AP42 Section: **11.4 Calcium Carbide Manufacturing**

Title: **Comments**

Note: This material is related to a section in *AP42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the file number, the AP42 chapter and then the section. The file name "rel01_c01s02.pdf" would mean the file relates to AP42 chapter 1 section 2. The document may be out of date and related to a previous version of the section. The document has been saved for archival and historical purposes. The primary source should always be checked. If current related information is available, it will be posted on the AP42 webpage with the current version of the section.

Elkem

July 8, 1993

Mr. Ronald E. Myers
Emission Factors and Methodologies Section
Emission Inventory Branch
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Subject: **Calcium Carbide Manufacturing Update - AP - 42**

As discussed during our phone conversation of July 1, 1993, Elkem has reviewed draft Section 8.4 of AP - 42 prepared by Mr. Brian Shrager and prepared the following comments:

pg. 1 paragraph 2 - Lime for the reaction is usually made by calcining limestone in a kiln. . .

pg. 2 paragraph 1 - There are two basic types of electric arc furnaces: open and semi-covered. Elkem does not have a closed furnace. Electrode paste is fed into the electrode casings but not on a continuous basis. Molten carbide is tapped into chills not chill cars.

pg. 2 paragraph 2 - The major components of the PM are calcium and carbon compounds. Magnesium compounds are found in significantly lesser amounts.

pg. 2 paragraph 3 - To what degree is SO_x emitted from these operations? Carbon monoxide is a byproduct of calcium carbide production not formation. In semi-covered furnaces, mix is fed around the openings for the electrodes in the primary cover resulting in a mix seal. There are no furnace charge holes.

pg. 2 paragraph 4 - Again these are semi-covered furnaces with mix seals.

pg. 4 Reference 12 and pg. 5 Reference 13 - Both references report a CO_2 concentration of zero, yet you question these results. The tests were performed at different sites by different testing firms but arrived at the same conclusion. What is your reasoning for questioning both tests?

I agree - if reducing conditions are maintained and gas temps are reduced before additional O_2 mixes w/ it no CO_2 or little CO_2 should be generated.

pg. 5 paragraph 1 - The portion of furnace emissions which are ducted to scrubbers is significantly greater than 1 percent.

pg. 5 paragraph 3 - Process rates were provided to the agency following the test. It is suggested that OEPA be recontacted for this information. Then assumptions won't be necessary.

Should you require additional information please contact the writer at (412) 749-3941.

W. C. Miller

W.C. Miller
Sr. Environmental Engineer

CC: C.R. Allenbach (with attachment)

To: W.C. Miller
EDC-Pitts.

Rec. 6/7/93
CRA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

1 JUN 1993

For your Review + comment. Thanks
CRA

Dr. C. R. Allenbach
Elkem Metals Company
4625 Royal Avenue
Post Office Box 1344
Niagara Falls, New York 14302

Dear Dr. Allenbach:

As you may know, the Emission Inventory Branch of the U. S. Environmental Protection Agency (EPA) is in the process of updating the document *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources* (known more commonly as AP-42). As part of this process, we are now seeking comments on the draft sections that are to be included in this update of AP-42.

Chapter eight of AP-42 addresses the mineral products industry and is one of the chapters being updated. Enclosed is a copy of the draft Section 8.4, Calcium Carbide Manufacturing, and the corresponding background memorandum for the section. We would appreciate it if you or one of your associates would review the enclosed draft AP-42 section and background memorandum and would send us your comments. Unfortunately, we are on a very tight schedule, and it is important that we have all comments by July 2, 1993. July 30 →

The emission factors presented in AP-42 generally are based upon results from validated tests or other emission evaluations that are similar to EPA reference test methods. As a result, revisions to the emission factors presented in AP-42 sections must be supported by equivalent documentation. If you disagree with any emission factors presented in the enclosed AP-42 section or have additional supporting documentation, we would appreciate your providing either a copy of the documentation or information on how we can obtain copies of the supporting documentation.

We appreciate your cooperation and look forward to receiving your comments. If you have any questions, I can be reached by telephone at (919) 541-5407 or by fax at (919) 541-0684.

Sincerely,

Ronald E. Myers

Ronald E. Myers
Emission Factors and Methodologies Section
Emission Inventory Branch

2 Enclosures

Called July 1 & got extension

MRI

MIDWEST RESEARCH INSTITUTE
Suite 350
401 Harrison Oaks Boulevard
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FAX (919) 677-0065

Rec.
6/7/93
CRA

Date: April 12, 1993

Subject: Background Information for Revised AP-42 Section 8.4, Calcium Carbide Manufacturing
Review and Update Remaining Sections of Chapter 8 (Mineral Products Industry) of AP-42
EPA Contract 68-D2-0159, Work Assignment 012
MRI Project 3612

From: Brian Shrager

To: Ron Myers
EPA/EIB/EFMS (MD-14)
U. S. Environmental Protection Agency
Research Triangle Park, N.C. 27711

I. INTRODUCTION

This memorandum presents the background information that was used to develop the revised AP-42 Section 8.4 on calcium carbide manufacturing. A description of the industry is presented first. A process description followed by a discussion of emissions and controls is then presented. Following these sections, the references that were used to develop the draft section are described. A review of the information contained in the background file for the section is then presented, followed by a discussion of the results of the data analysis. Finally, a list of references is provided. The draft AP-42 section is provided as the attachment.

II. DESCRIPTION OF THE INDUSTRY[1]

Calcium carbide (CaC_2) is manufactured by heating a lime and carbon mixture to 2000° to 2100°C (3632° to 3812°F) in an electric arc furnace. At those temperatures, the lime is reduced by carbon to calcium carbide and carbon monoxide (CO), according to the following reaction:

$$CaO + 3C \rightarrow CaC_2 + CO$$

Lime for the reaction is usually made by ~~reducing~~ calcining limestone in a kiln at the plant site. The sources of carbon for the reaction are petroleum coke, metallurgical coke, or anthracite coal. Because impurities in the furnace charge remain in the calcium carbide product, the lime should contain no more than 0.5 percent each of magnesium oxide, aluminum oxide, and iron oxide and 0.004 percent phosphorus. Also, the coke or coal charge should be low in ash and sulfur. Analyses indicate that 0.2 to 1.0 percent ash and 5 to 6 percent sulfur are typical in petroleum coke. About 991 kilograms (kg) (2,185 pounds [lb]) of lime, 683 kg (1,506 lb) of coke, and 17 to 20 kg (37 to 44 lb) of electrode paste are required to produce 1 megagram (2,205 lb) of calcium carbide.

Calcium carbide is used primarily in generating acetylene and desulfurizing iron. The Standard Industrial Classification (SIC) code for calcium carbide manufacturing is 2819, industrial inorganic chemicals, not elsewhere classified. The six-digit Source Classification Code (SCC) for calcium carbide manufacturing is 3-05-004.

