

10.7 Charcoal

10.7.1 Process Description¹⁻⁴

Charcoal is the solid carbon residue following the pyrolysis (carbonization or destructive distillation) of carbonaceous raw materials. Principal raw materials are medium to dense hardwoods such as beech, birch, hard maple, hickory, and oak. Others are softwoods (primarily long leaf and slash pine), nutshells, fruit pits, coal, vegetable wastes, and paper mill residues. Charcoal is used primarily as a fuel for outdoor cooking. In some instances, its manufacture may be considered as a solid waste disposal technique. Many raw materials for charcoal manufacture are wastes, as noted. Charcoal manufacture is also used in forest management for disposal of refuse.

Recovery of acetic acid and methanol byproducts was initially responsible for stimulating the charcoal industry. As synthetic production of these chemicals became commercialized, recovery of acetic acid and methanol became uneconomical.

Charcoal manufacturing kilns generally can be classified as either batch or continuous multiple hearth kilns; continuous multiple hearth kilns are more commonly used than are batch kilns. Batch units such as the Missouri-type charcoal kiln (Figure 10.7-1) are small manually-loaded and -unloaded kilns producing typically 16 megagrams (Mg) (17.6 tons) of charcoal during a 3-week cycle. Continuous units (Figure 10.7-2) produce an average of 2.5 Mg per hour (Mg/hr) (2.75 tons per hour [tons/hr]) of charcoal. During the manufacturing process, the wood is heated, driving off water and highly volatile organic compounds (VOC). Wood temperature rises to approximately 275°C (527°F), and the VOC distillate yield increases. At this point, external application of heat is no longer required because the carbonization reactions become exothermic. At 350°C (662°F), exothermic pyrolysis ends, and heat is again applied to remove the less volatile tarry materials from the product charcoal.

Fabrication of briquettes from raw material may be either an integral part of a charcoal producing facility, or an independent operation, with charcoal being received as raw material. Figure 10.7-3 presents a flow diagram for charcoal briquette production. Raw charcoal is first crushed to pass through an approximately 3 millimeter (0.12 inch) screen aperture and then stored for briquetting. The charcoal is then mixed with a binder to form a 65 to 70 percent charcoal mixture. Typical binder solutions are 9 to 10 percent by weight solutions of cornstarch, milostarch, or wheatstarch. Sawdust or other materials may be added to obtain faster burning or higher temperatures. Briquettes are then formed in a press and dried at approximately 135°C (275°F) for 3 to 4 hours, resulting in a product with a 5 percent moisture content. This process generates a briquette of approximately 90 percent pyrolysis product.

10.7.2 Emissions And Controls³⁻¹²

There are five types of products and byproducts from charcoal production operations: charcoal, noncondensable gases (carbon monoxide [CO], carbon dioxide [CO₂], methane, and ethane), pyroacids (primarily acetic acid and methanol), tars and heavy oils, and water. With the exception of charcoal, all of these materials are emitted with the kiln exhaust. Product constituents and the distribution of these constituents vary, depending on raw materials and carbonization parameters. Organics and CO are naturally combusted to CO₂ and water before leaving the retort. Because the extent of this combustion varies from plant to plant, emission levels are quite variable. Some of the

