4.0 MODEL PROCESS UNITS, CONTROL OPTIONS, AND ENHANCED MONITORING OPTIONS

This chapter defines model process units, identifies HAP emission control options, and discusses enhanced monitoring options for combustion sources in the chemical recovery area at kraft pulp and paper mills. Model process units represent the types of units that currently exist in the industry and the types that may be constructed in the future. The control options represent demonstrated emission control techniques, and the enhanced monitoring options are methods of demonstrating continuous compliance for a particular control option. The use of model process units to characterize an industry allows the EPA to evaluate the environmental and energy impacts and costs of various control options for each combustion source. These impacts and costs are presented in Chapters 5 and 6, respectively.

4.1 MODEL PROCESS UNITS

This section presents the model process units that were developed for recovery furnaces, SDT’s, BLO units, and lime kilns. The following parameters were evaluated to develop the process units: process-specific characteristics, level of PM emission control, stack gas characteristics, and HAP emission levels. The model process unit parameters are typical for equipment that currently exists or may be constructed in the kraft pulp industry.

4.1.1 Recovery Furnace Models

The nine model process units that were developed to characterize kraft recovery furnaces are presented in Table 4-1. Two PM emission levels were developed for each of the nine models

TABLE 4-1a (METRIC). RECOVERY FURNACE MODEL PROCESS UNITS AND PROCESS PARAMETERS[a]

Model No.	Evaporator type	Black liquor firing rate, kg BLS/d	Equivalent pulp production rate		PM emission control device[b]	Gas flow rate--ESP exit, m^3/sec actual	Exhaust gas temp., °C	Moisture content--ESP exit, %	HCl emissions, kg/d	Methanol emissions, kg/d	PM emissions, g/dscm @ 8% O_2
			ADMUP/d	ADMBP/d							
RF-1a	NDCE	0.7 MM	450	380	Dry ESP system	93.4	199	26	81.6	3.4	0.27
RF-1b	NDCE	0.7 MM	450	380	Dry ESP system	93.4	199	26	81.6	3.4	0.10
RF-2a	NDCE	1.2 MM	820	680	Dry ESP system	168	199	26	147	6.0	0.27
RF-2b	NDCE	1.2 MM	820	680	Dry ESP system	168	199	26	147	6.0	0.10
RF-3a	NDCE	1.8 MM	1,200	1,000	Dry ESP system	243	199	26	212	8.7	0.27
RF-3b	NDCE	1.8 MM	1,200	1,000	Dry ESP system	243	199	26	212	8.7	0.10
RF-4a	NDCE	0.7 MM	450	380	Wet ESP system	93.4	199	26	81.6	34.3	0.27
RF-4b	NDCE	0.7 MM	450	380	Wet ESP system	93.4	199	26	81.6	34.3	0.10
RF-5a	NDCE	1.2 MM	820	680	Wet ESP system	168	199	26	147	61.7	0.27
RF-5b	NDCE	1.2 MM	820	680	Wet ESP system	168	199	26	147	61.7	0.10
RF-6a	NDCE	1.8 MM	1,200	1,000	Wet ESP system	243	199	26	212	89.4	0.27
RF-6b	NDCE	1.8 MM	1,200	1,000	Wet ESP system	243	199	26	212	89.4	0.10
RF-7a	DCE	0.4 MM	270	230	Wet ESP system	56.2	160	32	49.0	69.4	0.18
RF-7b	DCE	0.4 MM	270	230	Wet ESP system	56.2	160	32	49.0	69.4	0.10
RF-8a	DCE	0.7 MM	450	380	Wet ESP system	93.4	160	32	81.6	116	0.18
RF-8b	DCE	0.7 MM	450	380	Wet ESP system	93.4	160	32	81.6	116	0.10
RF-9a	DCE	1.2 MM	820	680	Wet ESP system	168	160	32	147	208	0.18
RF-9b	DCE	1.2 MM	820	680	Wet ESP system	168	160	32	147	208	0.10

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-1b.
[b]"Wet ESP system" includes ESP's with black liquor or HAP-contaminated process water in the ESP bottom or PM return system.

TABLE 4-1b (ENGLISH). RECOVERY FURNACE MODEL PROCESS UNITS AND PROCESS PARAMETERS

Model No.	Evaporator type	Black liquor firing rate, lb BLS/d	Equivalent pulp production rate		PM emission control device[a]	Gas flow rate--ESP exit, acfm	Exhaust gas temp., °F	Moisture content, %	HCl emissions, lb/d	Methanol emissions, lb/d	PM emissions, gr/dscf @ 8% O_2
			ADTUP/d	ADTBP/d							
RF-1a	NDCE	1.5 MM	500	420	Dry ESP system	198,000	390	26	180	7.4	0.12
RF-1b	NDCE	1.5 MM	500	420	Dry ESP system	198,000	390	26	180	7.4	0.044
RF-2a	NDCE	2.7 MM	900	750	Dry ESP system	357,000	390	26	324	13.3	0.12
RF-2b	NDCE	2.7 MM	900	750	Dry ESP system	357,000	390	26	324	13.3	0.044
RF-3a	NDCE	3.9 MM	1,300	1,100	Dry ESP system	515,000	390	26	468	19.2	0.12
RF-3b	NDCE	3.9 MM	1,300	1,100	Dry ESP system	515,000	390	26	468	19.2	0.044
RF-4a	NDCE	1.5 MM	500	420	Wet ESP system	198,000	390	26	180	75.6	0.12
RF-4b	NDCE	1.5 MM	500	420	Wet ESP system	198,000	390	26	180	75.6	0.044
RF-5a	NDCE	2.7 MM	900	750	Wet ESP system	357,000	390	26	324	136	0.12
RF-5b	NDCE	2.7 MM	900	750	Wet ESP system	357,000	390	26	324	136	0.044
RF-6a	NDCE	3.9 MM	1,300	1,100	Wet ESP system	515,000	390	26	468	197	0.12
RF-6b	NDCE	3.9 MM	1,300	1,100	Wet ESP system	515,000	390	26	468	197	0.044
RF-7a	DCE	0.9 MM	300	250	Wet ESP system	119,000	320	32	108	153	0.08
RF-7b	DCE	0.9 MM	300	250	Wet ESP system	119,000	320	32	108	153	0.044
RF-8a	DCE	1.5 MM	500	420	Wet ESP system	198,000	320	32	180	255	0.08
RF-8b	DCE	1.5 MM	500	420	Wet ESP system	198,000	320	32	180	255	0.044
RF-9a	DCE	2.7 MM	900	750	Wet ESP system	357,000	320	32	324	459	0.08
RF-9b	DCE	2.7 MM	900	750	Wet ESP system	357,000	320	32	324	459	0.044

[a]"Wet ESP system" includes ESP's with black liquor or HAP-contaminated process water in the ESP bottom or PM return system.

(RF-1a and RF-1b, RF-2a and RF-2b, etc.). Model designations ending in "a" represent pre-new source performance standards (NSPS) furnaces with PM emissions above the NSPS PM limit promulgated in 1978; designations ending in "b" represent furnaces with PM emissions at or below the NSPS. Recovery furnaces have been characterized based on the following parameters: (1) type of final-stage black liquor evaporator (i.e., DCE or NDCE); (2) size (i.e., BLS firing rate and pulp production rate); (3) type of PM emission control device; (4) stack gas characteristics (i.e., flow rate, temperature, and moisture content); and (5) HAP emission levels (i.e., HCl, methanol as a surrogate for gaseous organic HAP's, and PM as a surrogate for PM HAP's). Each of these parameters is discussed below.

4.1.1.1 Evaporator Type. The recovery furnace models were characterized based on whether a DCE or an NDCE (i.e., concentrator) is used in the final stage of black liquor evaporation. Models RF-1 through RF-6 represent NDCE recovery furnaces, and models RF-7 through RF-9 represent DCE recovery furnaces. Separate models were developed for these two types of evaporators because the type of evaporator affects methanol emissions. As discussed in Chapter 2, higher methanol emissions are associated with DCE recovery furnace systems because methanol can be stripped from the black liquor in the DCE and in the BLO unit, which is only used with the DCE systems. Approximately 61 percent of existing recovery furnaces are NDCE recovery furnaces, and the remaining 39 percent are DCE recovery furnace systems.[1] Based on the current trend in the industry, all new recovery furnace installations are expected to be of the NDCE design.

4.1.1.2 Recovery Furnace Size. Model recovery furnaces were characterized by size, based on the BLS firing rate and equivalent unbleached and bleached pulp production rates. The BLS firing rates are expressed in terms of kg BLS/d (lb BLS/d). Equivalent unbleached pulp production rates are expressed in terms of air-dried megagrams of unbleached pulp per day (ADMUP/d) (air-dried tons of unbleached pulp per day [ADTUP/d]). Similar units (air-dried megagrams of bleached pulp per day [ADMBP/d] and air-dried tons of bleached pulp per day [ADTBP/d]) are used to express the equivalent bleached pulp production rates. The equivalent pulp production rates are based on the BLS firing rates and conversion factors of 1,500 kg BLS/ADMUP (3,000 lb BLS/ADTUP) and 1,800 kg BLS/ADMBP (3,600 lb BLS/ADTBP).[2,3]

The models include three sizes of NDCE recovery furnaces and three sizes of DCE recovery furnaces. For the NDCE recovery furnace models, the BLS firing rates are 0.7 million (MM), 1.2 MM, and 1.8 MM kg BLS/d (1.5 MM, 2.7 MM, and 3.9 MM lb BLS/d). Equivalent unbleached pulp production rates are 450, 820, and 1,200 ADMUP/d (500, 900, and 1,300 ADTUP/d). Equivalent bleached pulp production rates are 380, 680, and 1,000 ADMBP/d (420, 750, and 1,100 ADTBP/d). For the DCE recovery furnace models, the BLS firing rates are 0.4 MM, 0.7 MM, and 1.2 MM kg BLS/d (0.9 MM, 1.5 MM, and 2.7 MM lb BLS/d). Equivalent unbleached pulp production rates are 270, 450, and 820 ADMUP/d (300, 500, and 900 ADTUP/d). Equivalent bleached pulp production rates are 230, 380, and 680 ADMBP/d (250, 420, and 750 ADTBP/d).