III. PROCESS DESCRIPTION

The process for manufacturing calcium carbide is illustrated in Figure 1. Moisture is removed from coke in a coke dryer, while limestone is converted to lime in a lime kiln. Fines from coke drying and lime operations are removed and may be recycled. The two charge materials are then conveyed to an electric arc furnace, the primary piece of equipment used to produce calcium carbide. There are two basic types of electric arc furnaces: the open furnace, in which the CO burns to carbon dioxide (CO_2) when it contacts the air above the charge, and the ~~closed~~ furnace, in which the gas is collected from the furnace and either used as fuel for other processes or flared. Electrode paste composed of coal tar pitch binder and anthracite coal is ~~continuously~~ fed into a steel casing, in which it is baked by heat from the electric arc furnace before being introduced into the furnace. The baked electrode exits the steel casing just inside the furnace cover and is consumed in the calcium carbide production process. Molten calcium carbide is tapped continuously from the furnace into chill ~~cars~~ and is allowed to cool and solidify. Then, the solidified calcium carbide goes through primary crushing by jaw crushers, followed by secondary crushing and screening for size. To prevent explosion hazards from acetylene generated by the reaction of calcium carbide with ambient moisture, crushing and screening operations may be performed in an air-swept environment before the calcium carbide has completely cooled or in an inert atmosphere. The calcium carbide product is used primarily in generating acetylene and in desulfurizing iron.

Semi-Covered

?

IV. EMISSIONS AND CONTROLS

Emissions from calcium carbide manufacturing include particulate matter (PM), sulfur oxides (SO_x), CO, CO_2, and hydrocarbons. Particulate matter is emitted from a variety of equipment and operations in the production of calcium carbide, including the coke dryer, lime kiln, electric furnace, tap fume vents, furnace room vents, primary and secondary crushers, and conveying equipment. (Lime kiln emission factors are presented in Section 8.15). Particulate matter emitted from a process source such as an electric furnace is ducted to a PM control device, usually a fabric filter or wet scrubber. Fugitive PM from sources such as tapping operations, the furnace room, and conveyors is captured and sent to a PM control device. The composition of the PM varies according to the specific equipment or operation, but the primary components are magnesium, calcium, and carbon compounds.

to what degree

[Sulfur oxides are emitted by the electric furnace from volatilization and oxidation of sulfur in the coke feed and by the coke dryer and lime kiln from fuel combustion. These process sources are not controlled specifically for SO_x emissions.] Carbon monoxide is a byproduct of calcium carbide production formation in the electric furnace. Carbon monoxide emissions to the atmosphere are usually negligible. In open furnaces, CO is oxidized to CO_2, thus eliminating CO emissions. In ~~closed~~ furnaces, a portion of the generated CO is burned in the flames surrounding the furnace charge holes, and the remaining CO is used as fuel for other processes or is flared.

Semi-Covered

?

The only potential source of hydrocarbon emissions from the manufacture of calcium carbide is the coal tar pitch binder in the furnace electrode paste. Because the maximum volatiles content in the electrode paste is about 18 percent, the electrode paste represents only a small potential source of hydrocarbon emissions. In closed furnaces, actual hydrocarbon emissions from the consumption of electrode paste typically ~~are~~ negligible due to high furnace operating temperature and flames ?

Semi-Covered

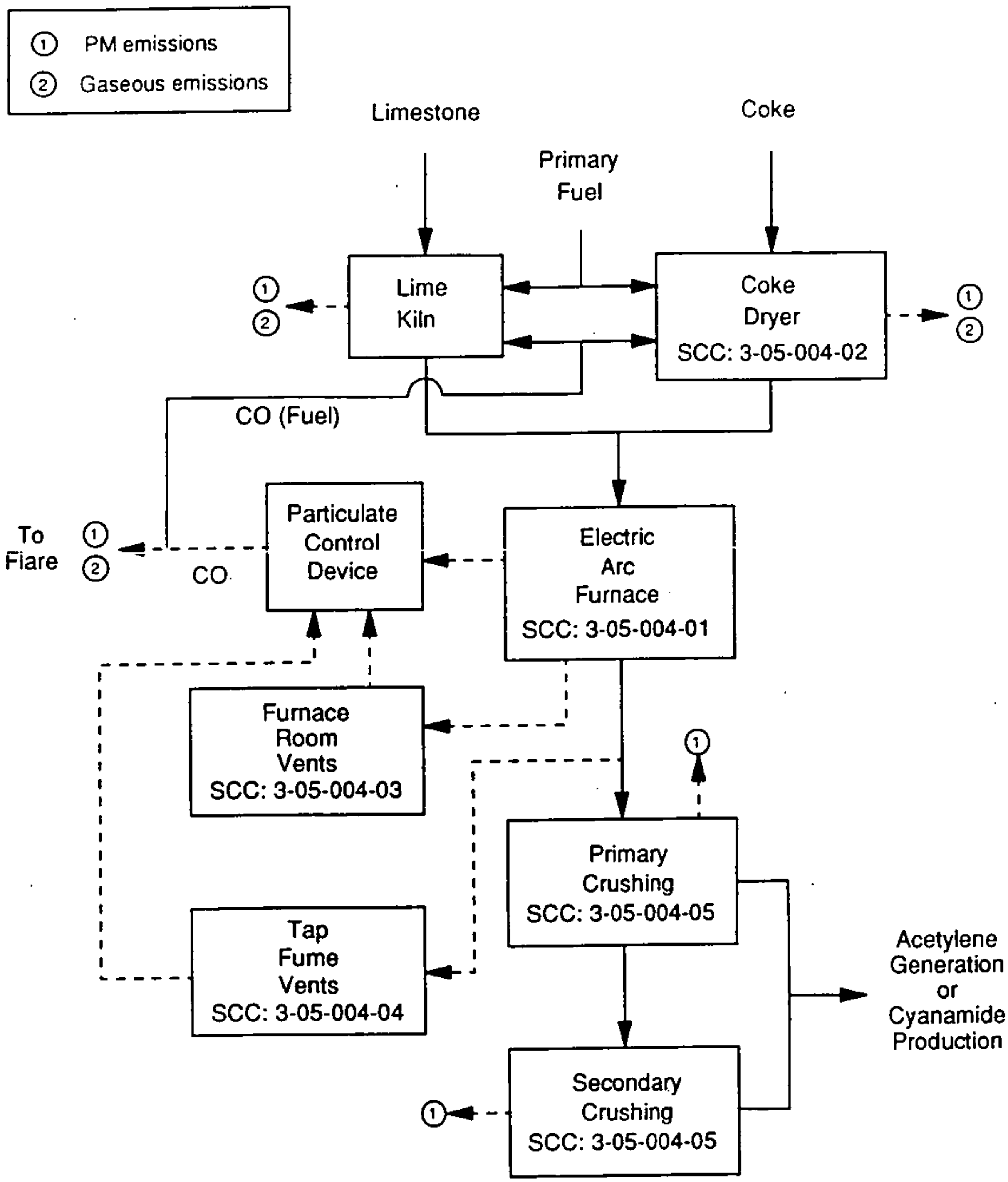

Figure 1. Process flow diagram for calcium carbide manufacturing.

surrounding the furnace charge holes. Hydrocarbon emissions from open furnaces are also expected to be negligible because of high furnace operating temperatures and the presence of excess oxygen above the furnace.

