flow rate in the cyclone and by their size. Large particles reach the wall and are collected. A series of cyclones with progressively decreasing cut-points can be used to obtain particle size distributions.

Cascade impactors used for the determination of particle size in process streams consist of a series of plates or stages containing either small holes or slits with the size of the openings decreasing from one plate to the next. In each stage of an impactor, the gas stream passes through the orifice or slit to form a jet directed toward an impaction plate. For each stage, there is a characteristic particle diameter that has a 50 percent probability of impaction. This characteristic diameter is called the cut-point (D50) of the stage. Typically, commercial instruments have six to eight impaction stages with a backup filter to collect those particles which are either too small to be collected by the last stage or which are re-entrained off the various impaction surfaces by the moving gas stream.

Table 4.1-1 presents filterable particulate matter emission data from References 3 and 26, which are discussed in more detail in Section 4.3 of this background report. No other primary emission data suitable for development of AP-42 emission factors for criteria pollutants were available.

Table 4.1-1 (Metric Units)
Filterable Particulate Matter

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Uncontrolled -NBVS (Preheater for coal)						
3	A	5	1	80.7	345	4.27
			2	80.7	514	6.27
			3	80.7	335	4.15
			Average	80.7	398	4.93
Control device: Venturi Scrubber - NBVS						
3	A	5	1	80.7	11.3	0.14
			2	80.7	12.2	0.15
			3	80.7	10.4	0.13
			Average	80.7	11.3	0.14
Control device: Uncontolled - SBVS (Preheater for coal)						
3	A	5	1	108.9	364	3.35
			2	108.9	410	3.77
			Average	108.9	387	3.56
Control device: Venturi Scrubber - SBVS						
3	A	5	1	108.9	35.8	0.33
			2	108.9	26.3	0.24
			Average	108.9	31.1	0.29

[a] Units in megagrams of coke produced per hour.
[b] Units in kilograms of particulate matter per hour.
[c] Units in kilograms of particulate per megagram of coke produced.

Table 4.1-1 (Metric Units)
Filterable Particulate Matter
(concluded)

Source Test #	Test Rating	Test Method	Stack #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
1	B	5	1		0.152	
			3		0.137	
			4		0.152	
			5		0.233	
			6		0.125	
			7		0.154	
			8		0.114	
			9		0.090	
			10		0.100	
			11		0.194	
			12		0.100	
			14		0.172	
			Total	87.930	1.723	0.0196

[a] Units in megagrams of coke produced per hour.
[b] Units in kilograms of particulate matter per hour.
[c] Units in kilograms of particulate per megagram of coke produced.

Table 4.1-1 (English Units)
Filterable Particulate Matter

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Uncontrolled - NBVS (Preheater for coal)						
3	A	5	1	89	760	8.54
			2	89	1,133	12.73
			3	89	738	8.29
			Average	89	877	9.85
Control device: Venturi Scrubber - NBVS						
3	A	5	1	89	25	0.28
			2	89	27	0.30
			3	89	23	0.26
			Average	89	25	0.28
Control device: Uncontrolled - SBVS (Preheater for coal)						
3	A	5	1	120	803	6.69
			2	120	903	7.53
			Average	120	853	7.11
Control device: Venturi Scrubber - SBVS						
3	A	5	1	120	79	0.66
			2	120	58	0.48
			Average	120	68.5	0.57

[a] Units in tons of coke produced per hour.
[b] Units in pounds of particulate per hour.
[c] Units in pounds of particulate per ton of coke produced.

Table 4.1-1 (English Units)
Filterable Particulate Matter
(concluded)

Source Test #	Test Rating	Test Method	Stack #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
1	B	5	1		0.336	
			3		0.302	
			4		0.335	
			5		0.514	
			6		0.276	
			7		0.339	
			8		0.251	
			9		0.198	
			10		0.221	
			11		0.428	
			12		0.220	
			14		0.379	
			Total	96.925	3.799	0.0392

[a] Units in tons of coke produced per hour.

[b] Units in pounds of particulate per hour.

[c] Units in pounds of particulate per ton of coke produced.

4.2 Noncriteria Pollutant Emission Data

Hazardous Air Pollutants.

Hazardous Air Pollutants (HAP's) are defined in the 1990 Clean Air Act Amendments. Included in this list are benzene, toluene, isomers of xylene, cyanide compounds, naphthalene, phenol, and polycyclic organic matter, all of which are contained in coke oven gas. No quantitative emission data suitable for use in development of AP-42 emission factors are available for any of these HAP's.

Reference 9 is an "A" rated source test of six byproduct coke emission recovery process emission sources. Four of the six emission sources are tabulated in Table 4.2-1. The remaining two processes are batch operations and as such are not related to average production. No emission factors could be developed for the two batch operation emissions. However, the emissions from the two batch operations are discussed in more detail in Section 4.3 of this background report.

In addition, References 12 and 13 are Locating and Estimating reports published by the EPA for benzene and polycyclic organic matter, respectively. Neither of these documents contains primary emission test data, but both present emission factors for these HAP's from operations associated with metallurgical coke production and byproduct recovery. These factors are presented in Table 4.2-2.

Global Warming Gases.

Methane, carbon dioxide, and nitrous oxide have been found to contribute to overall global warming. All of these compounds are present in coke oven gas, but no quantitative data suitable for the development of emission factors are available.

Stratospheric Ozone-Depleting Gases.

Chlorofluorocarbons, hydrochlorofluorocarbons, carbon tetrachloride, methyl chloroform, and halons have been found to contribute to stratospheric ozone depletion. No evidence that any of these compounds exist in coke oven gas is available.