The distributions of BLS firing rates for DCE and NDCE recovery furnaces are shown in Figures 4-1a and 4-1b, respectively. The sample populations of DCE and NDCE recovery furnaces were divided into small, medium, and large model sizes. The median BLS firing rate within each size range was then selected as the production rate for the model. Figure 4-2a and 4-2b show the BLS firing rate ranges for DCE and NDCE recovery furnaces, respectively, for the small, medium, and large size categories and the corresponding medians for each size.

As shown in Figures 4-1 through 4-2, DCE recovery furnaces tend to be smaller than NDCE recovery furnaces. The difference in recovery furnace size reflects the fact that in recent years (i.e., since 1980), mills have installed larger recovery furnaces, and the majority of these mills selected the newer NDCE recovery furnace technology.[1,4] Consequently, the six model recovery furnace sizes reflect the size variation between the DCE

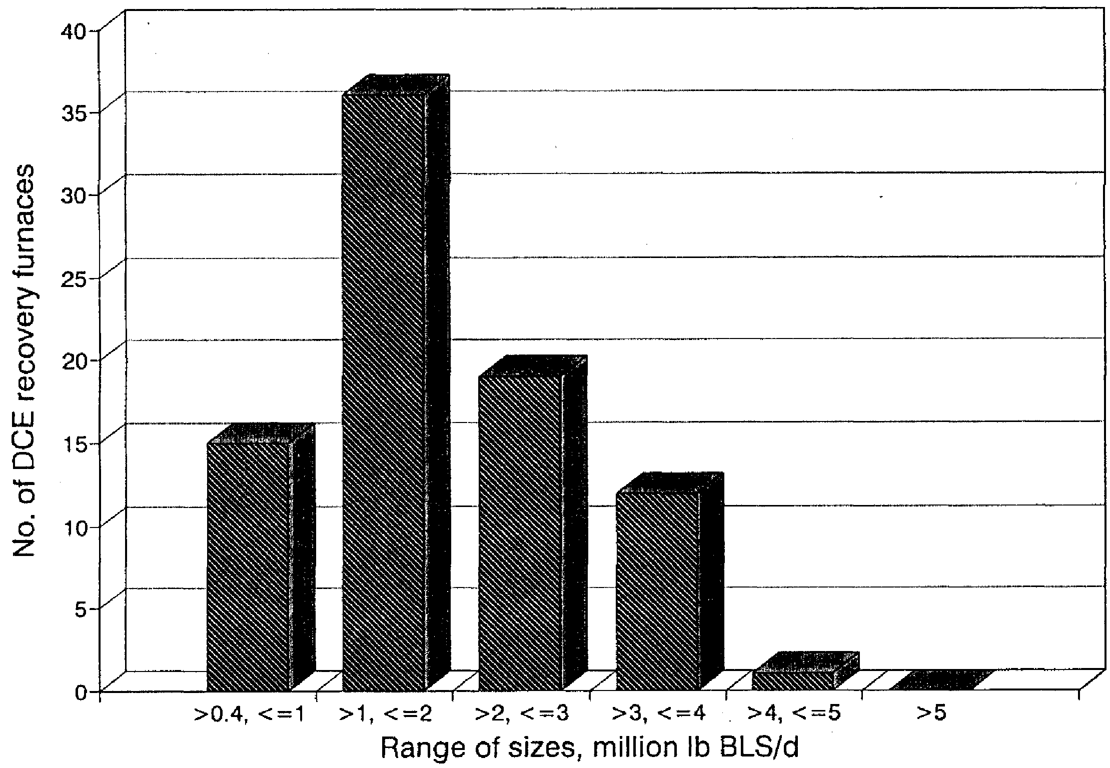

Figure 4-1a. Size distribution for DCE recovery furnaces.

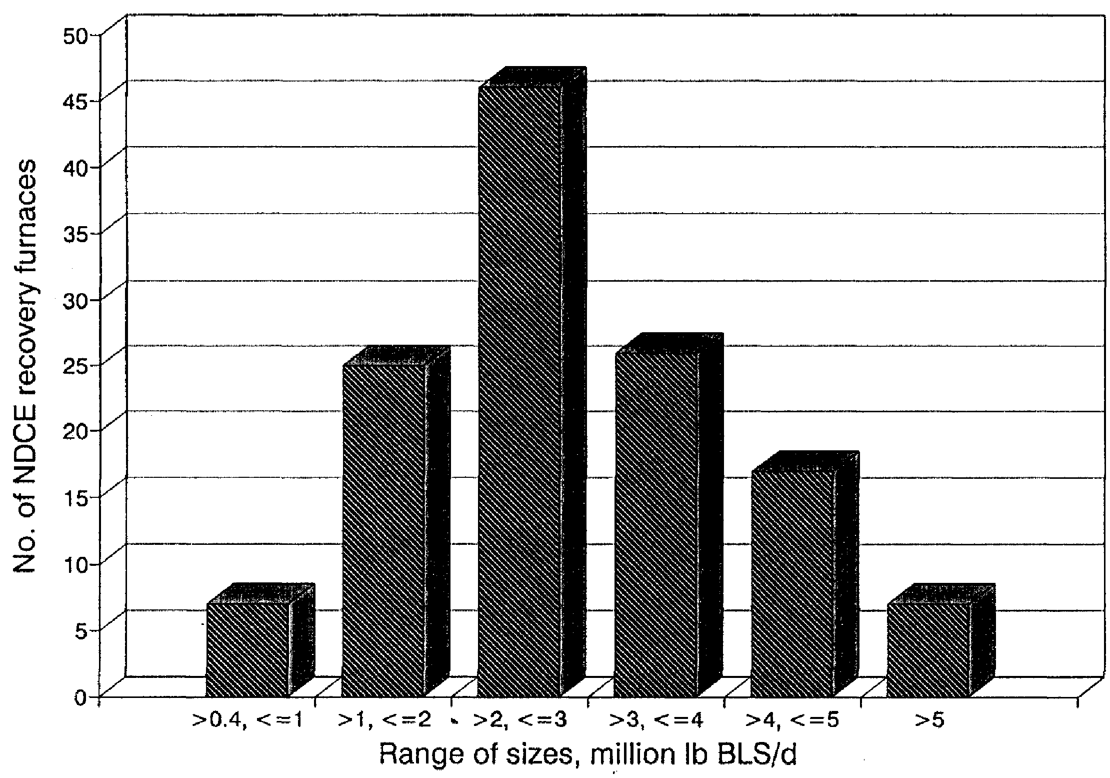

Figure 4-1b. Size distribution for NDCE recovery furnaces.

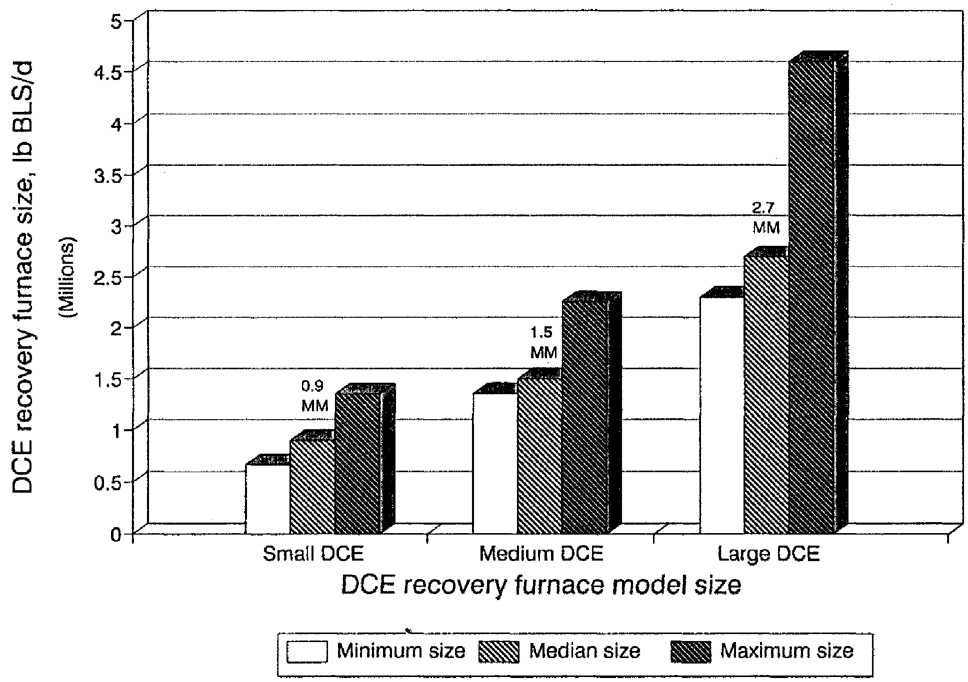

Figure 4-2a. DCE recovery furnace model size ranges.