V. DESCRIPTION OF REFERENCES

This section describes the additional primary references that contain data on emissions from calcium carbide manufacturing that were used to develop emission factors for inclusion in the draft AP-42 section. Reference numbers for new references begin at No. 12 because there are 11 references (reviewed in Section VI of this memo, REVIEW OF THE BACKGROUND FILE) from the existing AP-42 section. Data from References 1, 4, 8, and 9 were used to develop emission factors and are discussed in Section VI.

A. Reference 12

This test report includes measurements of filterable PM and CO_2 emissions from an electric arc furnace and a carbide cooling conveyor at the Airco Carbide facility in Calvert City, Kentucky. The emissions from both sources are ducted to the furnace fabric filtration system, which consists of a baghouse and four stacks, one of which was not in operation during the test. Filterable PM emissions were measured using an EPA Method 5 sampling train for three test runs conducted at the southwest stack. Total filterable PM emissions were estimated by calculating the total volumetric flow rate through the three operating stacks, dividing this total flow rate by the southwest stack flow rate, and multiplying this ratio by the filterable PM mass flux. Flue gas composition was analyzed using Orsat, and CO_2 concentrations are reported as zero. However, these results are questionable because CO_2 emissions from the furnace should be significant.

A rating of B was assigned to the test data for controlled filterable PM emissions. The report included adequate detail, the test methodology was sound, and no problems were reported during the valid test runs. However, the procedure used for estimating the total emissions from all three stacks may have introduced a small degree of error, so the data could not be rated A. The emission data for this test are summarized in Table 1.

TABLE 1. SUMMARY OF EMISSION DATA FROM CALCIUM CARBIDE MANUFACTURING TEST REPORTS[a]

Source	Type of control	Pollutant	No. of test runs	Data rating	Emission factor range, kg/Mg (lb/ton)	Average emission factor, kg/Mg (lb/ton)	Ref No.
Electric arc furnace and CaC_2 cooler	Fabric filter	Filterable PM	3	B	0.015-0.055[b] (0.03-0.11)	0.035[b] (0.07)	12
Electric arc furnace	Fabric filter	Filterable PM	6	B	0.25-0.64 (0.50-1.27)	0.43 (0.85)	13
Electric arc furnace	Fabric filter	Condensible inorganic PM	3	B	0.50-0.79 (0.99-1.57)	0.60 (1.19)	13

[a]Emission factors in units of raw material feed (coke and lime) unless noted.
[b]Emission factor in units of calcium carbide produced.

B. Reference 13

This reference, provided by the State of Ohio EPA, includes the results of two emission tests conducted on a calcium carbide electric arc furnace at the Elkem Metals Company in Ashtabula, Ohio. The tests were conducted on September 21, 1992 and March 21, 1989. Controlled emissions of filterable PM and condensible inorganic PM from the No. 13 furnace were quantified using an EPA Method 5 sampling train (front- and back-half analyses) for three test runs. Emissions were measured at the outlet of the fabric filtration system that controls PM emissions from the furnace. A portion of the furnace emissions (~ 1 percent) are ducted to a set of scrubbers, but these emissions were not quantified during the testing and are not considered significant. During the 1992 test, the average differential pressure drop across the baghouse was 2.5 inches of water. Carbon dioxide concentrations in the exhaust gas were measured using Orsat and are reported as zero. However, these results are suspect because CO_2 emissions should have been significant.

A rating of B was assigned to the test data for controlled filterable PM and condensible inorganic PM emissions. The report included adequate detail, the test methodology was sound, and no problems were reported during the valid test runs. However, the process rate (feed) from the 1992 test was used for calculating emission factors for the 1989 test because no process rate was provided for the 1989 test. In addition, the condensible PM data from the 1992 test were not used because there appeared to be an error made either in the reporting of the data or in the calculations, but the error could not be traced. The emission data for this test are summarized in Table 1. ?

VI. REVIEW OF THE BACKGROUND FILE

The current version of AP-42 Section 8.12 is based on 11 references. Reference 1 is a compilation of operating permits for calcium carbide manufacturing equipment at Airco Carbide Division (Airco), located in Louisville, Kentucky. Undocumented secondary emission data are presented in Reference 1 and are used to develop emission factors for sources and controls for which no other data are available. Reference 2 provides details about the process operations at Airco and contains process rates for various operations that are used in conjunction with emission data from Reference 1 for emission factor development. Reference 3 is a memorandum stating that volatile organic compound (VOC) emissions from the closed-top electric arc furnace at Airco are negligible. No usable emission data are presented in Reference 3. Reference 4 documents an emission test conducted at Airco in 1975. Filterable PM tests and flue gas analyses were performed at the inlet and outlet of a scrubber that controlled furnace emissions. Process rates could not be located in the document, but the filterable PM emission factors already included in the AP-42 section are assumed to be valid and will be presented in the revised section. The results of this test are summarized in Table 2. Reference 5 is a document describing calcium carbide manufacturing operations at Airco during the early 1970's. No emission data are presented in Reference 5. Reference 6 contains a description of the calcium carbide manufacturing industry and the chemical properties of calcium carbide but does not contain emission data for emission factor development. Reference 7 also provides only a description of the calcium carbide manufacturing industry. Reference 8 is a test report documenting the results of a 1978 compliance test on a calcium carbide electric arc furnace at Midwest Carbide Corporation in Pryor, Oklahoma. Controlled filterable and condensible inorganic PM emissions were quantified using an EPA Method 5-type sampling train (front- and back-half analyses) at the outlets of the three baghouses that controlled furnace emissions. The results of this test are summarized in Table 2. Reference 9 is an emission test report that could not be located for review. The existing emission factors from this document are assumed to represent filterable PM and are included in Table 2, as well as in the revised AP-42 section. Reference 10 is a document that No

TABLE 2. SUMMARY OF EMISSION DATA FROM AP-42 BACKGROUND FILE REFERENCES[a]

Source	Type of control	Pollutant	No. of test runs	Data rating	Emission factor range, kg/Mg (lb/ton)	Average emission factor, kg/Mg (lb/ton)	Ref No.
Coke dryer	None	Filterable PM	NA	D	NA	1.0 (2.0)	b
Coke dryer	None	SO_x	NA	D	NA	1.5 (3.0)	b
Coke dryer	Fabric filter	Filterable PM	NA	D	NA	0.13 (0.26)	1
Tap fume vents	Fabric filter	Filterable PM	NA	D	NA	0.07 (0.14)	1
Furnace room vents	None	Filterable PM	NA	D	NA	13 (26)	b
Furnace room vents	Fabric filter	Filterable PM	NA	D	NA	0.07 (0.14)	1
Primary and secondary crushing	Fabric filter	Filterable PM	NA	D	NA	0.055 (0.11)	1
Circular charging conveyor	Fabric filter	Filterable PM	NA	D	NA	0.11 (0.22)	1
Electric furnace main stack[c]	None	Filterable PM	NA	C	NA	13 (26)	4
Electric furnace main stack[c]	None	SO_x	NA	D	NA	1.5 (3.0)	b
Electric furnace main stack[c]	Scrubber	Filterable PM	NA	C	NA	0.25 (0.50)	4
Electric furnace main stack[c]	Fabric filter	Filterable PM	3	B	0.18-0.24 (0.36-0.47)	0.20 (0.40)	8
Electric furnace main stack[c]	Fabric filter	Condensible inorganic PM	3	B	0.060-0.21 (0.12-0.41)	0.14 (0.27)	8
Electric furnace main stack[c]	Fabric filter	Filterable PM	NA	C	NA	0.36 (0.72)	9

NA = not available.