Table 4.2-1 (Metric Units)
Hazardous Air Pollutants

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Uncontrolled - Benzene - Cooling Tower						
9	A	110	1	147	30.0	0.21
			2	147	36.1	0.25
			3	147	33.8	0.23
			Average	147	33.3	0.23
Control device: Uncontrolled - Benzene - Tar Decanter						
9	A	110	1	147	1.32	0.009
			2	147	0.64	0.005
			3	147	1.63	0.011
			Average	147	1.18	0.09
Control device: Uncontrolled - Benzene - Light Oil Decanter						
9	A	110	1	147	11.5	0.08
			2	147	14.1	0.10
			3	147	13.6	0.09
			Average	147	13.1	0.09
Control device: Uncontrolled - Benzene - Denver Float Unit						
9	A	110	1	147	4.35	0.030
			2	147	3.33	0.023
			3	147	4.04	0.028
			Average	147	3.91	0.027

[a] Units in megagrams of coke produced per hour.
[b] Units in kilograms of benzene matter per hour.
[c] Units in kilograms of benzene per megagram of coke produced.

Table 4.2-1 (English Units)
Hazardous Air Pollutants
(Units in lb/ton Product)

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Uncontrolled - Benzene - Cooling Tower						
9	A	110	1	162	66.2	0.41
			2	162	79.5	0.49
			3	162	74.5	0.46
			Average	162	73.4	0.45
Control device: Uncontrolled - Benzene - Tar Decanter						
9			1	162	2.9	0.018
			2	162	1.4	0.009
			3	162	3.6	0.022
			Average	162	2.6	0.016
Control device: Uncontrolled - Benzene - Light Oil Decanter						
9			1	162	25.3	0.16
			2	162	31.1	0.19
			3	162	29.9	0.18
			Average	162	28.8	0.17
Control device: Uncontrolled - Benzene - Denver Float Unit						
9			1	162	9.60	0.059
			2	162	7.35	0.045
			3	162	8.91	0.055
			Average	162	8.62	0.053

[a] Units in tons of coke produced per hour.

[b] Units in pounds of benzene per hour.

[c] Units in pounds of benzene per ton of coke produced.

Table 4.2-2
Benzene Emission Factors For Furnace and Foundry Coke Byproduct Plants[a]

Source	Uncontrolled Emission Factor		Controlled Emission Factor		Control Option	Control Efficiency (%)
	Furnace Coke	Foundry Coke	Furnace Coke	Foundry Coke		
Cooling Tower						
Direct-water	270	197	51	37.4	Use tar-bottom final cooler	81
			---	---	Use wash-oil final cooler	100
Tar Bottom	70	51	---	---	Use wash-oil final cooler	100
Light-oil Condenser Vent	89	48	1.8	0.9	Gas blanketing	98
Naphthalene Separation and Processing	107	79	---	---		---
Tar-intercepting Sump	90	45	1.9	0.9	Gas blanketing	98
Tar Dewatering	21	9.9	0.42	0.2	Gas blanketing	98
			2.1	0.9	Wash-oil scrubber	90
Tar Decanter	77	36	3.9	1.8	Gas blanketing	95
Tar Storage	12	5.6	0.24	0.1	Gas blanketing	98
			1.2	0.5	Wash-oil scrubber	90
Light-oil Sump	15	8.1	0.3	0.2	Source enclosure	98
Light-oil Storage	5.8	3.1	0.12	0.06	Gas blanketing	98
			0.58	0.3	Wash-oil scrubber	90

Table 4.2.2 (Continued)

Source	Uncontrolled Emission Factor		Controlled Emission Factor		Control Option	Control Efficiency (%)
	Furnace Coke	Foundry Coke	Furnace Coke	Foundry Coke		
Flushing-liquor Circulation Tank	9	6.6	0.18	0.13	Gas blanketing	98
Excess-ammonia Liquor Tank	9	6.6	0.18	0.13	Gas blanketing	98
					Wash-oil scrubber	90
Wash-oil Decanter	3.8	2.1	0.076	0.04	Gas blanketing	98
Wash-oil Circulation Tank	3.8	2.1	0.076	0.04	Gas blanketing	98

[a] Reference 16. All units in grams of benzene emitted per megagram of coke produced.

Table 4.2-3
Polycyclic Organic Matter Emission Factor Data for Metallurgical Coke Production and Byproduct Recovery[a]

Emission Source	Total POM Emission Factor	Comments
Door Leaks	4.3[b]	Control status unknown
Door Leaks	0.00007[c]	Controlled by a wet ESP
Coke Quenching	0.002 to 0.009[d]	---
Coke Quenching	1.85[e]	Clean water used for quench
Coke Quenching	613[e]	Contaminated water used for quench
Door leaks	0.11[f]	German coke oven equipped with spring loaded door seals
Cooling Tower for Contact Cooler	6.4	
Tar Processing		
Tar Decanter	4.1[g]	
Tar Dewatering and Storage	0.003	
Tar Distillation Production Storage	0.011	

References for Table 4.2-3

[a] Reference 13. All units in grams of POM emitted per megagram of cool charged, unless otherwise noted.

[b] Constituents of total POM include benzo(a)phenanthrene, benzo(e)pyrene, benzofluoranthenes, benzo(k)fluoanthene, chrysene, dibenzanthracenes, dibenzpyrene, dimethylbenz(a)anthracene, fluoranthene, pyrene, naphthalene, benzo(a)pyrene, and indeno(1,2,3-c,d)pyrene.

[c] Constituents of total POM include naphthalene, fluoranthene, pyrene, chrysene, benz(c)phenanthrene, benz(a)anthracene, 7,12-dimethylbenz(a)anthracene, benzofluoranthenes, benzo(a)pyrene, benzo(e)pyrene, cholanthrene, indeno(1,2,3-c,d)pyrene, dibenz(a,h)anthracene, dibenzacridines, dibenz(c,g)carbazole, dibenzpyrenes, and 3-methyl cholanthrene.

[d] Constituents of total POM include anthracene, phenanthrene, methyl anthracenes, fluoranthene, pyrene, methylpyrene/fluoranthene, benzo(c)phenanthrene, methyl chrysenes, benzo(a)pyrene, dimethylbenz(a)anthracene, and chrysene/benz(a)anthracene.