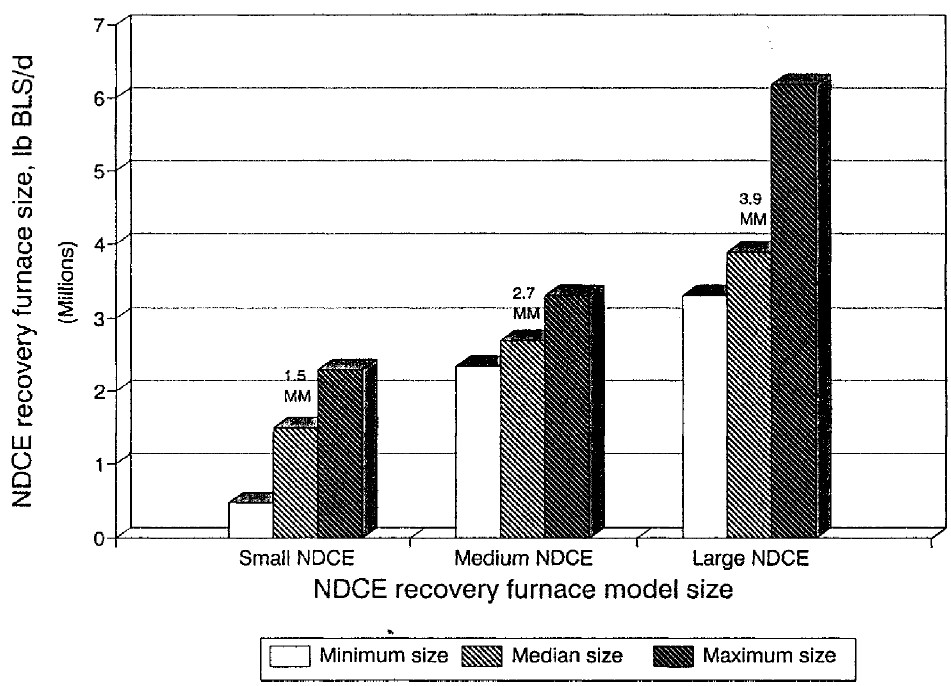

Figure 4-2b. NDCE recovery furnace model size ranges.

and NDCE recovery furnaces. The 0.7 and 1.2 MM kg BLS/d (1.5 and 2.7 MM lb BLS/d BLS firing rates for the medium (RF-8) and large (RF-9) model DCE recovery furnaces correspond to the small (RF-1 and RF-4) and medium (RF-2 and RF-5) model NDCE recovery furnaces, respectively. A separate small DCE recovery furnace model (RF-7) with a BLS firing rate of 0.4 MM kg BLS/d (0.9 MM lb BLS/d) and large NDCE recovery furnace models (RF-3 and RF-6) with a BLS firing rate of 1.8 MM kg BLS/d (3.9 MM lb BLS/d) were also selected to characterize the existing population of kraft recovery furnaces.

4.1.1.3 PM Emission Control Device. The PM emission control device for all of the model recovery furnaces is an ESP. Electrostatic precipitators are the most prevalent PM emission control device for recovery furnaces, installed on about 99 percent of recovery furnaces.[1] The model recovery furnaces are further characterized by the type of ESP system (i.e., with or without black liquor or HAP-contaminated process water in the ESP bottom or PM return system). The DCE recovery furnace systems are represented by models RF-7 through RF-9; NDCE recovery furnaces with dry ESP systems (i.e., dry-bottom ESP's with dry PM return systems) are represented by models RF-1 through RF-3; NDCE recovery furnaces with wet ESP systems (i.e., wet-bottom ESP's or dry-bottom ESP's with wet PM return systems) are represented by models RF-4 through RF-6. Nondirect contact evaporator recovery furnaces equipped with wet ESP systems emit higher quantities of gaseous organic HAP's than those equipped with dry ESP systems, due to stripping of HAP's from the black liquor or HAP-contaminated water in the ESP bottom or PM return system. However, new ESP's tend to have dry ESP systems.[5] For NDCE recovery furnaces, models were developed for both types of ESP systems. All of the DCE recovery furnace models have wet ESP systems because 94 percent of DCE recovery furnaces are equipped with wet-bottom ESP's, and information is not available to determine if the remaining 6 percent that are equipped with dry-bottom ESP's also have dry PM return systems.

4.1.1.4 Stack Gas Characteristics. Model recovery furnaces were characterized by stack gas characteristics (i.e., flow rate at the ESP exit, temperature, and moisture content). The gas flow rates were calculated from the BLS feed rates using conversion factors of 13.9 MJ/kg BLS (6,000 Btu/lb BLS) and 0.242 dscm at 0 percent O_2/MJ (9,000 dscf at 0 percent $O_2/10^6$ Btu).[3,6]

The exhaust gas temperatures used for the model recovery furnaces are based on ESP inlet gas temperatures from emissions tests.[2] Inlet temperature is an acceptable estimator for outlet temperature because the temperature does not vary significantly across an ESP. For model NDCE recovery furnaces, the stack gas temperature is 199°C (390°F). For model DCE recovery furnaces, the stack gas temperature is 160°C (320°F).

Stack gas moisture contents for the recovery furnace models are averages of measurements taken during emission tests of two NDCE recovery furnaces and two DCE recovery furnaces.[7] The average stack gas moisture content based on the two NDCE recovery furnace emission tests is 26 percent. The average stack gas moisture content based on the two DCE recovery furnace emission tests is 32 percent.

4.1.1.5 HAP Emissions. Model recovery furnaces were characterized by the levels of HCl, methanol, which is a surrogate for gaseous organic HAP's, and PM, which is a surrogate for PM HAP's. The HCl emission levels for the model recovery furnaces are based on the HCl emission factor of 1.20×10^{-4} kg of HCl/kg of BLS fired (1.20×10^{-4} lb of HCl/lb of BLS fired) presented in Chapter 2. As discussed in Chapter 2, HCl emissions from recovery furnace systems are highly variable, and insufficient data exist to determine the process operating parameters that significantly influence emissions. In addition, the available data on HCl emissions from NDCE and DCE recovery furnaces show a significant overlap. Therefore, the same emission factor is applied for both NDCE and DCE model recovery furnaces.

The methanol emission levels for model recovery furnaces are also based on emission factors presented in Chapter 2. Methanol emissions for the model DCE recovery furnaces are based on an emission factor of 1.70 x 10^{-4} kg methanol/kg BLS (1.70 x 10^{-4} lb methanol/lb BLS). For model NDCE recovery furnaces with wet ESP systems, methanol emission levels are based on an emission factor of 5.04 x 10^{-5} kg methanol/kg BLS (5.04 x 10^{-5} lb methanol/lb BLS). For model NDCE recovery furnaces with dry ESP systems, methanol emission levels are based on an emission factor of 4.93 x 10^{-6} kg methanol/kg BLS (4.93 x 10^{-6} lb methanol/lb BLS). Separate methanol emission levels were developed because DCE recovery furnaces have higher methanol emissions than NDCE recovery furnaces due to the stripping of methanol from the black liquor. Also, methanol emissions are higher from NDCE recovery furnaces with wet ESP systems than from NDCE recovery furnaces with dry ESP systems, due to the same stripping effects.

The NSPS for kraft pulp mills establishes a PM emission limit of 0.1 g/dscm (0.044 gr/dscf) at 8 percent O_2 that is applicable to recovery furnaces constructed, modified, or reconstructed after September 24, 1976.[8,9] Available data indicate only the year, not the month, that recovery furnaces were installed.[1,2] Consequently, this analysis assumes that those recovery furnaces installed during or after 1977 are subject to the NSPS, and those recovery furnaces installed before 1977 are not subject to the NSPS. Also, recovery furnaces subject to the NSPS are assumed to be in compliance with the NSPS PM standard.

The "a" model recovery furnaces shown in Table 4-1 characterize those recovery furnaces with PM emissions above the NSPS PM emission limit. Therefore, the "a" model PM emission levels were based on the PM emission concentrations for those recovery furnaces that are not subject to the NSPS and that emit more than the NSPS PM limit. Different PM levels were calculated for the DCE and NDCE recovery furnaces that are subject to these parameters. For NDCE recovery furnaces, the PM emission level is

0.27 g/dscm (0.12 gr/dscf). For DCE recovery furnaces, the PM emission level is 0.18 g/dscm (0.08 gr/dscf).[10]

The "b" model recovery furnaces represent those recovery furnaces with PM emissions at or below the NSPS PM limit of 0.10 g/dscm (0.044 gr/dscf). The "b" model recovery furnace PM emission level is equivalent to the NSPS limit and represents the maximum emission level for these recovery furnaces. Although only 30 percent of the recovery furnaces are subject to the NSPS, the majority (approximately 80 percent) of all recovery furnaces reportedly are meeting the NSPS PM emission level.[1,2] Therefore, the "b" models represent the majority of existing recovery furnaces.

4.1.2 Smelt Dissolving Tank Models

The seven model process units (SDT-1 through SDT-7) that were developed to characterize existing SDT's are presented in Table 4-2. Model process units SDT-1 through SDT-4 are also representative of those SDT's that are expected to be constructed in the future. The parameters selected to characterize typical SDT's are (1) size (i.e., BLS firing rate of the associated recovery furnace, equivalent pulp production rate, and smelt flow rate), (2) PM emission control device, (3) inlet and outlet gas stream characteristics (i.e., flow rate, temperature and moisture content), and (4) HAP emission levels (i.e., PM as a surrogate for PM HAP's).