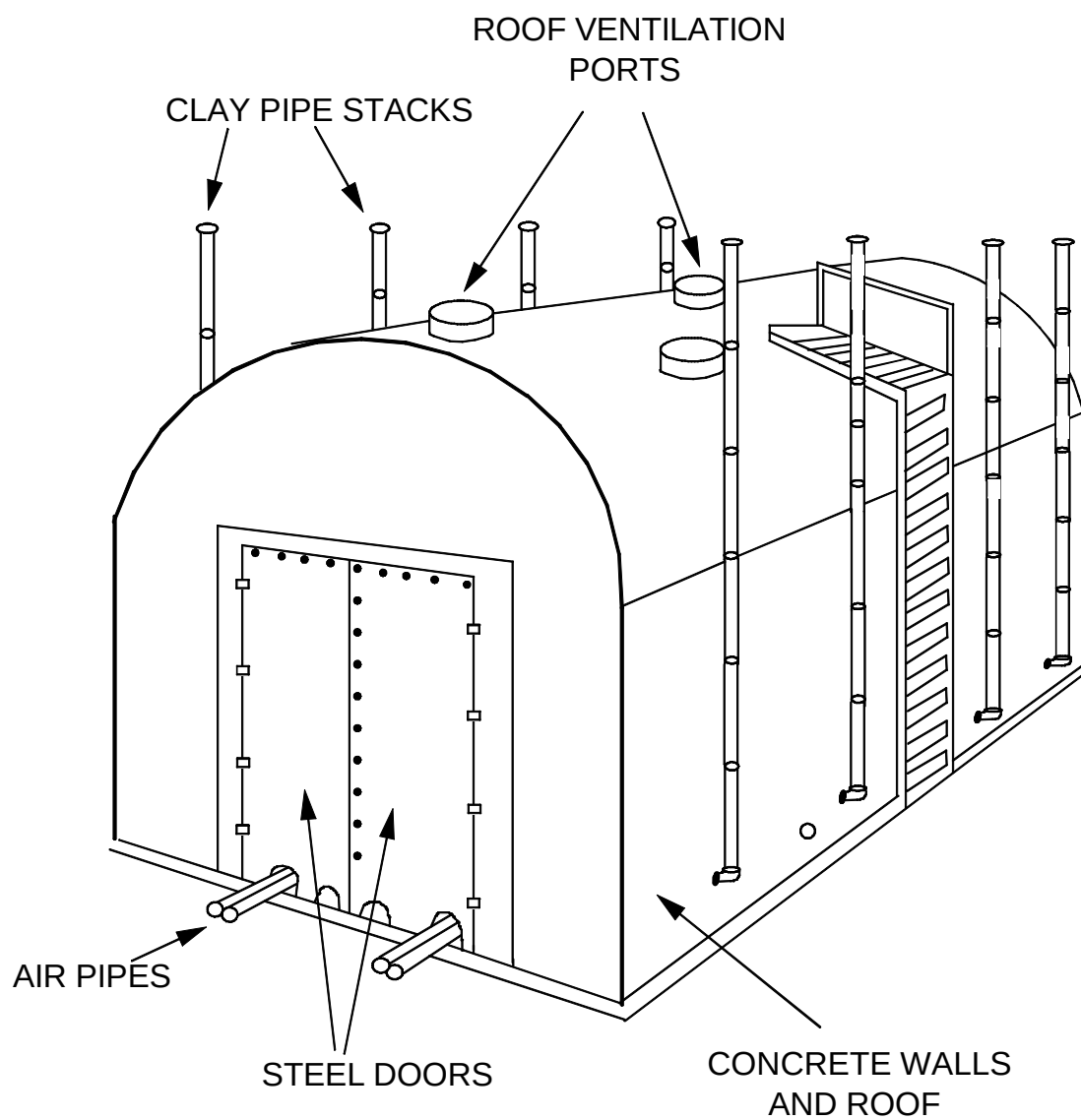


Figure 10.7-1. The Missouri-type charcoal kiln.⁷
(Source Classification Code: 3-01-006-03.)