[a] Emission factors in units of raw material feed unless noted. Furnace feed: coke and lime. Coke dryer feed: coke. Tap fume vent feed: coke and lime. Furnace room vent feed: coke and lime. Crusher feed: calcium carbide. Charging conveyor feed: coke and lime.

[b] From previous AP-42 section; reference not identified.

[c] Emission factors applicable to open furnaces using petroleum coke.

Engineering Calculations that provides two tables documenting chemical properties of different types of coke and combustion properties of coal and coke constituents. No emission data are presented in Reference 11.

Emission data from secondary references, such as Reference 1, generally are not used to develop emission factors for AP-42. However, because other test data are lacking, emission factors developed from Reference 1 have been included in the revised AP-42 section. These emission factors should be useful for order of magnitude estimates and are assigned a rating of E.

VII. RESULTS OF DATA ANALYSIS

Emission factors were developed using data from Reference 1 for sources for which no other data were available. Emission factors for electric arc furnaces were calculated using References 4, 8, and 13. Emission factors developed from Reference 4 data were assigned an E rating because the emission factors were developed from C-rated data from a single source. These emission factors represent uncontrolled filterable PM emissions and filterable PM emissions controlled by two scrubbers (scrubber parameters were not provided). Filterable PM and condensible inorganic PM emission factors for fabric filter- controlled electric furnaces were calculated using data from References 8 and 13 and are assigned a C rating because B-rated data from two sources were used, and an emission factor rating of C is the highest rating that can be assigned to an emission factor developed from B-rated data. The data from Reference 9 representing fabric filter-controlled electric furnaces were not used because C-rated data cannot be combined with B-rated data. Filterable PM emission factors for an electric furnace and calcium carbide cooling conveyor combination were developed from data from Reference 12 and were assigned a D rating because they were developed from data from a single source. Uncontrolled emission factors for filterable PM and SO_x emissions from coke dryers and electric furnaces (from previous AP-42 section--unspecified references section) were assigned an E rating because the references could not be reviewed. Table 3 summarizes the calcium carbide manufacturing emission factors that have been incorporated in the revised AP-42 Section 8.12.

Elkern

TABLE 3. SUMMARY OF EMISSION FACTORS FOR CALCIUM CARBIDE MANUFACTURING[a]

Process	Pollutant	No. of tests	Average emission factor, kg/Mg (lb/ton)	Emission factor rating	Ref No.
Coke dryer	Filterable PM	NA	1.0 (2.0)	E	b
Coke dryer	SO_x	NA	1.5 (3.0)	E	b
Coke dryer with fabric filter	Filterable PM	NA	0.13 (0.26)	E	1
Tap fume vents with fabric filter	Filterable PM	NA	0.07 (0.14)	E	1
Furnace room vents	Filterable PM	NA	13 (26)	E	b
Furnace room vents with fabric filter	Filterable PM	NA	0.07 (0.14)	E	1
Primary and secondary crushing with fabric filter	Filterable PM	NA	0.055 (0.11)	E	1
Circular charging conveyor with fabric filter	Filterable PM	NA	0.11 (0.22)	E	1
Electric furnace main stack[c]	Filterable PM	1	13 (26)	E	4
Electric furnace main stack[c]	SO_x	NA	1.5 (3.0)	E	b
Electric furnace main stack with scrubber[c]	Filterable PM	1	0.25 (0.50)	E	4
Electric furnace main stack with fabric filter[c]	Filterable PM	2	0.32 (0.63)	C	~~8, 13~~ Elkem
Electric furnace main stack with fabric filter[c]	Condensible inorganic PM	2	0.37 (0.73)	C	~~8, 13~~ Elkem
Electric furnace and calcium carbide cooling conveyor with fabric filter[c]	Filterable PM	1	0.035[d] (0.070)	D	12

NA = not available.
[a]Emission factors in units of raw material feed unless noted. Furnace feed: coke and lime. Coke dryer feed: coke. Tap fume vent feed: coke and lime. Furnace room vent feed: coke and lime. Crusher feed: calcium carbide. Charging conveyor feed: coke and lime.
[b]From previous AP-42 section; reference not specified.
[c]Emission factors applicable to open furnaces using petroleum coke.
[d]Emission factor in units of calcium carbide produced.

VIII. REFERENCES

1. "Permits to Operate: Airco Carbide, Louisville, Kentucky," Jefferson County Air Pollution Control District, Louisville, KY, December 16, 1980.

2. "Manufacturing or Processing Operations: Airco Carbide, Louisville, Kentucky," Jefferson County Air Pollution Control District, Louisville, KY, September 1975.

3. Written communication from A. J. Miles, Radian Corp., Durham, NC, to Douglas Cook, U. S. Environmental Protection Agency, Atlanta, GA, August 20, 1981.

4. "Furnace Offgas Emissions Survey: Airco Carbide, Louisville, Kentucky," Environmental Consultants, Inc., Clarksville, IN, March 17, 1975.

5. J. W. Frye, "Calcium Carbide Furnace Operation," Electric Furnace Conference Proceedings, American Institute of Mechanical Engineers, NY, December 9-11, 1970.

6. The Louisville Air Pollution Study, U.S. Department of Health and Human Services, Robert A. Taft Center, Cincinnati, OH, 1961.

7. R. N. Shreve and J. A. Brink, Jr., Chemical Process Industries, Fourth Edition, McGraw-Hill Company, NY, 1977.

8. J. H. Stuever, "Particulate Emissions - Electric Carbide Furnace Test Report: Midwest Carbide, Pryor, Oklahoma," Stuever and Associates, Oklahoma City, OK, April 1978.

9. L. Thomsen, "Particulate Emissions Test Report: Midwest Carbide, Keokuk, Iowa," Being Consultants, Inc., Moline, IL, July 1, 1980.

10. D. M. Kirkpatrick, "Acetylene from Calcium Carbide Is an Alternate Feedstock Route," Oil and Gas Journal, June 7, 1976.

11. L. Clarke and R. L. Davidson, Manual for Process Engineering Calculations, Second Edition, McGraw-Hill Company, NY, 1962.

12. "Test Report: Particulate Emissions-Electric Carbide Furnace, Midwest Carbide Corporation, Pryor, Oklahoma," Stuever and Associates, Oklahoma City, Oklahoma, April 1978.

13. Letter from C. McPhee, State of Ohio EPA, Twinsburg, Ohio, to R. Marinshaw, Midwest Research Institute, Cary, NC, March 16, 1993.