[e] Average of tests for green and non-green coke. Samples were gathered using a modified Method 5 procedure; such results are for particulate and gaseous POM. Constituents of total POM include benzo(a)pyrene, 3-methyl cholanthrene, 7,12-dimethylbenz(a)anthracene, dibenz(a,h)anthracene, dibenzo(a,h)pyrene, dibenzo(a,i)pyrene, benz(a)anthracene, pyridine, indeno(1,2,3-c,d)pyrene, phenanthrene, phenol, cresol, and quinoline.

[f] Grams of condensable POM (only) per megagram of coke produced.

[g] Naphthalene is the major constituent of total POM.

4.3 Review of Specific Data Sets

The emission factors presented in AP-42 Section 12.2 for metallurgical coke production for particulate matter, sulfur dioxide, carbon monoxide, volatile organic compounds, nitrogen oxides, and ammonia and for size-specific particulate matter emissions are duplicated in Tables 4.3-1 and 4.3-2, respectively. These factors are taken from Reference 1, Metallurgical Coke Industry Particulate Emissions: Source Category Report. This comprehensive 1986 study includes a review of much of the data utilized in development of previous versions of AP-42 Section 12.2. In particular, all particle size distribution information contained in these previous versions was compiled for, and first presented in, this document. Where available, the primary emission data from which these emission factors are derived have been reviewed as part of this update of AP-42 Section 12.2. The original data sources are discussed in more detail below. A lack of available recent emission test data precluded the development of revised emission factors for metallurgical coke manufacture, but all available emission data are discussed for the purpose of comparison.

Reference 2. Final Technological Report on a Systems Analysis Study of the Integrated Iron and Steel Industry, Contract No. PH-22-68-65, U.S. Environmental Protection Agency, Research Triangle Park, NC, May 1969.

This document does not contain primary emission source test data, but is the basis for emission factors for sulfur dioxide from the uncontrolled combustion of coke oven gas presented in the emission factor tables.

Reference 3. Stack Test Report for J & L Steel, Aliquippa Works, Betz Environmental Engineers, Plymouth Meeting, PA, April 1977.

This emission test report, which is the basis for the size-specific particulate matter emission factors for coal preheating presented in the emission factor tables on both controlled and uncontrolled bases, evaluates particulate emissions before and after a venturi scrubber. The scrubber removes particulates and sulfur dioxide from a preheater exhaust stack. The preheater uses natural gas to produce the hot air that is used to dry and preheat wet coal prior to the coal being charged into coke ovens. This source test involves two scrubbers called the North Bleed Venturi Scrubber (NBVS), and the South Bleed Venturi Scrubber (SBVS). The filterable particulate emissions (uncontrolled and controlled) are reported in Table 4.1-1 of this background report for both the NBVS and the SBVS.

Reference 4. Coke Oven Charging Emission Control Test Program, Volume I, EPA-650/2-74-062-1, U.S. Environmental Protection Agency, Washington, DC, September 1977.

This reference is a study of coke charging emissions using a "Wilputte" larry car and a prototype AISI/EPA larry car. Each larry car had six emission points tested. Table 21 of the emission test reports a particulate size distribution of particulate emissions during coke oven charging operations. This reference does not contain production rates, but is

Table 4.3-1 (Metric Units)
Emission Factors for Coke Manufacturing[a]

All Emission Factors in kg/Mg of Coke Produced
Ratings (A-E) Follow Each Factor

Type of operation	Particulate[b]		SO_2		CO[c]		VOC[c,d]		NO_x[c]		Ammonia[c]	
Coal crushing												
SCC 3-03-003-07												
with cyclone	0.055	D										
Coal preheating												
Uncontrolled[e]	1.75	C										
With scrubber	0.125	C										
With wet ESP	0.006	C										
Wet coal charging[f] (larry car)												
SCC 3-03-003-02												
Uncontrolled	0.24	E	0.01	D	0.3	D	1.25	D	0.015	D	0.01	D
With sequential charging	0.008	E										
With scrubber	0.007	E										
Door leak												
SCC 3-03-003-08												
Uncontrolled	0.27	D			0.3	D	0.75	D	0.005	D	0.03	D
Coke pushing												
Uncontrolled	0.58	B			0.035	D	0.1	D			0.05	D
With ESP[g]	0.225	C										
With venturi scrubber[h]	0.09	D										
With baghouse[h]	0.045	D										
With mobile scrubber car[j]	0.036	C										
Quenching												
Uncontrolled												
Dirty water[k]	2.62	D										
Clean water[m]	0.57	D										
With baffles												
Dirty water[k]	0.65	B										
Clean water[m]	0.27	B										

Table 4.3-1 (Metric Units)
Emission Factors for Coke Manufacturing[a]
(Concluded)

Type of operation	Particulate[b]		SO_2		CO[c]	VOC[c,d]	NO_x[c]	Ammonia[c]
Uncontrolled (COG)	0.234	A	2.0[n]	D				
Uncontrolled (BFG)	0.085	A						
With ESP (COG)	0.046	D						
With Baghouse	0.055	D						
Coke handling SCC 3-03-003-12								
With cyclone[p]	0.003	D						

[a] ESP = electrostatic precipitator. COG = coke oven gas. BFG = blast furnace gas.

[b] Reference 1.

[c] Reference 11.

[d] Expressed as methane.

[e] Exhaust gas discharged from series of primary and secondary cyclones used to separate flash dried coal from hot gas.

[f] Charged coal has not been dried.

[g] Emissions captured by coke side shed.

[h] Emissions captured by travelling hood.

[j] Emissions captured by quench car enclosure.

[k] Dirty water ≥5000 mg/l total dissolved solids.

[m] Clean water ≤1500 mg/l total dissolved solids.

[n] Reference 4. Factor for SO_2 is based on these representative conditions: 1) sulfur content of coal charged to oven is 0.8 weight %; 2) about 33 weight % of total sulfur in coal charged to oven is transferred to coke oven gas; 3) about 40% of coke oven gas is burned during underfiring operation, and about 60% is used in other operations where the rest of the SO_2 [3 kg/Mg (6 lb/ton) of coal charged] is discharged; 4) gas used in underfiring has not been desulfurized.

