11.4 Calcium Carbide Manufacturing

11.4.1 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 calcining 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 (Mg) (2,205 lb) of calcium carbide.

The process for manufacturing calcium carbide is illustrated in Figure 11.4-1. 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 three 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; the closed furnace, in which the gas is collected from the furnace and is either used as fuel for other processes or flared; and the semi-covered furnace, in which mix is fed around the electrode openings in the primary furnace cover resulting in mix seals. Electrode paste composed of coal tar pitch binder and anthracite coal is 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 chills 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 either 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.

11.4.2 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 11.17). 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

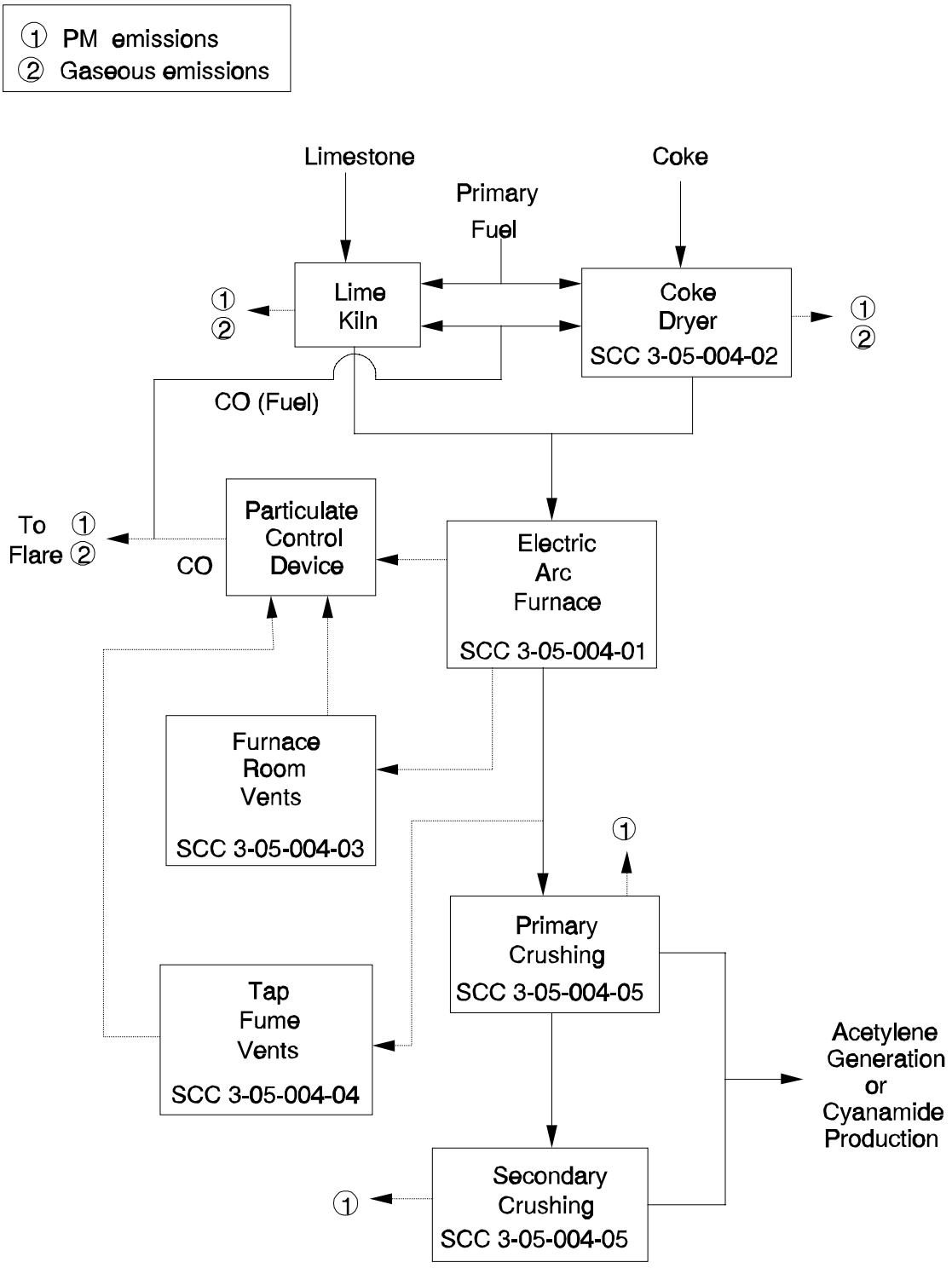

Figure 11.4-1. Process flow diagram for calcium carbide manufacturing.
(SCC = Source Classification Code).

equipment or operation, but the primary components are calcium and carbon compounds, with significantly smaller amounts of magnesium compounds.