4.1.2.1 SDT Size. The SDT size is indicated by the BLS firing rate and equivalent pulp production rate of the associated recovery furnace and the smelt flow rate. The smelt flow rate was calculated based on a conversion factor of 0.37 kg smelt/kg BLS (0.37 lb smelt/lb BLS).[2] An equivalent BLS firing rate was used as an indicator of SDT size because the SDT is an integral part of the kraft recovery furnace. The SDT models represent the majority of recovery furnace configurations, i.e., one SDT per recovery furnace. Approximately 8 percent of recovery furnaces have two SDT's.[1] The SDT models SDT-1 and SDT-5 correspond to the small DCE recovery furnace model (RF-7); SDT models SDT-2 and SDT-6 correspond to the medium DCE and small

TABLE 4-2a (METRIC). SMELT DISSOLVING TANK MODEL PROCESS UNITS AND PROCESS PARAMETERS[a]

Model No.	Equivalent black liquor firing rate, kg BLS/d	Equivalent pulp production rate		Smelt flow rate, kg/d	PM emission control device	PM emission control device inlet gas flow rate, m^3/sec actual @ 93°C	Stack gas flow rate, m^3/sec actual @ 77°C	Moisture content, %	PM emissions, kg/Mg BLS
		ADMUP/d	ADMBP/d						
SDT-1	0.4 MM	270	230	151,000	Wet scrubber	4.4	4.2	36	0.18
SDT-2	0.7 MM	450	380	252,000	Wet scrubber	7.4	7.1	36	0.18
SDT-3	1.2 MM	820	680	453,000	Wet scrubber	13.4	12.7	36	0.18
SDT-4	1.8 MM	1,200	1,000	655,000	Wet scrubber	19.3	18.4	36	0.18
SDT-5	0.4 MM	270	230	151,000	Mist eliminator	4.4	4.2	36	0.23
SDT-6	0.7 MM	450	380	252,000	Mist eliminator	7.4	7.1	36	0.23
SDT-7	1.2 MM	820	680	453,000	Mist eliminator	13.4	12.7	36	0.23

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-2b.

TABLE 4-2b (ENGLISH). SMELT DISSOLVING TANK MODEL PROCESS UNITS AND PROCESS PARAMETERS

Model No.	Equivalent black liquor firing rate, lb BLS/d	Equivalent pulp production rate		Smelt flow rate, lb/d	PM emission control device	PM emission control device inlet gas flow rate, acfm @ 200°F	Stack gas flow rate, acfm @ 170°F	Moisture content, %	PM emissions, lb/ton BLS
		ADTUP/d	ADTBP/d						
SDT-1	0.9 MM	300	250	333,000	Wet scrubber	9,400	9,000	36	0.37
SDT-2	1.5 MM	500	420	555,000	Wet scrubber	15,700	15,000	36	0.37
SDT-3	2.7 MM	900	750	999,000	Wet scrubber	28,300	27,000	36	0.37
SDT-4	3.9 MM	1,300	1,100	1,443,000	Wet scrubber	40,900	39,000	36	0.37
SDT-5	0.9 MM	300	250	333,000	Mist eliminator	9,400	9,000	36	0.46
SDT-6	1.5 MM	500	420	555,000	Mist eliminator	15,700	15,000	36	0.46
SDT-7	2.7 MM	900	750	999,000	Mist eliminator	28,300	27,000	36	0.46

NDCE recovery furnace models (RF-1, RF-4, and RF-8); SDT models SDT-3 and SDT-7 correspond to the large DCE and medium NDCE recovery furnace models (RF-2, RF-5, and RF-9); SDT model SDT-4 corresponds to the large NDCE recovery furnace models (RF-3 and RF-6).

4.1.2.2 PM Emission Control Device. Two types of emission control devices are predominantly used to control PM emissions from SDT’s--wet scrubbers and mist eliminators. Wet scrubbers are used to control PM emissions from about 87 percent of the SDT’s, and mist eliminators are used to control PM emissions from about 10 percent of the SDT’s.[11] The type of PM emission control device will impact PM emission levels because wet scrubbers are generally more effective than mist eliminators at controlling PM emissions. The PM emission control device for SDT models SDT-1 through SDT-4 is a wet scrubber. These SDT models correspond to all four recovery furnace model sizes and include sizes for both DCE and NDCE recovery furnaces. The PM emission control device for SDT models SDT-5 through SDT-7 is a mist eliminator. These SDT models correspond to the three DCE recovery furnace model sizes and the small and medium NDCE recovery furnace model sizes. An SDT model with a mist eliminator that corresponds to the large NDCE recovery furnace model size was not included because less than 1 percent of recovery furnaces have this configuration.

4.1.2.3 Inlet and Outlet Gas Stream Characteristics. The model SDT stack gas flow rates represent typical gas flow rates within each size range. Available recovery furnace BLS firing rates and corresponding SDT gas flow rates were used to develop a factor of 1.04×10^{-5} m^3/sec/kg BLS/d (0.01 acfm/lb BLS/d).[2] The model gas flow rates calculated with this factor were then compared to, and found to be consistent with, the gas flow rates at actual mills with comparable BLS firing rates.

The model stack temperature of 77°C (170°F) is based on process information reported by mills and on measurements during emission tests.[1,12,13] The process information shows stack temperatures range from 49° to 100°C (120° to 212°F). The emission test reports listed stack temperatures of 82°C (180°F) and 76°C (168°F).

The stack gas moisture content for model SDT's is 36 percent, which is the average moisture content from four emission tests.[7] The average moisture contents of the stack gases for the four SDT's that were tested are 35.5 percent, 46.7 percent, 25.4 percent, and 38.5 percent.[7]

The inlet gas flow rates were calculated from the stack gas flow rates and estimated inlet temperature and moisture content. The model inlet temperature of 93°C (200°F) was estimated based on available process information reported by individual mills.[2]

4.1.2.4 HAP Emissions. Particulate matter emissions, as a surrogate for PM HAP emissions, are characterized by the model SDT's. The models characterize SDT's with PM emissions above the NSPS PM emission limit for SDT's, i.e., 0.10 kg/Mg (0.20 lb/ton) BLS. Therefore, the model PM emission levels were based on the PM levels for those SDT's that are not subject to the NSPS and that emit more than the NSPS PM limit. The PM levels do not represent the PM emission performance of typical SDT's because approximately 75 percent of existing SDT's emit, on average, less than the NSPS.[2] The model SDT PM emission levels were selected so that the emission reduction potential and control costs for those SDT's with PM emission levels higher than the NSPS could be evaluated.

Scrubbers are generally more effective at removing PM than mist eliminators; therefore, different PM levels were calculated for SDT's with wet scrubbers and SDT's with mist eliminators. Average PM emissions are 0.18 kg/Mg (0.37 lb/ton) BLS if a wet scrubber is the PM emission control device, and 0.23 kg/Mg (0.46 lb/ton) BLS if a mist eliminator is the PM emission control device.[10]

4.1.3 Black Liquor Oxidation Unit Models

The three model process units that were developed to characterize existing BLO units are presented in Table 4-3. With the possible exception of the estimated one kraft pulp mill that operates DCE recovery furnaces but does not have a BLO unit, no

TABLE 4-3a (METRIC). BLACK LIQUOR OXIDATION UNIT MODEL PROCESS UNITS AND PROCESS PARAMETERS[a]

Model No.	Equipment type	Equivalent black liquor firing rate, kg BLS/d	Equivalent pulp production rate		Vent gas flow rate, m^3/sec actual @ 54°C	Moisture content, %	Air pollution control device	Methanol emissions, kg/d
			ADMUP/d	ADTBP/d				
BLO-1	2-stage, air-sparging	0.4 MM	270	230	4.2	35	Uncontrolled	70.8
BLO-2	2-stage, air-sparging	0.7 MM	450	380	8.5	35	Uncontrolled	118
BLO-3	2-stage, air sparging	1.2 MM	820	680	12.7	35	Uncontrolled	212

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-3b.

TABLE 4-3b (ENGLISH). BLACK LIQUOR OXIDATION UNIT MODEL PROCESS UNITS AND PROCESS PARAMETERS

Model No.	Equipment type	Equivalent black liquor firing rate, lb BLS/d	Equivalent pulp production rate		Vent gas flow rate, acfm @ 130°F	Moisture content, %	Air pollution control device	Methanol emissions, lb/d
			ADTUP/d	ADTBP/d				
BLO-1	2-stage, air-sparging	0.9 MM	300	250	8,900	35	Uncontrolled	156
BLO-2	2-stage, air-sparging	1.5 MM	500	420	18,000	35	Uncontrolled	260
BLO-3	2-stage, air-sparging	2.7 MM	900	750	26,900	35	Uncontrolled	467

new BLO units are expected to be built.[11] The parameters selected to characterize typical BLO units are (1) equipment type, (2) size (i.e., equivalent BLS firing rate and pulp production rate), (3) air pollution control device, (4) vent characteristics (i.e., flow rate and moisture content), and (5) HAP emission levels (i.e., methanol).

4.1.3.1 Equipment Type. Two types of BLO units are used at kraft pulp mills--air-sparging units and molecular O_2 systems. Models were developed only for air-sparging units, which account for an estimated 94 percent of the BLO units.[1,11] The BLO models were selected to characterize the majority of BLO systems; therefore, BLO models were not developed for molecular O_2 systems. Also, molecular O_2 BLO systems are essentially closed systems that do not emit HAP's.

4.1.3.2 BLO Size. Three model sizes for BLO systems were selected to correspond to the DCE recovery furnace model sizes. Therefore, the BLS firing rates and pulp production rates for the DCE recovery furnace models were selected as the parameters that reflect the size of the BLO unit. The equivalent BLS firing rates for models BLO-1, BLO-2, and BLO-3 are 0.4 MM, 0.7 MM, and 1.2 MM kg BLS/d (0.9 MM, 1.5 MM, and 2.7 MM lb BLS/d), respectively.