[p] Defined as crushing and screening.

[q] Reference 1. Uncontrolled emissions are 0.00018 kg/Mg (0.00035 lb/ton).

[r] Reference 9. Desulfurized COG.

[s] Reference 10.

[t] Reference 11.

Table 4.3-1 (English Units)
Emission Factors for Coke Manufacturing[a]

All Emission Factors are in lb/ton of Coke Produced
Ratings (A-E) Follow Each Factor

Type of operation	Particulate[b]		SO_2		CO[c]		VOC[c,d]		NO_x[c]		Ammonia[c]	
Coal crushing												
SCC 3-03-003-07												
with cyclone	0.11	D										
Coal preheating												
Uncontrolled[e]	3.50	C										
With scrubber	0.25	C										
With wet ESP	0.012	C										
Wet coal charging[f] (larry car)												
SCC 3-03-003-02												
Uncontrolled	0.48	E	0.02	D	0.6	D	2.5	D	0.03	D	0.02	D
With sequential charging	0.016	E										
With scrubber	0.014	E										
Door leak												
SCC 3-03-003-08												
uncontrolled	0.54	D			0.6	D	1.50	D	0.01	D	0.06	D
Coke pushing												
Uncontrolled	1.15	B			0.07	D	0.2	D			0.1	D
With ESP[g]	0.45	C										
With venturi scrubber[h]	0.18	D										
With baghouse[h]	0.09	D										
With mobile scrubber car[j]	0.072	C										
Quenching												
Uncontrolled												
Dirty water[k]	5.24	D										
Clean water[m]	1.13	D										
With baffles												
Dirty water[k]	1.30	B										
Clean water[m]	0.54	B										

Table 4.3-1 (English Units)
Emission Factors for Coke Manufacturing[a]
(Concluded)

Type of operation	Particulate[b]		SO_2		CO[c]	VOC[c,d]	NO_x[c]	Ammonia[c]
Uncontrolled (COG)	0.47	A	4.0[n]	D				
Uncontrolled (BFG)	0.17	A						
With ESP (BFG)		B						
With ESP (COG)	0.091	D						
With Baghouse (COG)	0.11	D						
Coke handling								
SCC 3-03-003-12								
With cyclone[p]	0.006	D						

[a] ESP = electrostatic precipitator. COG = coke oven gas. BFG = blast furnace gas.

[b] Reference 1.

[c] Reference 11.

[d] Expressed as methane.

[e] Exhaust gas discharged from series of primary and secondary cyclones used to separate flash dried coal from hot gas.

[f] Charged coal has not been dried.

[g] Emissions captured by coke side shed.

[h] Emissions captured by travelling hood.

[j] Emissions captured by quench car enclosure.

[k] Dirty water ≥5000 mg/l total dissolved solids.

[m] Clean water ≤1500 mg/l total dissolved solids.

[n] Reference 4. Factor for SO_2 is based on these representative conditions: 1) sulfur content of coal charged to oven is 0.8 weight %; 2) about 33 weight % of total sulfur in coal charged to oven is transferred to coke oven gas; 3) about 40% of coke oven gas is burned during underfiring operation, and about 60% is used in other operations where the rest of the SO_2 [3 kg/Mg (6 lb/ton) of coal charged] is discharged; 4) gas used in underfiring has not been desulfurized.

[p] Defined as crushing and screening.

[q] Reference 1. Uncontrolled emissions are 0.00018 kg/Mg (0.00035 lb/ton).

[r] Reference 9. Desulfurized COG.

[s] Reference 10.

[t] Reference 11.

Table 4.3-2. (Metric Units)
Size-Specific Emission Factors for Coke Manufacturing[a]

All Emission Factors are in kg/Mg of Coke Produced
Ratings (A-E) Follow Each Factor

Process	Particle size (μm)	Cumulative Mass % ≤ stated size	Cumulative mass emission factors	
Coal preheating				
Uncontrolled	0.5	44	0.8	D
	1.0	48.5	0.8	D
	2.0	55	1.0	D
	2.5	59.5	1.0	D
	5.0	79.5	1.4	D
	10.0	97.5	1.7	D
	15.0	99.9	1.7	D
		100	1.7	D
Controlled with venturi scrubber	0.5	78	0.10	D
	1.0	80	0.10	D
	2.0	83	0.10	D
	2.5	84	0.11	D
	5.0	88	0.11	D
	10.0	94	0.12	D
	15.0	96.5	0.12	D
		100	0.12	D
Coal charging (sequential or stage)	0.5	13.5	0.001	D
	1.0	25.2	0.002	D
	2.0	33.6	0.003	D
	2.5	39.1	0.003	D
	5.0	45.8	0.004	D
	10.0	48.9	0.004	D
	15.0	49.0	0.004	D
		100	0.008	D

Table 4.3-2. (Metric Units)
(Continued)

Process	Particle size (μm)	Cumulative Mass % ≤ stated size	Cumulative mass emission factors	
Coke pushing				
Uncontrolled	0.5	3.1	0.02	D
	1.0	7.7	0.04	D
	2.0	14.8	0.09	D
	2.5	16.7	0.10	D
	5.0	26.6	0.15	D
	10.0	43.3	0.25	D
	15.0	50.0	0.29	D
		100	0.58	D
Controlled with venturi scrubber	0.5	24	0.02	D
	1.0	47	0.04	D
	2.0	66.5	0.06	D
	2.5	73.5	0.07	D
	5.0	75	0.07	D
	10.0	87	0.08	D
	15.0	92	0.08	D
		100	0.09	D
Mobile scrubber car	1.0	28.0	0.010	D
	2.0	29.5	0.011	D
	2.5	30.0	0.011	D
	5.0	30.0	0.011	D
	10.0	32.0	0.012	D
	15.0	35.0	0.013	D
		100	0.036	D
Quenching				
Uncontrolled (dirty water)	1.0	13.8	0.36	D
	2.5	19.3	0.15	D
	5.0	21.4	0.56	D
	10.0	22.8	0.60	D
	15.0	26.4	0.69	D
		100	2.62	D