ATTACHMENT

DRAFT AP-42 SECTION 8.4

8.4 CALCIUM CARBIDE MANUFACTURING

8.4.1 General

Calcium carbide (CaC_2) is manufactured by heating a lime and carbon mixture to 2000° to 2100°C (3632° to 3812°F) in an electric arc furnace. At those temperatures, the lime is reduced by carbon to calcium carbide and carbon monoxide (CO), according to the following reaction:

$$CaO + 3C \rightarrow CaC_2 + CO$$

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Lime for the reaction is usually made by ~~reducing~~ limestone in a kiln at the plant site. The sources of carbon for the reaction are petroleum coke, metallurgical coke, and anthracite coal. Because impurities in the furnace charge remain in the calcium carbide product, the lime should contain no more than 0.5 percent each of magnesium oxide, aluminum oxide, and iron oxide and 0.004 percent phosphorus. Also, the coke charge should be low in ash and sulfur. Analyses indicate that 0.2 to 1.0 percent ash and 5 to 6 percent sulfur are typical in petroleum coke. About 991 kilograms (kg) (2,185 pounds [lb]) of lime, 683 kg (1,506 lb) of coke, and 17 to 20 kg (37 to 44 lb) of electrode paste are required to produce 1 megagram (2,205 lb) of calcium carbide.

The process for manufacturing calcium carbide is illustrated in Figure 8.4-1. Moisture is removed from coke in a coke dryer, while limestone is converted to lime in a lime kiln. Fines from coke drying and lime operations are removed and may be recycled. The two charge materials are then conveyed to an electric arc furnace, the primary piece of equipment used to produce calcium carbide. There are two basic types of electric arc furnaces: the open furnace, in which the CO burns to carbon dioxide (CO_2) when it contacts the air above the charge, and the closed furnace, in which the gas is collected from the furnace and either used as fuel for other processes or flared. Electrode paste composed of coal tar pitch binder and anthracite coal is continuously fed into a steel casing, where it is baked by heat from the electric arc furnace before being introduced into the furnace. The baked electrode exits the steel casing just inside the furnace cover and is consumed in the calcium carbide production process. Molten calcium carbide is tapped continuously from the furnace into chill

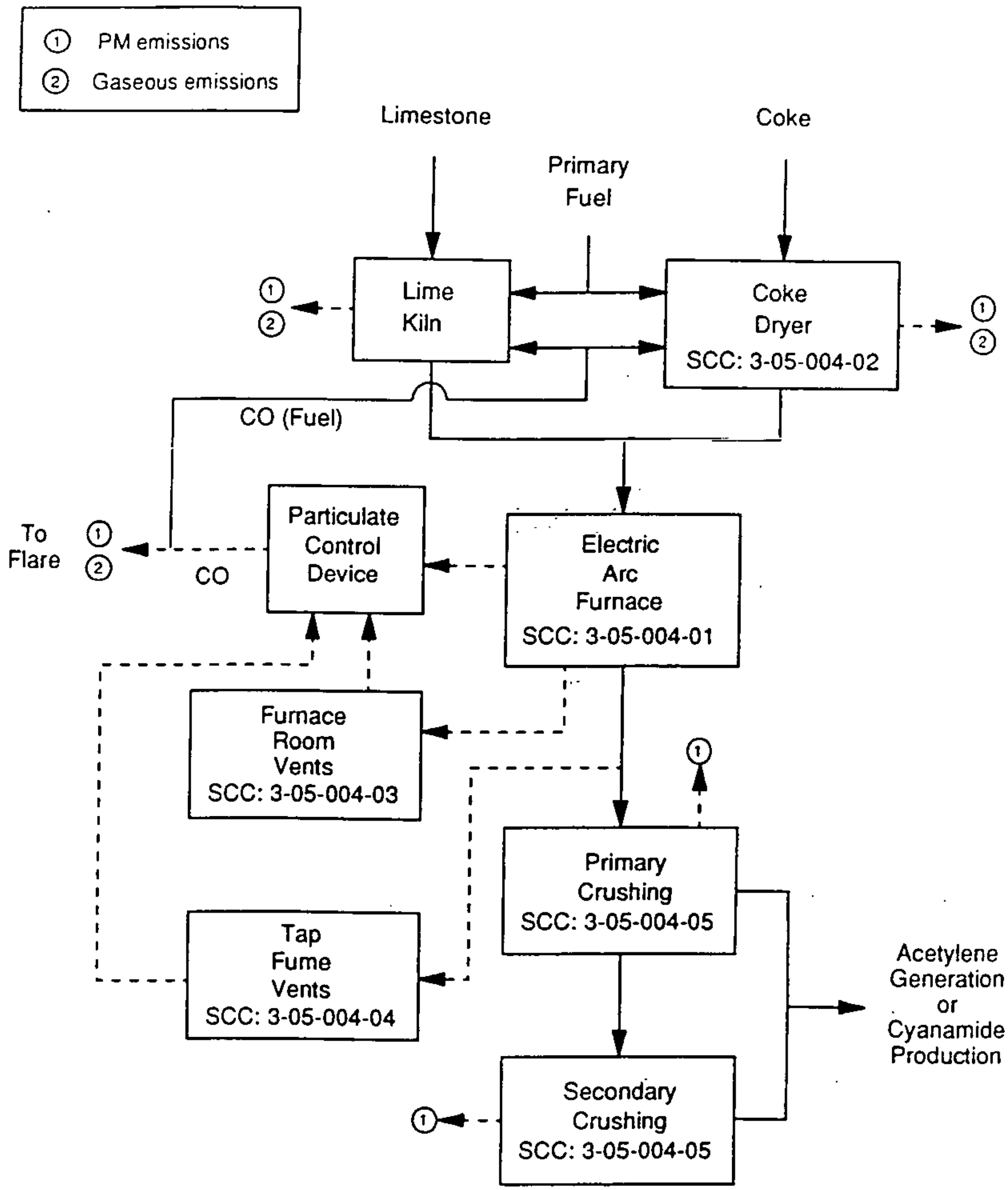

Figure 8.4-1. Process flow diagram for calcium carbide manufacturing.

cars and is allowed to cool and solidify. Then, the solidified calcium carbide goes through primary crushing by jaw crushers, followed by secondary crushing and screening for size. To prevent explosion hazards from acetylene generated by the reaction of calcium carbide with ambient moisture, crushing and screening operations may be performed in an air-swept environment before the calcium carbide has completely cooled or in an inert atmosphere. The calcium carbide product is used primarily in acetylene generation and also as a desulfurizer of iron.

8.4.2 Emissions and Controls

Emissions from calcium carbide manufacturing include particulate matter (PM), sulfur oxides (SO_x), CO, CO_2, and hydrocarbons. Particulate matter is emitted from a variety of equipment and operations in the production of calcium carbide, including the coke dryer, lime kiln, electric furnace, tap fume vents, furnace room vents, primary and secondary crushers, and conveying equipment. (Lime kiln emission factors are presented in Section 8.15). Particulate matter emitted from a process source such as an electric furnace is ducted to a PM control device, usually a fabric filter or wet scrubber. Fugitive PM from sources such as tapping operations, the furnace room, and conveyors is captured and sent to a PM control device. The composition of the PM varies according to the specific equipment or operation, but the primary components are magnesium, calcium, and carbon compounds.