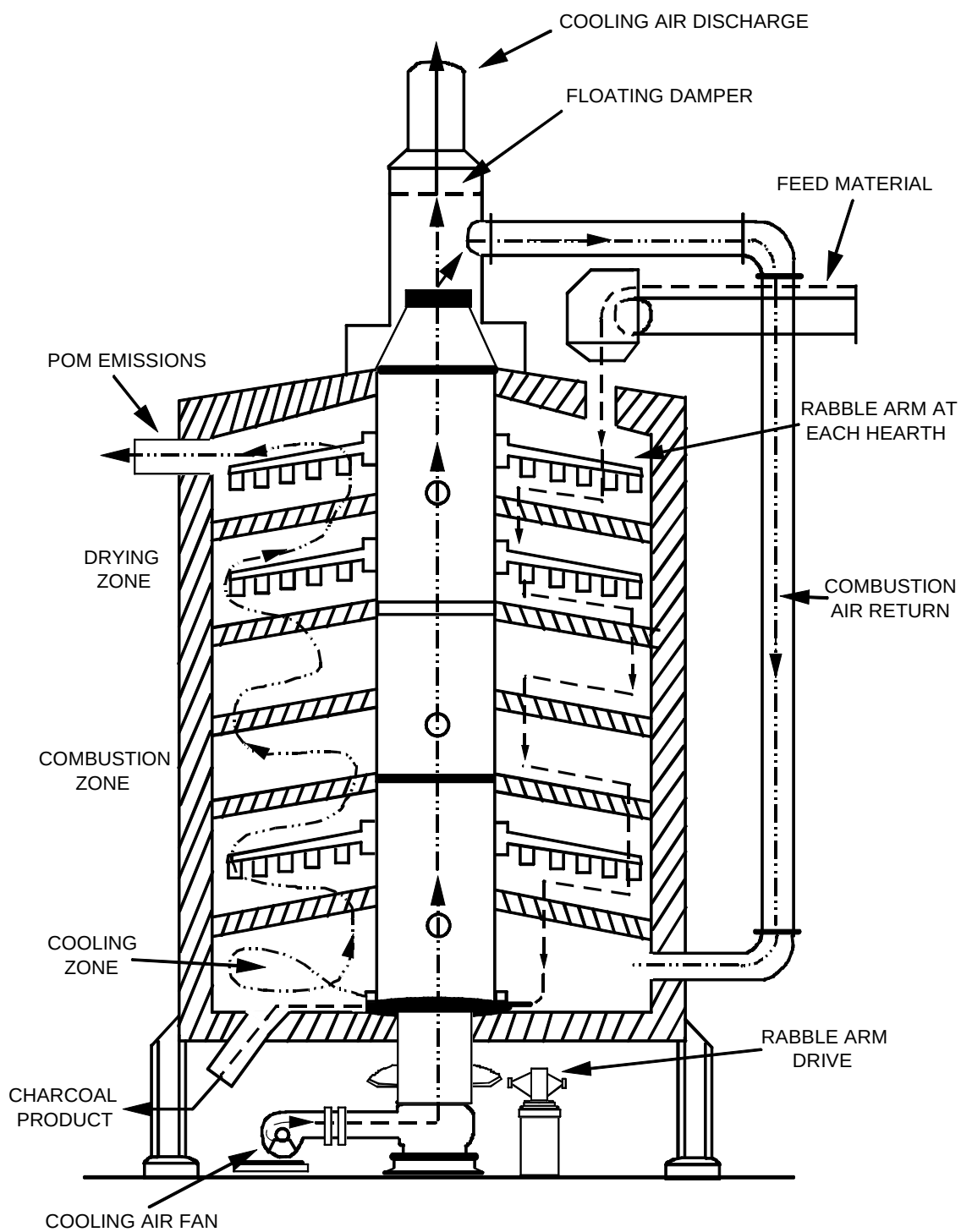


Figure 10.7-2. The continuous multiple hearth kiln for charcoal production.⁴
 (Source Classification Code: 3-01-006-04.)