Table 4.3-2. (Metric Units)
(Concluded)

Process	Particle size (μm)	Cumulative Mass % $\leq$ stated size	Cumulative mass emission factors	
Quenching (continued)				
Uncontrolled (clean water)	1.0	4.0	0.02	D
	2.5	11.1	0.06	D
	5.0	19.1	0.11	D
	10.0	30.1	0.17	D
	15.0	37.4	0.21	D
		100	0.57	D
With baffles (dirty water)	1.0	8.5	0.06	D
	2.5	20.4	0.13	D
	5.0	24.8	0.16	D
	10.0	32.3	0.21	D
	15.0	49.8	0.32	D
		100	0.65	D
With baffles (clean water)	1.0	1.2	0.003	D
	2.5	6.0	0.02	D
	5.0	7.0	0.02	D
	10.0	9.8	0.03	D
	15.0	15.1	0.04	D
		100	0.27	D
Combustion stack				
Uncontrolled	1.0	77.4	0.18	D
	2.0	85.7	0.20	D
	2.5	93.5	0.22	D
	5.0	95.8	0.22	D
	10.0	95.9	0.22	D
	15.0	96	0.22	D
		100	0.23	D

[a] Reference 1.

Table 4.3-2. (English Units)
Size Specific Emission Factors for Coke Manufacturing[a]

All Emission Factors are in lb/ton of Product
Ratings (A-E) Follow Each Factor

Process	Particle size (μm)	Cumulative Mass % ≤ stated size	Cumulative mass emission factors	
Coal preheating				
Uncontrolled	0.5	44	1.5	D
	1.0	48.5	1.7	D
	2.0	55	1.9	D
	2.5	59.5	2.1	D
	5.0	79.5	2.8	D
	10.0	97.5	3.4	D
	15.0	99.9	3.5	D
		100	3.5	D
Controlled with venturi scrubber	0.5	78	0.20	D
	1.0	80	0.20	D
	2.0	83	0.20	D
	2.5	84	0.21	D
	5.0	88	0.22	D
	10.0	94	0.24	D
	15.0	96.5	0.24	D
		100	0.25	D
Coal charging (sequential or stage)	0.5	13.5	0.002	D
	1.0	25.2	0.004	D
	2.0	33.6	0.005	D
	2.5	39.1	0.006	D
	5.0	45.8	0.007	D
	10.0	48.9	0.008	D
	15.0	49.0	0.008	D
		100	0.016	D

Table 4.3-2. (English Units)

Process	Particle size	Cumulative Mass % ≤	Cumulative mass	
Coke pushing				
Uncontrolled	0.5	3.1	0.04	D
	1.0	7.7	0.09	D
	2.0	14.8	0.17	D
	2.5	16.7	0.19	D
	5.0	26.6	0.30	D
	10.0	43.3	0.50	D
	15.0	50.0	0.58	D
		100	1.15	D
Controlled with venturi scrubber	0.5	24	0.04	D
	1.0	47	0.08	D
	2.0	66.5	0.12	D
	2.5	73.5	0.13	D
	5.0	75	0.13	D
	10.0	87	0.16	D
	15.0	92	0.17	D
		100	0.18	D
Mobile scrubber car	1.0	28.0	0.020	D
	2.0	29.5	0.021	D
	2.5	30.0	0.022	D
	5.0	30.0	0.022	D
	10.0	32.0	0.024	D
	15.0	35.0	0.023	D
		100	0.072	D
Quenching				
Uncontrolled (dirty water)	1.0	13.8	0.72	D
	2.5	19.3	1.01	D
	5.0	21.4	1.12	D
	10.0	22.8	1.19	D
	15.0	26.4	1.38	D
		100	5.24	D

Table 4.3-2. (English Units)

Process	Particle size	Cumulative Mass % ≤	Cumulative mass	
Quenching (continued)				
Uncontrolled (clean water)	1.0	4.0	0.05	D
	2.5	11.1	0.13	D
	5.0	19.1	0.22	D
	10.0	30.1	0.34	D
	15.0	37.4	0.42	D
		100	1.13	D
With baffles (dirty water)	1.0	8.5	0.11	D
	2.5	20.4	0.27	D
	5.0	24.8	0.32	D
	10.0	32.3	0.42	D
	15.0	49.8	0.65	D
		100	1.30	D
With baffles (clean water)	1.0	1.2	0.006	D
	2.5	6.0	0.03	D
	5.0	7.0	0.04	D
	10.0	9.8	0.05	D
	15.0	15.1	0.08	D
		100	0.54	D
Combustion stack				
Uncontrolled	1.0	77.4	0.36	D
	2.0	85.7	0.40	D
	2.5	93.5	0.44	D
	5.0	95.8	0.45	D
	10.0	95.9	0.45	D
	15.0	96	0.45	D
		100	0.47	D

[a] Reference 1.

the source of the size-specific particulate matter emission factors presented in the emission factor tables for coal charging operations. In addition, attempts to define total emissions from one coke oven charging operation failed, as each of the six emission points had to be tested sequentially during different charging times. When the single point emission tests were duplicated, the emission rates were found to be different (i.e., emission rates varied at the same emission point source from charge to charge). Since production rates are not available, emission factor calculations cannot be duplicated. Charging operation emission rates averaged over 10 charges are reported at 815 grams per charge for the "Wilputte" larry car, while the new AISI/EPA larry car averaged only 120 grams per charge. A leaking side door seal was found to emit 1.2 pounds of hydrocarbons over a 19 hour period per ton of coal charged, but this information cannot be used to represent side door seal integrity as each oven is unique during any particular time in a planned maintenance period.

Reference 5. Stack Test Report for Allied Chemical Corporation, Ashland, KY, York Research Corporation, Stamford, CT, April 1979.