Sulfur oxides are emitted by the electric furnace from volatilization and oxidation of sulfur in the coke feed and by the coke dryer and lime kiln from fuel combustion. These process sources are not controlled specifically for SO_x emissions. Carbon monoxide is a byproduct of calcium carbide formation in the electric furnace. Carbon monoxide emissions to the atmosphere are usually negligible. In open furnaces, CO is oxidized to CO_2, thus eliminating CO emissions. In closed furnaces, a portion of the generated CO is burned in the flames surrounding the furnace charge holes, and the remaining CO is used as fuel for other processes or is flared.

The only potential source of hydrocarbon emissions from the manufacture of calcium carbide is the coal tar pitch binder in the furnace electrode paste. Since the maximum volatiles content in the electrode paste is about 18 percent, the electrode paste represents only a small potential source of hydrocarbon emissions. In closed furnaces, actual hydrocarbon emissions from the consumption of electrode paste typically are negligible due to high furnace operating temperature and flames

surrounding the furnace charge holes. Hydrocarbon emissions from open furnaces are also expected to be negligible because of high furnace operating temperatures and the presence of excess oxygen above the furnace.

Table 8.4-1 gives controlled and uncontrolled emission factors for various processes in the manufacture of calcium carbide. Controlled factors are based on test data and permitted emissions for operations with the fabric filters and wet scrubbers that are typically used to control PM emissions in calcium carbide manufacturing.

TABLE 8.4-1 (METRIC UNITS) EMISSION FACTORS FOR CALCIUM CARBIDE MANUFACTURING[a]

All Emission Factors in kg/Mg of Feed Unless Noted
Ratings A-E Follow Each Emission Factor

Process (SCC)	Filterable PM[b]		Condensible Inorganic PM[c]		Sulfur oxides	
Electric furnace main stack (3-05-004-01)[d]	13[e]	E	ND		1.5[f]	E
Electric furnace main stack with fabric filter (3-05-004-01)[d]	0.32[g]	C	0.37[g]	C	ND	
Electric furnace main stack with scrubber (3-05-004-01)[d]	0.25[e]	E	ND		ND	
Electric furnace and calcium carbide cooling conveyor with fabric filter (3-05-004-__)[d]	0.035[h]	D	ND		ND	
Coke dryer (3-05-004-02)	1.0[f]	E	ND		1.5[f]	E
Coke dryer with fabric filter (3-05-004-02)	0.13[i]	E	ND		NA	
Furnace room vents (3-05-004-03)	13[f]	E	ND		ND	
Furnace room vents with fabric filter (3-05-004-03)	0.07[i]	E	ND		ND	
Tap fume vents with fabric filter (3-05-004-04)	0.07[i]	E	ND		ND	
Primary and secondary crushing with fabric filter (3-05-004-05)	0.055[i]	E	ND		NA	
Circular charging conveyor with fabric filter (3-05-004-0	0.11[i]	E	ND		NA	

NA = not applicable; ND = no data available.

[a]Emission factors represent uncontrolled emissions unless otherwise noted. Feed materials: electric furnace--coke and lime; coke dryer--coke; tap fume vent-- coke and lime; furnace room vent--coke and lime; crusher--calcium carbide; charging conveyor--coke and lime.

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

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

[d]Emission factors applicable to open furnaces using petroleum coke.

[e]Reference 4.

[f]From previous AP-42 section; *reference not specified.*

[g]References 8 and 13.

[h]Reference 12; emission factor in kg/Mg of calcium carbide produced.

[i]Reference 1.

TABLE 8.4-1 (ENGLISH UNITS) EMISSION FACTORS FOR CALCIUM CARBIDE MANUFACTURING[a]

All Emission Factors in lb/ton of Feed Unless Noted
Ratings A-E Follow Each Emission Factor

Process (SCC)	Filterable PM[b]		Condensible Inorganic PM[c]		Sulfur oxides	
Electric furnace main stack (3-05-004-01)[d]	26[e]	E	ND		3.0[f]	E
Electric furnace main stack with fabric filter (3-05-004-01)[d]	0.63[g]	C	0.73[g]	C	ND	
Electric furnace main stack with scrubber (3-05-004-01)[d]	0.50[e]	E	ND		ND	
Electric furnace and calcium carbide cooling conveyor with fabric filter (3-05-004-__)[d]	0.070[h]	D	ND		ND	
Coke dryer (3-05-004-02)	2.0[f]	E	ND		3.0[f]	E
Coke dryer with fabric filter (3-05-004-02)	0.26[i]	E	ND		NA	
Furnace room vents (3-05-004-03)	26[f]	E	ND		ND	
Furnace room vents with fabric filter (3-05-004-03)	0.14[i]	E	ND		ND	
Tap fume vents with fabric filter (3-05-004-04)	0.14[i]	E	ND		ND	
Primary and secondary crushing with fabric filter (3-05-004-05)	0.11[i]	E	ND		NA	
Circular charging conveyor with fabric filter (3-05-004-06)	0.22[i]	E	ND		NA	

NA = not applicable; ND = no data available.

[a]Emission factors represent uncontrolled emissions unless otherwise noted. Feed materials: electric furnace--coke and lime; coke dryer--coke; tap fume vent-- coke and lime; furnace room vent--coke and lime; crusher--calcium carbide; charging conveyor--coke and lime.

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

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

[d]Emission factors applicable to open furnaces using petroleum coke.

[e]Reference 4.

[f]From previous AP-42 section; reference not specified.

[g]References 8 and 13.

[h]Reference 12; emission factor in lb/ton of calcium carbide produced.

[i]Reference 1.

References for Section 8.4

1. "Permits to Operate: Airco Carbide, Louisville, Kentucky," Jefferson County Air Pollution Control District, Louisville, KY, December 16, 1980.

2. "Manufacturing or Processing Operations: Airco Carbide, Louisville, Kentucky," Jefferson County Air Pollution Control District, Louisville, KY, September 1975.

3. Written communication from A. J. Miles, Radian Corp., Durham, NC, to Douglas Cook, U. S. Environmental Protection Agency, Atlanta, GA, August 20, 1981.

4. "Furnace Offgas Emissions Survey: Airco Carbide, Louisville, Kentucky," Environmental Consultants, Inc., Clarksville, IN, March 17, 1975.

5. J. W. Frye, "Calcium Carbide Furnace Operation," Electric Furnace Conference Proceedings, American Institute of Mechanical Engineers, NY, December 9-11, 1970.

6. The Louisville Air Pollution Study, U.S. Department of Health and Human Services, Robert A. Taft Center, Cincinnati, OH, 1961.