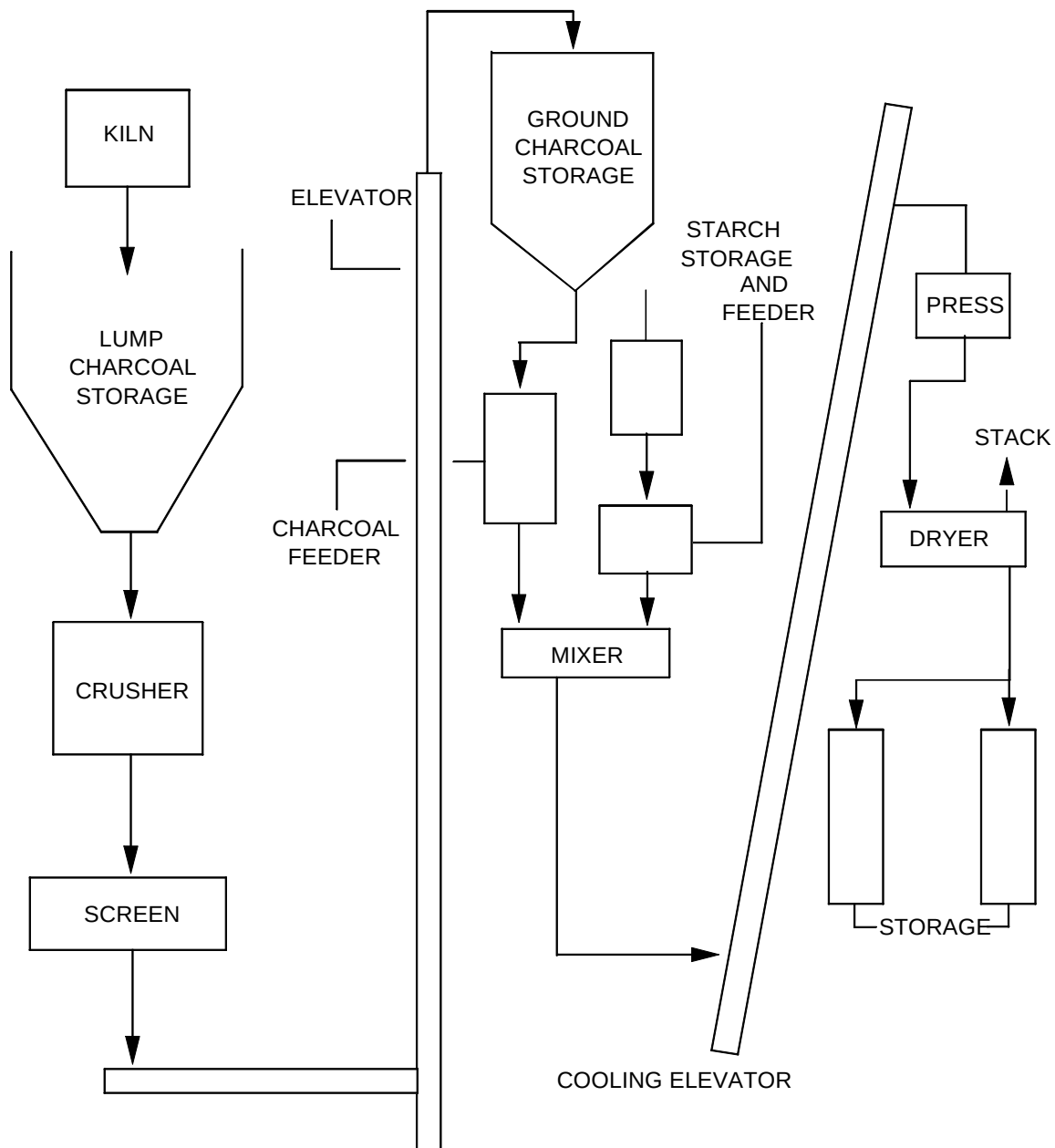


Figure 10.7-3. Flow diagram for charcoal briquette production.³
 (Source Classification Code: 3-01-006-05.)

specific organic compounds that may be found in charcoal kiln emissions include ethane, methane, ethanol, and polycyclic organic matter (POM). If uncombusted, tars may solidify to form PM emissions, and pyroacids may form aerosol emissions.

The charcoal briquetting process is also a potential source of emissions. The crushing, screening, and handling of the dry raw charcoal may produce PM and PM-10 emissions. Briquette pressing and drying may be a source of VOC emissions, depending on the type of binder and other additives used.

Continuous production of charcoal is more amenable to emission control than batch production because emission composition and flow rate are relatively constant. Emissions from continuous multiple hearth charcoal kilns generally are controlled with afterburners. Cyclones, which commonly are used for product recovery, also reduce PM emissions from continuous kilns. Afterburning is estimated to reduce emissions of PM, CO, and VOC by at least 80 percent. Control of emissions from batch-type charcoal kilns is difficult because the process and, consequently, the emissions are cyclic. Throughout a cycle, both the emission composition and flow rate change. Batch kilns do not typically have emission control devices, but some may use after-burners.

Particulate matter emissions from briquetting operations can be controlled with a centrifugal collector (65 percent control) or fabric filter (99 percent control).