This report, which is one of three sources of the size-specific particulate matter emission factors presented in the emission factor tables for uncontrolled coke pushing operations, has been assigned an emission data quality rating of "D," as reported particulate emission rates may be nonrepresentative. Large diameter particles were found in the probe when filterable particulate was washed out of the probe after testing was completed. This size material was not expected to pass through the scrubber. Apparently, there was an inoperative louvered damper between the scrubber and the exhaust fan. The damper (left in the open position) allowed large particulate to be pulled into the duct during the exhaust fan speed reduction during the start of quenching. Simply put, particulate bypassed the scrubber through the open damper during standard operating procedures (the damper should have been closed and the exhaust fan at low speed at this point) and was deposited in the duct. When the exhaust fan returned to high speed, the increased air flow through the duct (between the scrubber and the exhaust fan) picked up these large particles. This resulted in particulate emissions being overstated.

Reference 6. Wet Coke Quench Tower Emission Factor Development, Dofasco, Ltd., EPA-600/X-85-340, U.S. Environmental Protection Agency, Research Triangle Park, NC, August 1982.

This report details the results of testing performed in order to quantify particulate matter emissions from a single stack that services two coke oven batteries. This report is the source of all size-specific particulate matter emission factors presented in the emission factor tables for quenching operations, but no process rate is documented, precluding duplication of the emission factor development calculations.

Reference 7. Stack Test Report for Shenango Steel, Inc., Neville Island, PA, Betz Environmental Engineers, Plymouth Meeting, PA, July 1976.

This report documents the results of testing performed in order to quantify emissions from two coke oven battery underfiring systems, and is one of three sources of the size-specific particulate matter emission factors presented in the emission factor tables for uncontrolled combustion of coke oven gas. The heat content of the gas, as well as gas consumption data, are included in the report. However, the emission factor calculations cannot be duplicated due to a lack of documented coke production rates.

Reference 8. Stack Test Report for Republic Steel, Cleveland,OH, PEDCO (Under contract to USEPA), Weeks of October 26 and November 7, 1981. EMB Report 81-CBS-1.

This reference does not document process rates to permit emission factor development. However, a modified Method 5 was used to ascertain the effects of particulate collection in the first half by heating the probe to 350, 450, and 600 degrees Fahrenheit. This study demonstrated that an indirect relationship exists between the probe temperature and sulfur related particulate captured in the front half. In addition, both the coal and the resulting coke product were analyzed to evaluate the reduction in sulfur content resulting from the coke making process. In the first test, coal with a 0.82 percent sulfur content resulted in a coke product with a sulfur content of 0.70 percent. In the second analysis, the respective sulfur content of the coal to coke sampled was found to be 0.80 and 0.72 percent. This reference is not the basis for any emission factors presented in the emission factor tables.

Reference 9. Emission Test Report, Bethlehem Steel, Bethlehem, PA, Benzene, Coke Oven By-Product Plant, EMB Report 80-BYC-1, March 1981.

This "A" rated emission test was conducted to identify benzene emission factors from six process emission points during recovery of byproducts during the manufacturing of coke. Uncontrolled benzene emissions from a cooling tower, a tar decanter, a light oil condenser, and a Denver flotation unit are reported in Table 4.2-1. An emission factor was calculated for the emission points. Production rates were reported for each 24 hour period during the 9 day testing period. PES averaged the daily production rate of coke and then divided that average by 24 to get an average hourly production rate. The remaining two processes are batch operations with variable emission rates. Emissions appear not to be related directly to production rates. The first of these two batch operations is a naphthalene drying tank. It has a batch time period of 12 to 14 hours. During that time period, eight benzene emission tests were conducted for 30 minutes or more, evenly distributed over the batch run period. The range of benzene emission rates was 0.002 to 0.098 kg/hr (0.005 to 0.217 lb/hr), with an average rate of 0.020 kg/hr (0.042 lb/hr). Information on the weight or volume of naphthalene in the tank was not available. The second of the two batch processes involves operations in the naphthalene melt pit. Benzene emission rates were found to be variable, related to the process heating, process cycle, and ambient conditions in the immediate area of the pit. Collection of samples were found to be difficult due to heat convection currents lifting emissions above the sensors. Benzene emission rates for these two batch operations are not reported in this background document. This reference is not the basis for any emission factors presented in the emission factor tables.

Reference 10. Emission Test Report, Kaiser Steel Corporation, Fontaina, CA. July 1, 1979. EMB Test Report Number 79-CKO-14.

Although this "A" rated emission test does not contain production rates, it does demonstrate the inconsistent emission rates resulting from the operation of a coke battery. Particulates at the fabric filter inlet averaged 25.88 lbs/hr during three testing periods, while the highest reading was 28 percent above the average rate, and the lowest was calculated at 24 percent below average. A coke battery is intentionally operated as nearly constant as possible in order to produce a steady production of coke oven gas. In addition, there appears to be an inverse relationship between the generation of carbon monoxide and carbon dioxide, while at the same time there is a direct relationship between the amount of free oxygen and carbon monoxide. Benzene had a range during the emission testing of 1.8 to 4.1 parts per million (ppm), with a three test run average of 2.8 ppm. This reference is not the basis for any emission factors presented in the emission factor tables.

Reference 11. Emission Test Report Wisconsin Steel, Chicago, IL. November 1977. EMB Test Report Number 77-CKO-11.

The goal of this emission test was to determine the efficiency of a wet electrostatic precipatator for the collection of polycyclic organic matter (POM). Polycyclic means an organic compound having three or more ring structures. No emission factor can be developed due to a lack of information on related production rates during the three test periods. The results are relevant to future investigations in this area as they relate to understanding air pollution control. Efficiency calculations indicate a 69 percent average for the control device over four testing periods for POM and naphthalene. When the naphthalene is mathematically removed from the calculations, the efficiency of the control device increases to 95.6 percent. This increase in efficiency is most probably related to the physical properties of naphthalene; it is insoluble in water and sublimes (changes from a solid to a gas directly) at room temperature. This reference is not the basis for any emission factors presented in the emission factor tables.

