1.8 Bagasse Combustion In Sugar Mills

1.8.1 Process Description[1-5]

Bagasse is the matted cellulose fiber residue from sugar cane that has been processed in a sugar mill. Previously, bagasse was burned as a means of solid waste disposal. However, as the cost of fuel oil, natural gas, and electricity has increased, bagasse has come to be regarded as a fuel rather than refuse. Bagasse is a fuel of varying composition, consistency, and heating value. These characteristics depend on the climate, type of soil upon which the cane is grown, variety of cane, harvesting method, amount of cane washing, and the efficiency of the milling plant. In general, bagasse has a heating value between 3,000 and 4,000 British thermal units per pound (Btu/lb) on a wet, as-fired basis. Most bagasse has a moisture content between 45 and 55 percent by weight.

The U. S. sugar cane industry is located in the tropical and subtropical regions of Florida, Texas, Louisiana, Hawaii, and Puerto Rico. Except for Hawaii, where sugar cane production takes place year round, sugar mills operate seasonally from 2 to 5 months per year.

Sugar cane is a large grass with a bamboo-like stalk that grows 8 to 15 feet tall. Only the stalk contains sufficient sucrose for processing into sugar. All other parts of the sugar cane (i. e., leaves, top growth, and roots) are termed "trash". The objective of harvesting is to deliver the sugar cane to the mill with a minimum of trash or other extraneous material. The cane is normally burned in the field to remove a major portion of the trash and to control insects and rodents. (See Section 13.1 for methods to estimate these emissions.) The three most common methods of harvesting are hand cutting, machine cutting, and mechanical raking. The cane that is delivered to a particular sugar mill will vary in trash and dirt content depending on the harvesting method and weather conditions. Inside the mill, cane preparation for extraction usually involves washing the cane to remove trash and dirt, chopping, and then crushing. Juice is extracted in the milling portion of the plant by passing the chopped and crushed cane through a series of grooved rolls. The cane remaining after milling is bagasse.

1.8.2 Firing Practices

Fuel cells, horseshoe boilers, and spreader stoker boilers are used to burn bagasse. Horseshoe boilers and fuel cells differ in the shapes of their furnace area but in other respects are similar in design and operation. In these boilers (most common among older plants), bagasse is gravity-fed through chutes and piles onto a refractory hearth. Primary and overfire combustion air flows through ports in the furnace walls; burning begins on the surface pile. Many of these units have dumping hearths that permit ash removal while the unit is operating.

In more recently built sugar mills, bagasse is burned in spreader stoker boilers. Bagasse fed to these boilers enters the furnace through a fuel chute and is spread pneumatically or mechanically across the furnace, where part of the fuel burns while in suspension. Simultaneously, large pieces of fuel are spread in a thin, even bed on a stationary or moving grate. The flame over the grate radiates heat back to the fuel to aid combustion. The combustion area of the furnace is lined with heat exchange tubes (waterwalls).

1.8.3 Emissions[1-3]

The most significant pollutant emitted by bagasse-fired boilers is particulate matter, caused by the turbulent movement of combustion gases with respect to the burning bagasse and resultant ash. Emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) are lower than conventional fossil fuels due to the characteristically low levels of sulfur and nitrogen associated with bagasse.

Auxiliary fuels (typically fuel oil or natural gas) may be used during startup of the boiler or when the moisture content of the bagasse is too high to support combustion; if fuel oil is used during these periods, SO_2 and NO_x emissions will increase. Soil characteristics such as particle size can affect the magnitude of particulate matter (PM) emissions from the boiler. Cane that is improperly washed or incorrectly prepared can also influence the bagasse ash content. Upsets in combustion conditions can cause increased emissions of carbon monoxide (CO) and unburned organics, typically measured as volatile organic compounds (VOCs) and total organic compounds (TOCs).

1.8.4 Controls

Mechanical collectors and wet scrubbers are commonly used to control particulate emissions from bagasse-fired boilers. Mechanical collectors may be installed in single cyclone, double cyclone, or multiple cyclone (i. e., multiclone) arrangements. The reported PM collection efficiency for mechanical collectors is 20 to 60 percent. Due to the abrasive nature of bagasse fly ash, mechanical collector performance may deteriorate over time due to erosion if the system is not well maintained.

The most widely used wet scrubbers for bagasse-fired boilers are impingement and venturi scrubbers. Impingement scrubbers normally operate at gas-side pressure drops of 5 to 15 inches of water; typical pressure drops for venturi scrubbers are over 15 inches of water. Impingement scrubbers are in greater use due to their lower energy requirements and fewer operating and maintenance problems. Reported PM collection efficiencies for both scrubber types are 90 percent or greater.

Fabric filters and electrostatic precipitators have not been used to a significant extent for controlling PM from bagasse-fired boilers because both are relatively costly compared to other control options. Fabric filters also pose a potential fire hazard.

Gaseous emissions (e. g., SO_2, NO_x, CO, and organics) may also be absorbed to a significant extent in a wet scrubber. Alkali compounds are sometimes utilized in the scrubber to prevent low pH conditions. If carbon dioxide (CO_2)-generating compounds (such as sodium carbonate or calcium carbonate) are used, CO_2 emissions will increase.

Fugitive dust may be generated by truck traffic and cane handling operations at the sugar mill. PM emissions from these sources may be estimated by consulting Section 13.2.

Emission factors and emission factor ratings for bagasse-fired boilers are shown in Table 1.8-1. Table 1.8-1 presents emission factors on a weight basis (lb/ton). To convert to an energy basis (lb/MMBtu), divide by a heating value of 7.0 MMBtu/ton.

1.8.5 Updates Since the Fifth Edition

The Fifth Edition was released in January 1995. Revisions to this section since that date are summarized below. For further detail, consult the memoranda describing each supplement or the background report for this section.

Supplement A, February 1996

No changes.

Supplement B, October 1996

- PM emission factors were revised for boilers controlled with wet scrubbers.

Table 1.8-1. EMISSION FACTORS FOR BAGASSE-FIRED BOILERS[a]

Pollutant	Emission Factor (lb/ton)[b]	EMISSION FACTOR RATING
PM[c]		
Uncontrolled[d]	15.6	C
Controlled		
Mechanical collector[e]	8.4	D
Wet scrubber[f]	1.4	A
PM-10		
Controlled		
Wet scrubber[g]	1.36	D
CO_2		
Uncontrolled[h]	1,560	A
NO_x		
Uncontrolled[j]	1.2	C
Polycyclic organic matter		
Uncontrolled[k]	0.001	D

[a] Source Classification Code is 1-02-011-01.
[b] Units are lb of pollutant/ton of wet, as-fired bagasse containing approximately 50% moisture, by weight. If lbs of steam produced is monitored, assume 1 lb of bagasse produces 2 lb of steam, in lieu of any site-specific conversion data. To convert from lb/ton to kg/Mg, multiply by 0.5.
[c] Includes only filterable PM (i. e., that particulate collected on or prior to the filter of an EPA Method 5 [or equivalent] sampling train).
[d] Reference 2.
[e] References 6-7.
[f] References 6,8-65.
[g] Reference 13.
[h] References 6-13,66. CO_2 emissions will increase following a wet scrubber in which CO_2-generating reagents (such as sodium carbonate or calcium carbonate) are used.
[j] References 7,13.
[k] Reference 7. Based on measurements collected downstream of PM control devices which may have provided some removal of polycyclic organic matter condensed on PM.

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