Emission factors for criteria pollutant emissions from the manufacture of charcoal are shown in Table 10.7-1. Table 10.7-2 presents factors for emission of organic pollutants from charcoal manufacturing.

Table 10.7-1 EMISSION FACTORS FOR CHARCOAL MANUFACTURING--
CRITERIA POLLUTANTS AND CO₂^a

EMISSION FACTOR RATING: E

Source	lb/ton				
	Total PM ^b	NO _x	CO	VOC	CO ₂
Charcoal kiln ^c (SCC 3-01-006-03, -04)	310 ^d	24 ^e	290 ^f	270 ^g	1,100 ^f
Briquetting ^h (SCC 3-01-006-05)	56 ^f	ND	ND	ND	ND

^a Factors represent uncontrolled emissions. SCC = Source Classification Code. ND = no data.

Emission factors units are lb/ton of product. One lb/ton = 0.5 kg/Mg.

^b Includes condensibles and consists primarily of tars and oils.

^c Applicable to both batch and continuous kilns.

^d References 2,6-7.

^e Reference 3. Based on 0.14 percent nitrogen content of wood.

^f References 2,6-7,11.

^g References 2-3,6.

^h For entire briquetting process.

Table 10.7-2. EMISSION FACTORS FOR CHARCOAL MANUFACTURING--
MISCELLANEOUS ORGANIC POLLUTANTS^a

EMISSION FACTOR RATING: E

Source	Pollutant	Emission factor, lb/ton
Charcoal kiln ^b (SCC 3-01-006-3, -04)	Methane ^c	110
	Ethane ^d	52
	Methanol ^e	150
	POM ^f	0.0095

^a Factors represent uncontrolled emissions. SCC = Source Classification Code. Emission factors units are lb/ton of product. One lb/ton = 0.5 kg/Mg.

^b Applicable to both batch and continuous kilns.

^c References 2,6.

^d References 3,6.

^e Reference 2.

^f Reference 7.

References For Section 10.7

1. *Air Pollutant Emission Factors*, APTD-0923, U. S. Environmental Protection Agency, Research Triangle Park, NC, April 1970.
2. R. N. Shreve, *Chemical Process Industries*, Third Edition, McGraw-Hill, NY, 1967.
3. C. M. Moscowitz, *Source Assessment: Charcoal Manufacturing State of the Art*, EPA-600/2-78-004z, U. S. Environmental Protection Agency, Cincinnati, OH, December 1978.
4. Radian Corporation, *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, May 1988.
5. *Riegel's Handbook Of Industrial Chemistry*, Seventh Edition, J. A. Kent, ed., Van Nostrand Reinhold, NY, 1974.
6. J. R. Hartwig, "Control of Emissions from Batch-Type Charcoal Kilns", *Forest Products Journal*, 21(9):49-50, April 1971.
7. W. H. Maxwell, *Stationary Source Testing Of A Missouri-Type Charcoal Kiln*, EPA-907/9-76-001, U. S. Environmental Protection Agency, Kansas City, MO, August 1976.
8. R. W. Rolke, *et al.*, *Afterburner Systems Study*, EPA-RZ-72-062, U. S. Environmental Protection Agency, Research Triangle Park, NC, August 1972.
9. B. F. Keeling, *Emission Testing The Missouri-Type Charcoal Kiln*, Paper 76-37.1, presented at the 69th Annual Meeting of the Air Pollution Control Association, Portland, OR, June 1976.

10. P. B. Hulman, *et al.*, *Screening Study On Feasibility Of Standards Of Performance For Wood Charcoal Manufacturing*, EPA Contract No. 68-02-2608, Radian Corporation, Austin, TX, August 1978.
11. *Emission Test Report, Kingsford Charcoal, Burnside, Kentucky*, prepared by Monsanto Research Corporation for U. S. Environmental Protection Agency, Research Triangle Park, NC, August 1980.
12. Written communication from J. Swiskow, Barbecue Industry Association, Naperville, IL, to D. Safriet, U. S. Environmental Protection Agency, Research Triangle Park, NC, February 11, 1994.