Sulfur oxides may be emitted both 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 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 either used as fuel for other processes or is flared. In semi-covered furnaces, the CO that is generated is either used as fuel for the lime kiln or 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 because of high furnace operating temperature and flames surrounding the furnace charge holes. In open furnaces, hydrocarbon emissions are expected to be negligible because of high furnace operating temperatures and the presence of excess oxygen above the furnace. Hydrocarbon emissions from semi-covered furnaces are also expected to be negligible because of high furnace operating temperatures.

Tables 11.4-1 and 11.4-2 give controlled and uncontrolled emission factors in metric and English units, respectively, 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 11.4-1 (Metric Units). EMISSION FACTORS FOR CALCIUM CARBIDE MANUFACTURING[a]

EMISSION FACTOR RATING: E (except as noted)

Process	Filterable PM[b] (kg/Mg feed)	Condensable Inorganic PM[c] (kg/Mg feed)	Sulfur Oxides (kg/Mg feed)	CO_2 (kg/Mg feed)
Electric arc furnace main stack (SCC 3-05-004-01)[d]	13[e]	ND	1.5[f]	ND
Electric arc furnace main stack with fabric filter (SCC 3-05-004-01)[d]	0.32[g]	0.37[g]	ND	Neg[h]
Electric arc furnace main stack with scrubber (SCC 3-05-004-01)[d]	0.25[e]	ND	ND	ND
Electric arc furnace and calcium carbide cooling conveyor with fabric filter (SCC 3-05-004-__)[d]	0.035[j,k]	ND	ND	Neg[m]
Coke dryer (SCC 3-05-004-02)	1.0[f]	ND	1.5[f]	ND
Coke dryer with fabric filter (SCC 3-05-004-02)	0.13[n]	ND	NA	ND
Furnace room vents (SCC 3-05-004-03)	13[f]	ND	ND	ND
Furnace room vents with fabric filter (SCC 3-05-004-03)	0.07[n]	ND	ND	ND
Tap fume vents with fabric filter (SCC 3-05-004-04)	0.07[n]	ND	ND	ND
Primary and secondary crushing with fabric filter (SCC 3-05-004-05)	0.055[n]	ND	NA	NA
Circular charging conveyor with fabric filter (SCC 3-05-004-06)	0.11[n]	ND	NA	NA

[a] Factors are for uncontrolled emissions, unless otherwise noted. Factors are kg/Mg of feed unless 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. NA = not applicable. ND = no data. Neg = negligible. SCC = Source Classification Code.

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

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

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

[e] Reference 4.

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

[g] References 8,13. EMISSION FACTOR RATING: C.

[h] Reference 13.

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

[k] EMISSION FACTOR RATING: D.

[m] Reference 12.

[n] Reference 1.

Table 11.4-2 (English Units). EMISSION FACTORS FOR CALCIUM CARBIDE MANUFACTURING[a]

EMISSION FACTOR RATING: E (except as noted)

Process	Filterable PM[b] (lb/ton)	Condensable Inorganic PM[c] (lb/ton)	Sulfur Oxides (lb/ton)	CO_2 (lb/ton)
Electric arc furnace main stack (SCC 3-05-004-01)[d]	26[e]	ND	3.0[f]	ND
Electric arc furnace main stack with fabric filter (SCC 3-05-004-01)[d]	0.63[g]	0.73[g]	ND	Neg[h]
Electric arc furnace main stack with scrubber (SCC 3-05-004-01)[d]	0.50[e]	ND	ND	ND
Electric arc furnace and calcium carbide cooling conveyor with fabric filter (SCC 3-05-004-__)[d]	0.70[j,k]	ND	ND	Neg[m]
Coke dryer (SCC 3-05-004-02)	2.0[f]	ND	3.0[f]	ND
Coke dryer with fabric filter (SCC 3-05-004-02)	0.26[n]	ND	NA	ND
Furnace room vents (SCC 3-05-004-03)	26[f]	ND	ND	ND
Furnace room vents with fabric filter (SCC 3-05-004-03)	0.14[n]	ND	ND	ND
Tap fume vents with fabric filter (SCC 3-05-004-04)	0.14[n]	ND	ND	ND
Primary and secondary crushing with fabric filter (SCC 3-05-004-05)	0.11[n]	ND	NA	NA
Circular charging conveyor with fabric filter (SCC 3-05-004-06)	0.22[n]	ND	NA	NA

[a] Factors are for uncontrolled emissions, unless otherwise noted. Factors in lb/ton of feed unless 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. NA = not applicable. ND = no data. Neg = negligible. SCC = Source Classification Code.

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

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

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

[e] Reference 4.

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

[g] References 8,13. EMISSION FACTOR RATING: C

[h] Reference 13.

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

[k] EMISSION FACTOR RATING: D.

[m] Reference 12.

[n] Reference 1.

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