Reference 12. Locating and Estimating Air Emissions from Sources of Benzene, EPA-450/4-84-007q, U.S. Environmental Protection Agency, Research Triangle Park, NC, March 1988.

This reference is one of a series of EPA documents that compile qualitative and quantitative information concerning emissions of specific HAP's from various source categories. Benzene may be emitted from many sources within a metallurgical coke production facility. Specifically, benzene is one of the primary constituents of coke oven gas, and is emitted from all sources (such as leaking doors) directly associated with the coke oven battery. In addition, benzene is often recovered by distillation from the light oil fraction of the coke oven effluent for its economic value. This reference does not contain any primary emission test results, but does include emission factors for benzene from several coke oven byproduct recovery operations. These factors are presented in Section 4.2 of this background report.

Reference 13. Locating and Estimating Air Emissions from Sources of Polycyclic Organic Matter (POM), EPA-450/4-84-007p, U.S. Environmental Protection Agency, Research Triangle Park, NC, September 1987. November 1977.

This reference is one of a series of EPA documents that compile qualitative and quantitative information concerning emissions of specific HAP's from various source categories. Polycyclic organic matter may be emitted from many sources within a metallurgical coke production facility. Specifically, polycyclic organic matter is emitted from all sources (such as leaking doors) directly associated with the coke oven battery, as well as from coal tar processing operations. This reference does not contain any primary emission test results, but does include emission factors for polycyclic organic matter from several coke oven sources and coal tar processing operations. These factors are presented in Section 4.2 of this background report.

Reference 14. Results of the Compliance Demonstration of the Pushing Emissions Control for B-Battery, USS Clairton Works, Clairton, PA, Keystone Environmental Resources, Inc., Monroeville, PA, April 1990.

This report details the results of testing performed in order to quantify emissions of filterable particulate matter from a coke pushing operation at a furnace coke production facility. This test was performed according to EPA Reference Methods 1 through 5, and contains documentation of all sampling, analysis, and QA procedures. However, sampling was not performed at the inlet to the baghouse serving this coke pushing operation, precluding the calculation of uncontrolled emission factors or control efficiency. This baghouse exhausts through twelve stacks simultaneously. Ideally, to accurately determine total filterable particulate matter emissions from the baghouse, all twelve of these stacks would be tested simultaneously for multiple runs. For the purpose of demonstrating compliance with permitted emission limitations imposed on this source by the Allegheny County Bureau of Air Pollution Control, a single test run was performed on each stack over a two-day period. As a result of this methodology, the results of this test have been assigned an emission data quality rating of "B." These results indicate a facility-specific filterable particulate matter emission factor of 0.019 kilograms per megagram of coke produced, as compared with a value of 0.045 kilograms per megagram presented in AP-42 Section 12.2 for this emission source and control device configuration.

The process and emission data contained in this emission test report are presented in Table 4.1-1 of this background report.

Reference 15. Final Phase I Method Validation Report for Quantitative Coke Door Leak Measurement Study. American Iron and Steel Institute, Washington, D.C. Document No. 0284-001-350 (322) December, 1991.

Measurement of mass flow rates from leaking coke battery doors was accomplished using a hood and shroud system. The study was undertaken because the visual emission observation (VEO) procedure that EPA is proposing for maximum achievable control technology (MACT) limits (Method 109) did not include a measure of the severity of leaks for individual doors. The objective of this study was to develop quantitative coke oven emission data when used with a VEO procedure, that would serve as the basis for a mass emission standard. The report summarizes the results of a method validation study conducted by ENSR Consulting and Engineering, at the ARMCO Middletown, Ohio facility during the week of July 8, 1991.

Mass emission is described using a range of six leak rate classifications for visual emissions. These classifications (0, 0.5, 1, 2, 3, and 4) ranged from a numerical value of 0 (no visible leak) to 4 (extraordinary heavy leak) with most of the leaks falling into the range of 1 to 3.

Two sample collecting methods were used to collect particulate samples concurrently. They were US EPA Method 5G and a modified PS-1 sampler. The PS-1 sampler has the ability to collect 8 times the sample volume as the Method SG train. By collecting more samples during the same time period, the PS-1 sampler could provide a much lower method detection limit for benzene soluble organics (BSO).

Although there were some recommended modifications to improve the method, data collected during the 12 test runs indicate that there exists a strong relationship between the mass emission rate and the percentage of particulate that is BSO.

By comparing total particulate rates to BSO particulate rates, it appears that large leaks contain a larger percentage of BSO particulate (85 percent of total) than small leaks (25 percent of total particulate).

Reference 16. Testing Non-Recovery Coke Ovens for Standards Development, Jewell Coal & Coke Company, Vansant, VA. Emission Measurement Branch, United States Environmental Protection Agency, Research Triangle Park, North Carolina 27711. September 1992.

The Jewell Coal & Coke Company in Vansant, Virginia is the only non-recovery coke manufacturer in the United States. EPA conducted a testing program to provide the most comprehensive and reliable data obtainable within reasonable cost. The primary purposes of the testing program were to conduct a laboratory and field validation study on the Modified Method 5 sampling train and to perform an emission characterization evaluation for particulate matter, toluene soluble organic compounds, condensible particulate matter, multiple-metals, semi-volatile organic quantitative compounds, volatile organic quantitative compounds, and continuous emissions monitoring for sulfur dioxide, nitrogen oxides, and carbon dioxide.

4.4 Data Gap Analysis

The number of potential emission sources associated with a coke oven battery, the schedule with which these sources operate, and the conditions in the immediate vicinity of these sources combine to make the execution of emission testing of these sources difficult at best. Review of numerous emission test reports for various sources associated with metallurgical coke production reveals that the simultaneous operation of 100 or more coke ovens in a single battery, all in different stages of the coking cycle, necessitates a highly labor-intensive sampling procedure if battery-wide emissions are to be accurately quantified. For example, one emission test report reviewed as part of this AP-42 section revision measured emission rates resulting from three door seals individually. Upon completion of testing on the third door seal leak, the first door seal was retested and found to have increased greatly over the short time period consumed in testing the other two door seal leaks.