4.1.3.3 Air Pollution Control Device. Air emissions from approximately 95 percent of air-sparging BLO systems are uncontrolled.[11] Those few mills (about 2 mills) that control BLO emissions incinerate the BLO vent gases in a power boiler.[11] The BLO models were selected to characterize the majority of BLO systems; therefore, BLO model vent emissions are uncontrolled.

4.1.3.4 Vent Characteristics. The vent gas flow rates, temperature, and moisture content for the model BLO units are based on typical process data provided by mills for actual units within each model size range. The vent gas flow rates for the three model BLO units are 4.2, 8.5, and 12.7 m^3/sec (8,900, 18,000, and 26,900 acfm).[2] The exhaust gas temperature is 54°C (130°F).[11] The exhaust gas moisture content is 35 percent.[14,15]

4.1.3.5 HAP Emissions. As noted in Chapter 2, methanol emission levels associated with the BLO models were calculated using an emission factor of 1.73×10^{-4} kg/kg BLS (1.73×10^{-4} lb/lb BLS).

4.1.4 Lime Kiln Models

The six model process units (LK-1 through LK-6) that were developed to characterize rotary lime kilns are presented in Table 4-4. Current industry trends are (1) using ESP's rather than scrubbers to control PM emissions and (2) longer and larger diameter lime kilns.[11] Therefore, the majority of new lime kiln installations will likely be represented by the larger models LK-5 and LK-6. The parameters selected to characterize lime kilns are (1) size (i.e., equivalent pulp production rate, lime production rate, length, and diameter), (2) PM emission control device, (3) stack gas characteristics (i.e., flow rate, temperature and moisture content), and (4) HAP emission levels (i.e., PM as a surrogate for PM HAP's).

4.1.4.1 Lime Kiln Size. The lime kiln size is indicated by the equivalent pulp production rate, lime (i.e., CaO) production rate, length, and diameter.

The model sizes for lime kilns were determined using available lime production rates.[2] The size distribution, in Mg/d (ton/d) of lime, for lime kilns is shown in Figure 4-3. The sample population of lime kilns was divided into small, medium, and large model sizes. The median lime production rate within each size range was then selected as the lime production rate for the model. Based on the data presented in Figure 4-3, the three lime kiln model sizes are 90, 180, and 270 Mg/d (100, 200, and 300 ton/d) of CaO. The daily equivalent pulp production rate was estimated using a conversion factor of 275 kg CaO/ADMP (550 lb CaO/ADTP).[3]

The length and diameter were determined based on the lime production rates for the small, medium, and large models and available data on lime kiln dimensions at similar production rates.[2] Lime kiln lengths range from 37 to 137 m (120 to 450 ft) and average 82 m (270 ft); lime kiln diameters range from 2.1 to

TABLE 4-4a (METRIC). LIME KILN MODEL PROCESS UNITS AND PROCESS PARAMETERS[a]

Model No.	Equivalent pulp production rate, ADMP/d	CaO production rate, Mg/d	Length, m	Diameter, m	PM emission control device	PM emission control device inlet gas flow rate, m^3/sec actual @ 249°C	Stack gas flow rate & temp., m^3/sec actual @ °C	Moisture content, %	PM emissions, g/dscm @10% O_2
LK-1	320	90	61	2.7	Venturi scrubber	10.4	7.3 @ 71°C	30	0.27
LK-2	680	180	84	3.0	Venturi scrubber	20.1	14.2 @ 71°C	30	0.27
LK-3	1,000	270	107	3.7	Venturi scrubber	34.1	24.1 @ 71°C	30	0.27
LK-4	320	90	61	2.7	ESP	10.4	10.4 @ 249°C	25	0.15
LK-5	680	180	84	3.0	ESP	20.1	20.1 @ 249°C	25	0.15
LK-6	1,000	270	107	3.7	ESP	34.1	34.1 @ 249°C	25	0.15

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-4b.

TABLE 4-4b (ENGLISH). LIME KILN MODEL PROCESS UNITS AND PROCESS PARAMETERS

Model No.	Equivalent pulp production rate, ADTP/d	CaO production rate, ton/d	Length, ft	Diameter, ft	PM emission control device	PM emission control device inlet gas flow rate, acfm @ 480 °F	Stack gas flow rate & temp., acfm @ °F	Moisture content, %	PM emissions, gr/dscf @10% O_2
LK-1	350	100	200	9.0	Venturi scrubber	22,000	15,500 @ 160°F	30	0.12
LK-2	750	200	275	10	Venturi scrubber	42,500	30,000 @ 160°F	30	0.12
LK-3	1,100	300	350	12	Venturi scrubber	72,200	51,000 @ 160°F	30	0.12
LK-4	350	100	200	9.0	ESP	22,000	22,000 @ 480°F	25	0.067
LK-5	750	200	275	10	ESP	42,500	42,500 @ 480°F	25	0.067
LK-6	1,100	300	350	12	ESP	72,200	72,200 @ 480°F	25	0.067

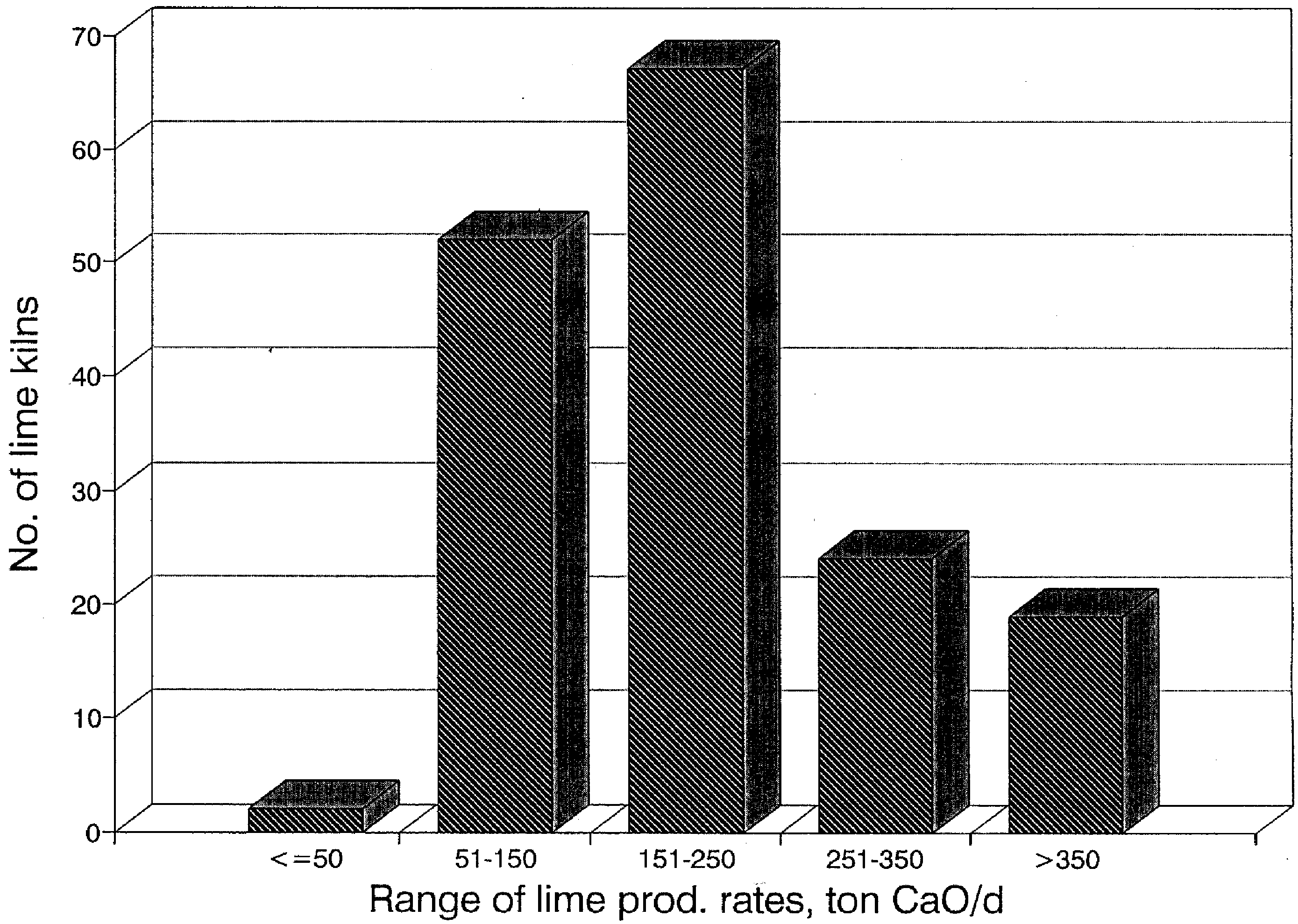

Figure 4-3. Size distribution for lime kilns.

4.6 m (7 to 15 ft) and average 3.2 m (10.5 ft).[11] The model lime kiln dimensions were selected to cover these ranges.

4.1.4.2 PM Emission Control Device. Both wet scrubbers and ESP's are used by the kraft pulp industry to control PM emissions from lime kilns.[11] Particulate matter emissions from the majority of lime kilns (90 percent) are controlled with wet scrubbers.[11] Venturi scrubbers are the most prevalent type of wet scrubber used (89 percent of all wet scrubbers used to control PM emissions are venturi scrubbers).[11] Particulate matter emissions from the remaining 10 percent of lime kilns are controlled by ESP's.[11] Lime kiln models were developed to characterize both types of PM emission control devices. The PM emission control device for models LK-1 through LK-3 is a venturi scrubber. For models LK-4 through LK-6, the PM emission control device is an ESP.