7. R. N. Shreve and J. A. Brink, Jr., Chemical Process Industries, Fourth Edition, McGraw-Hill Company, NY, 1977.

8. J. H. Stuever, "Particulate Emissions - Electric Carbide Furnace Test Report: Midwest Carbide, Pryor, Oklahoma," Stuever and Associates, Oklahoma City, OK, April 1978.

9. L. Thomsen, "Particulate Emissions Test Report: Midwest Carbide, Keokuk, Iowa," Being Consultants, Inc., Moline, IL, July 1, 1980.

10. D. M. Kirkpatrick, "Acetylene from Calcium Carbide Is an Alternate Feedstock Route," Oil and Gas Journal, June 7, 1976.

11. L. Clarke and R. L. Davidson, Manual for Process Engineering Calculations, Second Edition, McGraw-Hill Company, NY, 1962.

12. "Test Report: Particulate Emissions-Electric Carbide Furnace, Midwest Carbide Corporation, Pryor, Oklahoma," Stuever and Associates, Oklahoma City, Oklahoma, April 1978.

13. Letter from C. McPhee, State of Ohio EPA, Twinsburg, Ohio, to R. Marinshaw, Midwest Research Institute, Cary, NC, March 16, 1993.

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8.4 CALCIUM CARBIDE MANUFACTURING

8.4.1 General

Calcium carbide (CaC_2) is manufactured by heating a lime and carbon mixture to 2000° to 2100°C (3632° to 3812°F) in an electric arc furnace. At those temperatures, the lime is reduced by carbon to calcium carbide and carbon monoxide (CO), according to the following reaction:

$$CaO + 3C \rightarrow CaC_2 + CO$$

Lime for the reaction is usually made by reducing limestone in a kiln at the plant site. The sources of carbon for the reaction are petroleum coke, metallurgical coke, and anthracite coal. Because impurities in the furnace charge remain in the calcium carbide product, the lime should contain no more than 0.5 percent each of magnesium oxide, aluminum oxide, and iron oxide and 0.004 percent phosphorus. Also, the coke charge should be low in ash and sulfur. Analyses indicate that 0.2 to 1.0 percent ash and 5 to 6 percent sulfur are typical in petroleum coke. About 991 kilograms (kg) (2,185 pounds [lb]) of lime, 683 kg (1,506 lb) of coke, and 17 to 20 kg (37 to 44 lb) of electrode paste are required to produce 1 megagram (2,205 lb) of calcium carbide.

The process for manufacturing calcium carbide is illustrated in Figure 8.4-1. Moisture is removed from coke in a coke dryer, while limestone is converted to lime in a lime kiln. Fines from coke drying and lime operations are removed and may be recycled. The two charge materials are then conveyed to an electric arc furnace, the primary piece of equipment used to produce calcium carbide. There are two basic types of electric arc furnaces: the open furnace, in which the CO burns to carbon dioxide (CO_2) when it contacts the air above the charge, and the closed furnace, in which the gas is collected from the furnace and either used as fuel for other processes or flared. Electrode paste composed of coal tar pitch binder and anthracite coal is continuously fed into a steel casing, where it is baked by heat from the electric arc furnace before being introduced into the furnace. The baked electrode exits the steel casing just inside the furnace cover and is consumed in the calcium carbide production process. Molten calcium carbide is tapped continuously from the furnace into chill

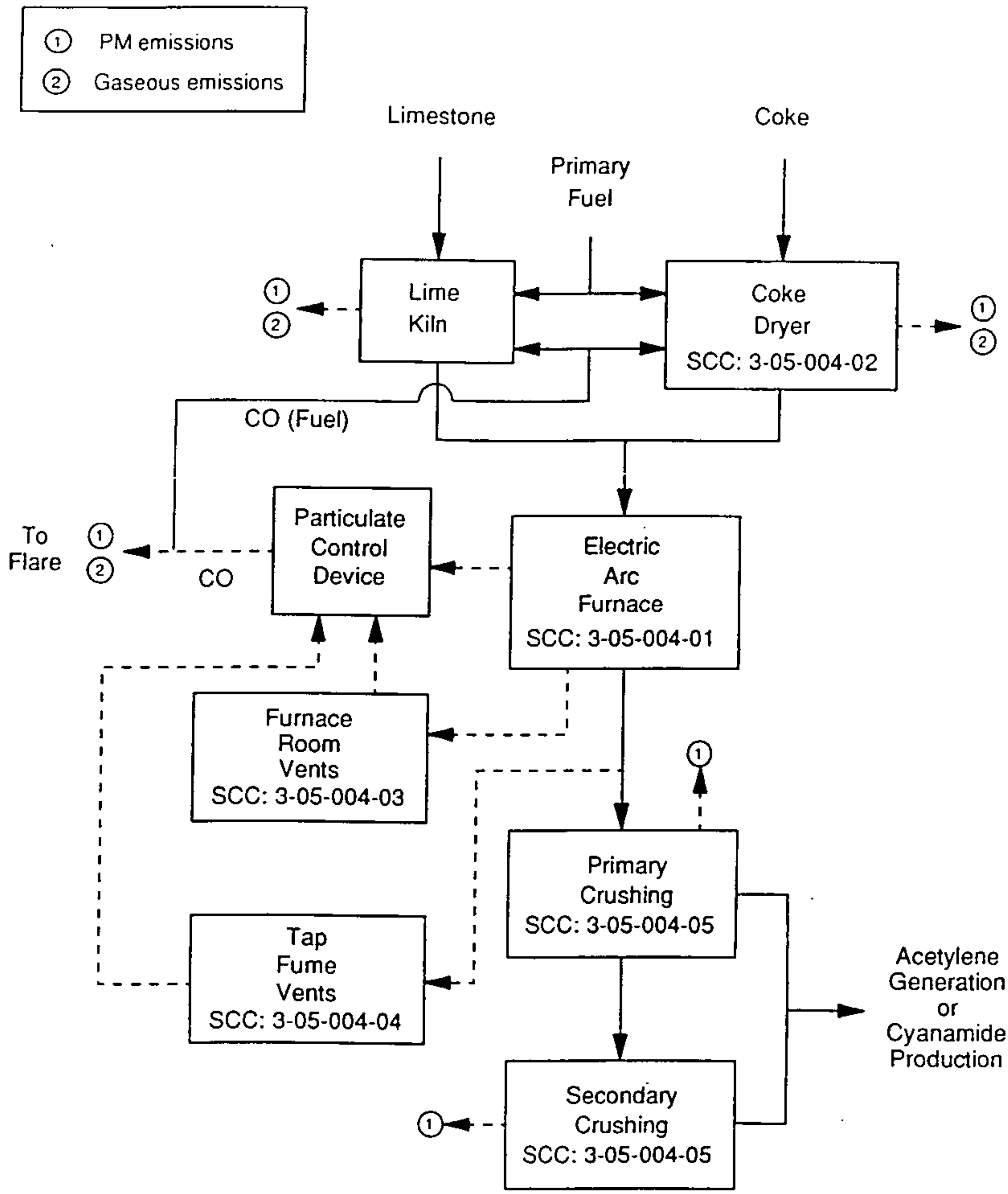

Figure 8.4-1. Process flow diagram for calcium carbide manufacturing.

cars and is allowed to cool and solidify. Then, the solidified calcium carbide goes through primary crushing by jaw crushers, followed by secondary crushing and screening for size. To prevent explosion hazards from acetylene generated by the reaction of calcium carbide with ambient moisture, crushing and screening operations may be performed in an air-swept environment before the calcium carbide has completely cooled or in an inert atmosphere. The calcium carbide product is used primarily in acetylene generation and also as a desulfurizer of iron.