Fugitive air emissions from coke oven batteries appear to vary in the amount and type of pollutants found and the fugitive emissions are dependent on the amount of time coal has been exposed to heat in the coking oven. In addition, there appears to be a relationship between the chemical composition of the particulate and the mass flow rates. The results of past visual observations and air testing indicate the need to maintain complete and accurate production records during testing, and to assume that testing results will vary across the entire coking time period. Also, volatile organic compounds (VOC) are believed to be related to the amount of light oil found in the coke oven gas, but will require additional study to substantiate the relationship.

Due in large part to the aforementioned difficulties encountered in performing emission testing at coke oven batteries, much of the available test data for this source category is not suitable for use in development of AP-42 emission factors. As a result, the particulate matter emission factors for coke production are not highly rated, and no emission factors for noncriteria pollutants and gaseous criteria pollutants have been developed for many of the sources associated with coke production. It is recommended that a series of comprehensive, EPA-sponsored emission tests be conducted for a wide range of pollutants at a number of coke oven batteries.

Table 4.4-1
List of Conversion Factors

Multiply:	by:	To obtain:
mg/dscm	4.37×10^{-4}	gr/dscf
m^2	10.764	ft^2
m^3	35.31	ft^3
m	3.281	ft
kg	2.205	lb
kPa	1.45×10^{-1}	psia
kg/Mg	2.0	lb/ton
Mg	1.1023	ton

Temperature conversion equations:

Fahrenheit to Celsius:

$$°C = \frac{(°F - 32)}{1.8}$$

Celsius to Fahrenheit:

$$°F = 1.8(°C) + 32$$

4.5 References for Chapter 4.0

1. Metallurgical Coke Industry Particulate Emissions: Source Category Report, EPA-600/7-86-050, U.S. Environmental Protection Agency, Washington, DC, December 1986.

2. Final Technological Report on a Systems Analysis Study of the Integrated Iron and Steel Industry, U.S. Environmental Protection Agency, Research Triangle Park, NC, May 1969.

3. Stack Test Report for J & L Steel, Aliquippa Works, Betz Environmental Engineers, Plymouth Meeting, PA, April 1977.

4 Coke Oven Charging Emission Control Test Program, Volume I, EPA-650/2-74-062-1, U.S. Environmental Protection Agency, Washington, DC, September 1977.

5. Stack Test Report for Allied Chemical Corporation, Ashland, KY, York Research Corporation, Stamford, CT, April 1979.

6. Wet Coke Quench Tower Emission Factor Development, Dofasco, Ltd., EPA-600/X-85-340, U.S. Environmental Protection Agency, Research Triangle Park, NC, August 1982.

7. Stack Test Report for Shenango Steel, Inc., Neville Island, PA, Betz Environmental Engineers, Plymouth Meeting, PA, July 1976.

8. Stack Test Report for Republic Steel, Cleveland,OH, PEDCo (Under contract to USEPA), Weeks of October 26 and November 7, 1981. EMB Report 81-CBS-1.

9. Emission Test Report, Bethlehem Steel, Bethlehem, PA, Benzene, Coke Oven By-Product Plant, March 1981.

10. Emission Test Report, Kaiser Steel Corporation, Fontaina, CA. July 1, 1979. EMB Test Report Number 79-CKO-14.

11. Emission Test Report Wisconsin Steel, Chicago, IL. November 1977. EMB Test Report Number 77-CKO-11.

12. Locating and Estimating Air Emissions from Sources of Benzene, EPA-450/4-84-007q, U.S. Environmental Protection Agency, Research Triangle Park, NC, March 1988.

13. Locating and Estimating Air Emissions from Sources of Polycyclic Organic Matter (POM), EPA-450/4-84-007p, U.S. Environmental Protection Agency, Research Triangle Park, NC, September 1987.

14. Results of the Compliance Demonstration of the Pushing Emissions Control for B-Battery, USS Clairton Works, Clairton, PA, Keystone Environmental Resources, Inc., Monroeville, PA, April 1990.

15. Final Phase I Method Validation Report for Quantitative Coke Door Leak Measurement Study. American Iron and Steel Institute, Washington, D.C. Document No. 0284-001-350 (322) December, 1991.

16. Benzene Emissions from Coke By-Product Recovery Plants - Background Information for Proposed Standards. EPA-450/3-83-016a. United States Environmental Agency, Washington, DC. May 1984.

17. Coke Oven Battery Stacks - Background Information for Proposed Standards. Draft EIS. Office of Air Quality, Planning and Standards, Research Triangle Park, NC 27711. May 1980.

18. Coke Oven Emissions from Wet-Coal Charged By-Product Coke Oven Batteries. Draft EIS. EPA-450/3-85-028a. April 1987.

19. Analysis of Coke Oven Quench Tower Water and Coke Samples. EMB Report 79-cko-21.

20. Wet Coke Quench Tower Emission Factor Development. Dominion Foundries and Steel, Limited. Hamilton, Ontario, Canada. August 1982.

21. Emission Test Report, Bethleham Steel, Sparrows Point, Maryland. September, 1979. EMB Test Report Number 79-CKO-15.

22. Emission Test Report, CF&I Steel, Pueblo, CO. EMB Test Report Number 79-CKO-16.

23. Emission Test Report, J&L Steel, Pittsburg, PA. EMB Test Report Number 79-CKO-17.

24. Emission Test Report, National Steel, Granite City, IL. September, 1979. EMB Test Report Number 79-CKO-18.

25. Emission Test Report, Kziser Steel, Fontana, CA. August, 1980. EMB Test Report Number 80-CKO-25.

26. Testing Non-Recovery Coke Ovens for Standards Development, Jewell Coal & Coke Company, Vansant, VA. Emission Measurement Branch, United States Environmental Protection Agency, Reseach Triangle Park, North Carolina 27711. September 1992.