4.1.4.3 Stack Gas Characteristics. The stack gas flow rates for the lime kiln models with scrubbers represent typical gas flow rates within each size range based on available process data.[2] The model gas flow rates for the small, medium, and large models are 7.3, 14.2, and 24.1 m^3/sec (15,500, 30,000, and 51,000 acfm), respectively. The exhaust gas temperature of 71°C (160°F) is based on process data provided by mills.[2,11] The range of stack temperatures reported is 49° to 102°C (120° to 216°F).[11] The model exhaust gas moisture content of 30 percent is based on test data.[14]

Model inlet gas flow rates were calculated from the stack gas flow rates for the lime kiln models with scrubbers and estimated inlet temperature and moisture content. An inlet temperature of 250°C (480°F) was based on process data provided by mills.[11] The range of inlet temperatures is 150° to 315°C (300° to 600°F).[11] An inlet moisture content of 25 percent was assumed based on the moisture content from test results for a lime kiln with an ESP.[2] Because the gas stream temperature and moisture content do not vary significantly across the ESP, the inlet and outlet gas stream conditions are the same for the model lime kilns with ESP's.

4.1.4.4 HAP Emissions. The model lime kilns shown in Table 4-4 include PM emission levels as a surrogate for PM HAP emissions. The PM emission level for model lime kilns with wet scrubbers (LK-1 through LK-3) is 0.27 g/dscm (0.12 gr/dscf) at 10 percent O_2.[10] This emission level characterizes all lime kilns with PM emission levels above the NSPS PM emission limit for lime kilns firing natural gas, i.e., 0.15 g/dscm (0.067 gr/dscf); the emission level represents both natural gas-fired and oil-fired lime kilns. The PM level does not represent the PM emission performance of typical lime kilns because approximately 64 percent of existing lime kilns emit less than the NSPS limit for gas-fired lime kilns.[2] The model lime kiln PM emission level was selected so that the emission reduction potential and control costs for those lime kilns with PM emission levels higher than the NSPS could be evaluated.

Electrostatic precipitators are generally more effective at removing PM than venturi scrubbers; therefore, different PM levels were calculated for lime kilns with ESP's. Particulate matter emission levels for lime kiln models with ESP's (LK-4 through LK-6) are equivalent to the NSPS level, 0.15 g/dscm (0.067 gr/dscf). All existing lime kilns equipped with ESP's reportedly have PM emissions less than or equal to the NSPS PM limit for gas-fired lime kilns.[2]

4.2 CONTROL OPTIONS

Control options for recovery furnaces, SDT's, BLO units, and lime kilns were developed based on the emission control information presented in Chapter 3. This section identifies and briefly describes these control options. Controlled emission levels are presented for each applicable model process unit, along with model control device parameters, where applicable.

4.2.1 Recovery Furnace Control Options

Table 4-5 presents the four control options that have been evaluated for recovery furnaces. Table 4-5 also identifies the recovery furnace type that is affected by the control option and the pollutants that would be controlled. The four control options are (1) conversion of a DCE recovery furnace system to an

NDCE recovery furnace (i.e., low-odor conversion), (2) wet to dry ESP system conversion, (3) PM controls, and (4) addition of a packed-bed scrubber.

TABLE 4-5. RECOVERY FURNACE CONTROL OPTIONS

Control option	Affected recovery furnace type	Pollutants Controlled
Low-odor conversion[a]	DCE recovery furnaces	Gaseous organic HAP's and PM HAP's
Wet to dry ESP system conversion	NDCE recovery furnaces with wet ESP systems	Gaseous organic HAP's (e.g., methanol)
PM Controls:		
(a) ESP upgrade or replacement in order to meet NSPS PM emission level of 0.10 g/dscm (0.044 gr/dscf)	NDCE and DCE recovery furnaces currently emitting PM in quantities above NSPS PM emission level	PM HAP's
(b) ESP upgrade or replacement plus addition of packed-bed scrubber in order to meet PM level of 0.034 g/dscm (0.015 gr/dscf).	NDCE and DCE recovery furnaces currently emitting PM in quantities greater than 0.034 g/dscm (0.015 gr/dscf).	PM HAP's
Packed-bed scrubber	All recovery furnaces	HCl

[a]In addition to the elimination of the BLO unit and the conversion of the evaporator to the noncontact design, the low-odor conversion option also includes an ESP upgrade or replacement (including wet to dry ESP system conversion) to meet the applicable PM emission limit listed under "PM Controls."

4.2.1.1 Conversion of a DCE Recovery Furnace System to an NDCE Recovery Furnace. Converting a DCE recovery furnace system to an NDCE recovery furnace (or "low-odor conversion") was evaluated as a control option for reducing gaseous organic HAP emissions from DCE recovery furnace systems. Under this control option, the DCE is eliminated from the chemical recovery process and replaced with a concentrator, the BLO unit is eliminated, and the wet ESP system is converted to a dry ESP system. Based on the emission factors presented in Sections 4.1.1.5 and 4.1.3.5, this control option reduces methanol emissions by 99 percent. Because the DCE provides some PM control, as discussed in Chapter 3, conversion to an NDCE recovery furnace has the potential to increase PM emissions. Therefore, depending on the design characteristics of the ESP, an ESP upgrade or replacement may be required to achieve compliance with PM emission limits.

Two levels of PM control were included as part of the low-odor conversion option. A PM control level of 0.10 g/dscm (0.044 gr/dscf) at 8 percent O_2 (i.e., the NSPS limit) was evaluated for both "a" and "b" model recovery furnaces. Although "b" model recovery furnaces have a baseline of 0.10 g/dcsm (0.044 gr/dscf), conversion to an NDCE recovery furnace has the potential to increase PM emissions above the baseline. Therefore, PM controls are necessary to maintain a PM level of 0.10 g/dscm (0.044 gr/dscf) for the "b" model recovery furnaces. A control level of 0.034 g/dscm (0.015 gr/dscf) at 8 percent O_2 was also evaluated for both "a" and "b" model recovery furnaces. Tables 4-6 and 4-7 present the model recovery furnaces that were evaluated for this control option. Controlled emission levels also are included in these tables.

4.2.1.2 Wet to Dry ESP System Conversion. Converting wet ESP systems to dry ESP systems was evaluated as a control option for reducing methanol and other gaseous organic HAP emissions from NDCE recovery furnaces. With this control option, stripping of methanol from the black liquor or HAP-contaminated water in the ESP bottom or PM return system is eliminated. Using the methanol emission factors presented in Section 4.1.1.5 for wet and dry ESP systems, methanol emissions are reduced by 72 percent. The model recovery furnaces used to evaluate the impact of this option are presented in Table 4-8.

4.2.1.3 PM Emission Controls. One PM emission control option was evaluated that would reduce PM emissions from existing NDCE and DCE recovery furnace systems to the NSPS PM limit. The control option would involve either an ESP upgrade or an ESP replacement to meet the NSPS limit of 0.10 g/dscm (0.044 gr/dscf). The model recovery furnaces (NDCE and DCE "a" models) analyzed for this control option are presented in Table 4-9.

A second PM emission control option was evaluated that would reduce PM emissions from NDCE and DCE recovery furnaces to a more stringent level of 0.034 g/dscm (0.015 gr/dscf). The control option would involve (1) upgrading the existing ESP and

TABLE 4-6a (METRIC). RECOVERY FURNACE MODELS: LOW-ODOR CONVERSION CONTROL OPTION (INCLUDES WET TO DRY ESP SYSTEM CONVERSION AND PM CONTROL TO NSPS LEVEL)[a]

Model No.	Evaporator type	Equivalent pulp production rate		Black liquor firing rate, kg BLS/d	PM emission control device	Control option PM emission control device	Gas flow rate--ESP exit, m^3/sec actual	PM emissions, g/dscm	Controlled PM emissions, g/dscm	Methanol emissions, kg/d[b]	Controlled methanol emissions, kg/d[b]
		ADMUP/d	ADMBP/d								
RF-7a	DCE	270	230	0.4 MM	Wet ESP system	Dry ESP system	56.2	0.18	0.10	140	2.0
RF-8a	DCE	450	380	0.7 MM	Wet ESP system	Dry ESP system	93.4	0.18	0.10	234	3.4
RF-9a	DCE	820	680	1.2 MM	Wet ESP system	Dry ESP system	168	0.18	0.10	420	6.0

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-6b.
[b]Includes methanol emissions from recovery furnace stack and BLO vent.

TABLE 4-6b (ENGLISH). RECOVERY FURNACE MODELS: LOW-ODOR CONVERSION CONTROL OPTION (INCLUDES WET TO DRY ESP SYSTEM CONVERSION AND PM CONTROL TO NSPS LEVEL)

Model No.	Evaporator type	Equivalent pulp production rate		Black liquor firing rate, lb BLS/d	PM emission control device	Control option PM emission control device	Gas flow rate--ESP exit, acfm	PM emissions, gr/dscf	Controlled PM emissions, gr/dscf	Methanol emissions, lb/d[a]	Controlled methanol emissions, lb/d[a]
		ADTUP/d	ADTBP/d								
RF-7a	DCE	300	250	0.9 MM	Wet ESP system	Dry ESP system	119,000	0.08	0.044	309	4.4
RF-8a	DCE	500	420	1.5 MM	Wet ESP system	Dry ESP system	198,000	0.08	0.044	515	7.4
RF-9a	DCE	900	750	2.7 MM	Wet ESP system	Dry ESP system	357,000	0.08	0.044	926	13.3

[a]Includes methanol emissions from recovery furnace stack and BLO vent.