8.4.2 Emissions and Controls

Emissions from calcium carbide manufacturing include particulate matter (PM), sulfur oxides (SO_x), CO, CO_2, and hydrocarbons. Particulate matter is emitted from a variety of equipment and operations in the production of calcium carbide, including the coke dryer, lime kiln, electric furnace, tap fume vents, furnace room vents, primary and secondary crushers, and conveying equipment. (Lime kiln emission factors are presented in Section 8.15). Particulate matter emitted from a process source such as an electric furnace is ducted to a PM control device, usually a fabric filter or wet scrubber. Fugitive PM from sources such as tapping operations, the furnace room, and conveyors is captured and sent to a PM control device. The composition of the PM varies according to the specific equipment or operation, but the primary components are magnesium, calcium, and carbon compounds.

Sulfur oxides are emitted by the electric furnace from volatilization and oxidation of sulfur in the coke feed and by the coke dryer and lime kiln from fuel combustion. These process sources are not controlled specifically for SO_x emissions. Carbon monoxide is a byproduct of calcium carbide formation in the electric furnace. Carbon monoxide emissions to the atmosphere are usually negligible. In open furnaces, CO is oxidized to CO_2, thus eliminating CO emissions. In closed furnaces, a portion of the generated CO is burned in the flames surrounding the furnace charge holes, and the remaining CO is used as fuel for other processes or is flared.

The only potential source of hydrocarbon emissions from the manufacture of calcium carbide is the coal tar pitch binder in the furnace electrode paste. Since the maximum volatiles content in the electrode paste is about 18 percent, the electrode paste represents only a small potential source of hydrocarbon emissions. In closed furnaces, actual hydrocarbon emissions from the consumption of electrode paste typically are negligible due to high furnace operating temperature and flames

surrounding the furnace charge holes. Hydrocarbon emissions from open furnaces are also expected to be negligible because of high furnace operating temperatures and the presence of excess oxygen above the furnace.

Table 8.4-1 gives controlled and uncontrolled emission factors for various processes in the manufacture of calcium carbide. Controlled factors are based on test data and permitted emissions for operations with the fabric filters and wet scrubbers that are typically used to control PM emissions in calcium carbide manufacturing.

TABLE 8.4-1 (METRIC UNITS) EMISSION FACTORS FOR CALCIUM CARBIDE MANUFACTURING[a]

All Emission Factors in kg/Mg of Feed Unless Noted
Ratings A-E Follow Each Emission Factor

Process (SCC)	Filterable PM[b]		Condensible Inorganic PM[c]		Sulfur oxides	
Electric furnace main stack (3-05-004-01)[d]	13[e]	E	ND		1.5[f]	E
Electric furnace main stack with fabric filter (3-05-004-01)[d]	0.32[g]	C	0.37[g]	C	ND	
Electric furnace main stack with scrubber (3-05-004-01)[d]	0.25[e]	E	ND		ND	
Electric furnace and calcium carbide cooling conveyor with fabric filter (3-05-004-__)[d]	0.035[h]	D	ND		ND	
Coke dryer (3-05-004-02)	1.0[f]	E	ND		1.5[f]	E
Coke dryer with fabric filter (3-05-004-02)	0.13[i]	E	ND		NA	
Furnace room vents (3-05-004-03)	13[f]	E	ND		ND	
Furnace room vents with fabric filter (3-05-004-03)	0.07[i]	E	ND		ND	
Tap fume vents with fabric filter (3-05-004-04)	0.07[i]	E	ND		ND	
Primary and secondary crushing with fabric filter (3-05-004-05)	0.055[i]	E	ND		NA	
Circular charging conveyor with fabric filter (3-05-004-0	0.11[i]	E	ND		NA	

NA = not applicable; ND = no data available.

[a]Emission factors represent uncontrolled emissions unless otherwise noted. Feed materials: electric furnace--coke and lime; coke dryer--coke; tap fume vent-- coke and lime; furnace room vent--coke and lime; crusher--calcium carbide; charging conveyor--coke and lime.

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

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

[d]Emission factors applicable to open furnaces using petroleum coke.

[e]Reference 4.

[f]*From previous AP-42 section; reference not specified.*

[g]References 8 and 13.

[h]Reference 12; emission factor in kg/Mg of calcium carbide produced.

[i]Reference 1.

TABLE 8.4-1 (ENGLISH UNITS) EMISSION FACTORS FOR CALCIUM CARBIDE MANUFACTURING[a]

All Emission Factors in lb/ton of Feed Unless Noted
Ratings A-E Follow Each Emission Factor

Process (SCC)	Filterable PM[b]		Condensible Inorganic PM[c]		Sulfur oxides	
Electric furnace main stack (3-05-004-01)[d]	26[e]	E	ND		3.0[f]	E
Electric furnace main stack with fabric filter (3-05-004-01)[d]	0.63[g]	C	0.73[g]	C	ND	
Electric furnace main stack with scrubber (3-05-004-01)[d]	0.50[e]	E	ND		ND	
Electric furnace and calcium carbide cooling conveyor with fabric filter (3-05-004-__)[d]	0.070[h]	D	ND		ND	
Coke dryer (3-05-004-02)	2.0[f]	E	ND		3.0[f]	E
Coke dryer with fabric filter (3-05-004-02)	0.26[i]	E	ND		NA	
Furnace room vents (3-05-004-03)	26[f]	E	ND		ND	
Furnace room vents with fabric filter (3-05-004-03)	0.14[i]	E	ND		ND	
Tap fume vents with fabric filter (3-05-004-04)	0.14[i]	E	ND		ND	
Primary and secondary crushing with fabric filter (3-05-004-05)	0.11[i]	E	ND		NA	
Circular charging conveyor with fabric filter (3-05-004-06)	0.22[i]	E	ND		NA	

NA = not applicable; ND = no data available.

[a]Emission factors represent uncontrolled emissions unless otherwise noted. Feed materials: electric furnace--coke and lime; coke dryer--coke; tap fume vent-- coke and lime; furnace room vent--coke and lime; crusher--calcium carbide; charging conveyor--coke and lime.

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

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

[d]Emission factors applicable to open furnaces using petroleum coke.

[e]Reference 4.

[f]From previous AP-42 section; reference not specified.

[g]References 8 and 13.

[h]Reference 12; emission factor in lb/ton of calcium carbide produced.

[i]Reference 1.

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12. "Test Report: Particulate Emissions-Electric Carbide Furnace, Midwest Carbide Corporation, Pryor, Oklahoma," Stuever and Associates, Oklahoma City, Oklahoma, April 1978.

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