TABLE 4-7a (METRIC). RECOVERY FURNACE MODELS: LOW-ODOR CONVERSION CONTROL OPTION (INCLUDING WET TO DRY ESP SYSTEM CONVERSION AND PM CONTROL TO 0.034 G/DSCM)[a]

Model No.	Evaporator type	Equivalent pulp production rate		Black liquor firing rate, kg BLS/d	PM emission control device	Control option PM emission control device	Gas flow rate--ESP exit, m^3/sec actual	PM emissions, g/dscm	Controlled PM emissions, g/dscm	Methanol emissions, kg/d[b]	Controlled methanol emissions, kg/d[b]
		ADMUP/d	ADMBP/d								
RF-7a	DCE	270	230	0.4 MM	Wet ESP system	Dry ESP system	56.2	0.18	0.034	140	2.0
RF-7b	DCE	270	230	0.4 MM	Wet ESP system	Dry ESP system	56.2	0.10	0.034	140	2.0
RF-8a	DCE	450	380	0.7 MM	Wet ESP system	Dry ESP system	93.4	0.18	0.034	234	3.4
RF-8b	DCE	450	380	0.7 MM	Wet ESP system	Dry ESP system	93.4	0.10	0.034	234	3.4
RF-9a	DCE	820	680	1.2 MM	Wet ESP system	Dry ESP system	168	0.18	0.034	420	6.0
RF-9b	DCE	820	680	1.2 MM	Wet ESP system	Dry ESP system	168	0.10	0.034	420	6.0

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-7b.
[b]Includes methanol emissions from recovery furnace stack and BLO vent.

TABLE 4-7b (ENGLISH). RECOVERY FURNACE MODELS: LOW-ODOR CONVERSION CONTROL OPTION (INCLUDING WET TO DRY ESP SYSTEM CONVERSION AND PM CONTROL TO 0.015 GR/DSCF)[a]

Model No.	Evaporator type	Equivalent pulp production rate		Black liquor firing rate, lb BLS/d	PM emission control device	Control option PM emission control device	Gas flow rate--ESP exit, acfm	PM emissions, gr/dscf	Controlled PM emissions, gr/dscf	Methanol emissions, lb/d[a]	Controlled methanol emissions, lb/d[a]
		ADTUP/d	ADTBP/d								
RF-7a	DCE	300	250	0.9 MM	Wet ESP system	Dry ESP system	119,000	0.08	0.015	309	4.4
RF-7b	DCE	300	250	0.9 MM	Wet ESP system	Dry ESP system	119,000	0.044	0.015	309	4.4
RF-8a	DCE	500	420	1.5 MM	Wet ESP system	Dry ESP system	198,000	0.08	0.015	515	7.4
RF-8b	DCE	500	420	1.5 MM	Wet ESP system	Dry ESP system	198,000	0.044	0.015	515	7.4
RF-9a	DCE	900	750	2.7 MM	Wet ESP system	Dry ESP system	357,000	0.08	0.015	926	13.3
RF-9b	DCE	900	750	2.7 MM	Wet ESP system	Dry ESP system	357,000	0.044	0.015	926	13.3

[a]Includes methanol emissions from recovery furnace stack and BLO vent.

TABLE 4-8a (METRIC). RECOVERY FURNACE MODELS: WET TO DRY ESP SYSTEM CONVERSION CONTROL OPTION[a]

Model No.	Evaporator type	Black liquor firing rate, kg BLS/d	Equivalent pulp production rate		PM emission control device[b]	Control option PM emission control device	Gas flow rate--ESP exit, m^3/sec actual	Methanol emissions, kg/d	Controlled methanol emissions, kg/d
			ADMUP/d	ADMBP/d					
RF-4	NDCE	0.7 MM	450	380	Wet ESP system	Dry ESP system	93.4	34.3	3.4
RF-5	NDCE	1.2 MM	820	680	Wet ESP system	Dry ESP system	168	61.7	6.0
RF-6	NDCE	1.8 MM	1,200	1,000	Wet ESP system	Dry ESP system	243	89.4	8.7

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-8b.
[b]"Wet ESP system" includes ESP's with black liquor or HAP-contaminated process water in the ESP bottom or PM return system.

TABLE 4-8b (ENGLISH). RECOVERY FURNACE MODELS: WET TO DRY ESP SYSTEM CONVERSION CONTROL OPTION

Model No.	Evaporator type	Black liquor firing rate, lb BLS/d	Equivalent pulp production rate		PM emission control device[a]	Control option PM emission control device	Gas flow rate--ESP exit, acfm	Methanol emissions, lb/d	Controlled methanol emissions, lb/d
			ADTUP/d	ADTBP/d					
RF-4	NDCE	1.5 MM	500	420	Wet ESP system	Dry ESP system	198,000	75.6	7.4
RF-5	NDCE	2.7 MM	900	750	Wet ESP system	Dry ESP system	357,000	136	13.3
RF-6	NDCE	3.9 MM	1,300	1,100	Wet ESP system	Dry ESP system	515,000	197	19.2

[a]"Wet ESP system" includes ESP's with black liquor or HAP-contaminated process water in the ESP bottom or PM return system.

TABLE 4-9a (METRIC). RECOVERY FURNACE MODELS: PM CONTROL OPTIONS (0.10 G/DSCM)[a]

Model No.	Evaporator type	Black liquor firing rate, kg BLS/d	Equivalent pulp production rate		PM emission control device	Gas flow rate--ESP exit, m^3/sec actual	PM emissions, g/dscm @ 8% O_2	Controlled PM emissions, g/dscm @ 8% O_2
			ADMUP/d	ADMBP/d				
RF-1a	NDCE	0.7 MM	450	380	ESP	93.4	0.27	0.10
RF-2a	NDCE	1.2 MM	820	680	ESP	168	0.27	0.10
RF-3a	NDCE	1.8 MM	1,200	1,000	ESP	243	0.27	0.10
RF-7a	DCE	0.4 MM	270	230	ESP	56.2	0.18	0.10
RF-8a	DCE	0.7 MM	450	380	ESP	93.4	0.18	0.10
RF-9a	DCE	1.2 MM	820	680	ESP	168	0.18	0.10

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-9b.

TABLE 4-9b (ENGLISH). RECOVERY FURNACE MODELS: PM CONTROL OPTIONS (0.044 GR/DSCF)

Model No.	Evaporator type	Black liquor firing rate, lb BLS/d	Equivalent pulp production rate		PM emission control device	Gas flow rate--ESP exit, acfm	PM emissions, gr/dscf @ 8% O_2	Controlled PM emissions, gr/dscf @ 8% O_2
			ADTUP/d	ADTBP/d				
RF-1a	NDCE	1.5 MM	500	420	ESP	198,000	0.12	0.044
RF-2a	NDCE	2.7 MM	900	750	ESP	357,000	0.12	0.044
RF-3a	NDCE	3.9 MM	1,300	1,100	ESP	515,000	0.12	0.044
RF-7a	DCE	0.9 MM	300	250	ESP	119,000	0.08	0.044
RF-8a	DCE	1.5 MM	500	420	ESP	198,000	0.08	0.044
RF-9a	DCE	2.7 MM	900	750	ESP	357,000	0.08	0.044

installing a packed-bed scrubber or (2) installing a new ESP and a packed-bed scrubber. The control option would be applicable to both new and existing recovery furnaces. The model recovery furnaces analyzed for this control option are presented in Table 4-10.

Note that because the type of ESP bottom or PM return system does not affect PM emission levels, this parameter was not considered in evaluating either of the PM control options.

4.2.1.4 Packed-Bed Scrubber. The installation of packed-bed scrubbers was evaluated as an HCl control option for existing and new NDCE and DCE recovery furnaces, and for DCE recovery furnaces that have undergone a conversion to the NDCE furnace design. Packed-bed scrubbers are capable of controlling outlet HCl emissions by 99 percent or to levels less than or equal to 5 ppmv.[16,17] This emission level (i.e., 5 ppmv) corresponds to an emission factor of 6.20×10^{-5} kg HCl/kg BLS (6.20×10^{-5} lb HCl/lb BLS) for the model NDCE recovery furnaces and converted DCE's. The corresponding emission factor for the model DCE recovery furnaces is 6.53×10^{-5} kg HCl/kg BLS (6.53×10^{-5} lb HCl/lb BLS). Under this control option, HCl emissions from the model NDCE recovery furnaces (and converted DCE's) are reduced by 48 percent, and HCl emissions from the model DCE's are reduced by 46 percent. The model recovery furnaces that were analyzed for this control option are listed in Tables 4-11 and 4-12.

4.2.2 SDT Control Options

One PM emission control option was evaluated that would reduce PM emissions from existing SDT's to the NSPS PM limit. The control option would involve replacing the existing mist eliminator or existing scrubber with a new wet scrubber designed to meet the NSPS PM limit. The model SDT's analyzed for this control option are presented in Table 4-13.

A second PM emission control option was evaluated that would reduce PM emissions to a more stringent level of 0.06 kg/Mg BLS (0.12 lb/ton BLS). The control option would involve (1) replacing the existing mist eliminator or scrubber with a new

TABLE 4-10a (METRIC). RECOVERY FURNACE MODELS: PM CONTROL OPTIONS (0.034 G/DSCM)[a]

Model No.	Evaporator type	Black liquor firing rate, kg BLS/d	Equivalent pulp production rate		PM emission control device	Gas flow rate--ESP exit, m^3/sec actual	PM emissions, g/dscm @ 8% O_2	Controlled PM emissions, g/dscm @ 8% O_2
			ADMUP/d	ADMBP/d				
RF-1a	NDCE	0.7 MM	450	380	ESP	93.4	0.27	0.034
RF-1b	NDCE	0.7 MM	450	380	ESP	93.4	0.10	0.034
RF-2a	NDCE	1.2 MM	820	680	ESP	168	0.27	0.034
RF-2b	NDCE	1.2 MM	820	680	ESP	168	0.10	0.034
RF-3a	NDCE	1.8 MM	1,200	1,000	ESP	243	0.27	0.034
RF-3b	NDCE	1.8 MM	1,200	1,000	ESP	243	0.10	0.034
RF-7a	DCE	0.4 MM	270	230	ESP	56.2	0.18	0.034
RF-7b	DCE	0.4 MM	270	230	ESP	56.2	0.10	0.034
RF-8a	DCE	0.7 MM	450	380	ESP	93.4	0.18	0.034
RF-8b	DCE	0.7 MM	450	380	ESP	93.4	0.10	0.034
RF-9a	DCE	1.2 MM	820	680	ESP	168	0.18	0.034
RF-9b	DCE	1.2 MM	820	680	ESP	168	0.10	0.034

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-10b.

TABLE 4-10b (ENGLISH). RECOVERY FURNACE MODELS: PM CONTROL OPTIONS (0.015 GR/DSCF)

Model No.	Evaporator type	Black liquor firing rate, lb BLS/d	Equivalent pulp production rate		PM emission control device	Gas flow rate--ESP exit, acfm	PM emissions, gr/dscf @ 8% O_2	Controlled PM emissions, gr/dscf @ 8% O_2
			ADTUP/d	ADTBP/d				
RF-1a	NDCE	1.5 MM	500	420	ESP	198,000	0.12	0.015
RF-1b	NDCE	1.5 MM	500	420	ESP	198,000	0.044	0.015
RF-2a	NDCE	2.7 MM	900	750	ESP	357,000	0.12	0.015
RF-2b	NDCE	2.7 MM	900	750	ESP	357,000	0.044	0.015
RF-3a	NDCE	3.9 MM	1,300	1,100	ESP	515,000	0.12	0.015
RF-3b	NDCE	3.9 MM	1,300	1,100	ESP	515,000	0.044	0.015
RF-7a	DCE	0.9 MM	300	250	ESP	119,000	0.08	0.015
RF-7b	DCE	0.9 MM	300	250	ESP	119,000	0.044	0.015
RF-8a	DCE	1.5 MM	500	420	ESP	198,000	0.08	0.015
RF-8b	DCE	1.5 MM	500	420	ESP	198,000	0.044	0.015
RF-9a	DCE	2.7 MM	900	750	ESP	357,000	0.08	0.015
RF-9b	DCE	2.7 MM	900	750	ESP	357,000	0.044	0.015

TABLE 4-11a (METRIC). RECOVERY FURNACE MODELS: HCl CONTROL OPTION (PACKED-BED SCRUBBER)[a]

Model No.	Black liquor firing rate, kg BLS/d	Equivalent pulp production rate		PM emission control device	Gas flow rate--ESP exit, m^3/sec actual	Control option control device	HCl emissions, kg/d	Controlled HCl emissions, kg/d
		ADMUP/d	ADMBP/d					
RF-1	0.7 MM	450	380	ESP	93.4	ESP+packed-bed scrubber	81.6	42.2
RF-2	1.2 MM	820	680	ESP	168	ESP+packed-bed scrubber	147	75.7
RF-3	1.8 MM	1,200	1,000	ESP	243	ESP+packed-bed scrubber	212	110
RF-7	0.4 MM	270	230	ESP	56.2	ESP+packed-bed scrubber	49.0	26.7
RF-8	0.7 MM	450	380	ESP	93.4	ESP+packed-bed scrubber	81.6	44.5
RF-9	1.2 MM	820	680	ESP	168	ESP+packed-bed scrubber	147	79.8

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-11b.

TABLE 4-11b (ENGLISH). RECOVERY FURNACE MODELS: HCl CONTROL OPTION (PACKED-BED SCRUBBER)

Model No.	Black liquor firing rate, lb BLS/d	Equivalent pulp production rate		PM emission control device	Gas flow rate--ESP exit, acfm	Control option control device	HCl emissions, lb/d	Controlled HCl emissions, lb/d
		ADTUP/d	ADTBP/d					
RF-1	1.5 MM	500	420	ESP	198,000	ESP+packed-bed scrubber	180	93.0
RF-2	2.7 MM	900	750	ESP	357,000	ESP+packed-bed scrubber	324	167
RF-3	3.9 MM	1,300	1,100	ESP	515,000	ESP+packed-bed scrubber	468	242
RF-7	0.9 MM	300	250	ESP	119,000	ESP+packed-bed scrubber	108	58.8
RF-8	1.5 MM	500	420	ESP	198,000	ESP+packed-bed scrubber	180	98.0
RF-9	2.7 MM	900	750	ESP	357,000	ESP+packed-bed scrubber	324	176

TABLE 4-12a (METRIC). RECOVERY FURNACE MODELS: HCl CONTROL OPTION (PACKED-BED SCRUBBER AFTER LOW-ODOR CONVERSION)[a]

Model No.	Black liquor firing rate, kg BLS/d	Equivalent pulp production rate		Control device	Gas flow rate--ESP exit, m^3/sec actual	Control option control device	HCl emissions, kg/d	Controlled HCl emissions, kg/d
		ADMUP/d	ADMBP/d					
RF-7	0.4 MM	270	230	ESP	56.2	ESP+packed-bed scrubber	49.0	25.3
RF-8	0.7 MM	450	380	ESP	93.4	ESP+packed-bed scrubber	81.6	42.2
RF-9	1.2 MM	820	680	ESP	168	ESP+packed-bed scrubber	147	75.7

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-12b.

TABLE 4-12b (ENGLISH). RECOVERY FURNACE MODELS: HCl CONTROL OPTION (PACKED-BED SCRUBBER AFTER LOW-ODOR CONVERSION)

Model No.	Black liquor firing rate, lb BLS/d	Equivalent pulp production rate		Control device	Gas flow rate--ESP exit, acfm	Control option control device	HCl emissions, lb/d	Controlled HCl emissions, lb/d
		ADTUP/d	ADTBP/d					
RF-7	0.9 MM	300	250	ESP	119,000	ESP+packed-bed scrubber	108	55.8
RF-8	1.5 MM	500	420	ESP	198,000	ESP+packed-bed scrubber	180	93.0
RF-9	2.7 MM	900	750	ESP	357,000	ESP+packed-bed scrubber	324	167

TABLE 4-13a (METRIC). SMELT DISSOLVING TANK MODELS: PM CONTROL OPTIONS(0.10 KG/MG BLS)[a]

Model No.	Equivalent pulp production rate		Smelt flow rate, kg/d	PM emission control device	Control option PM emission control device	Inlet gas flow rate, m^3/sec actual	Moisture content, %	PM emissions, kg/Mg BLS	Controlled PM emissions, kg/Mg BLS
	ADMUP/d	ADMBP/d							
SDT-1	270	230	151,000	Wet scrubber	Wet scrubber	4.4	36	0.18	0.10
SDT-2	450	380	252,000	Wet scrubber	Wet scrubber	7.4	36	0.18	0.10
SDT-3	820	680	453,000	Wet scrubber	Wet scrubber	13.4	36	0.18	0.10
SDT-4	1,200	1,000	655,000	Wet scrubber	Wet scrubber	19.3	36	0.18	0.10
SDT-5	270	230	151,000	Mist eliminator	Wet scrubber	4.4	36	0.23	0.10
SDT-6	450	380	252,000	Mist eliminator	Wet scrubber	7.4	36	0.23	0.10
SDT-7	820	680	453,000	Mist eliminator	Wet scrubber	13.4	36	0.23	0.10

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-13b.

TABLE 4-13b (ENGLISH). SMELT DISSOLVING TANK MODELS: PM CONTROL OPTIONS (0.20 LB/TON BLS)

Model No.	Equivalent pulp production rate		Smelt flow rate, lb/d	PM emission control device	Control option PM emission control device	Inlet gas flow rate, acfm	Moisture content, %	PM emissions, lb/ton BLS	Controlled PM emissions, lb/ton BLS
	ADTUP/d	ADTBP/d							
SDT-1	300	250	333,000	Wet scrubber	Wet scrubber	9,400	36	0.37	0.20
SDT-2	500	420	555,000	Wet scrubber	Wet scrubber	15,700	36	0.37	0.20
SDT-3	900	750	999,000	Wet scrubber	Wet scrubber	28,300	36	0.37	0.20
SDT-4	1,300	1,100	1,443,000	Wet scrubber	Wet scrubber	40,900	36	0.37	0.20
SDT-5	300	250	333,000	Mist eliminator	Wet scrubber	9,400	36	0.46	0.20
SDT-6	500	420	555,000	Mist eliminator	Wet scrubber	15,700	36	0.46	0.20
SDT-7	900	750	999,000	Mist eliminator	Wet scrubber	28,300	36	0.46	0.20

wet scrubber or (2) installing a new wet scrubber. The control option would be applicable to both new and existing SDT's. The model SDT's analyzed for this control option are presented in Table 4-14.

4.2.3 BLO Unit Control Option

Two control options, (1) conversion of a DCE recovery furnace system to an NDCE recovery furnace and (2) incineration of BLO vent gases, were evaluated for controlling gaseous organic HAP emissions from air-sparging BLO units. Converting the DCE recovery furnace eliminates the BLO unit from the chemical recovery process. Thus, this control option results in a 100 percent reduction in emissions of HAP's, such as methanol, from BLO units. As discussed in Section 4.2.1.1, the overall methanol emission reduction for the recovery furnace system is approximately 99 percent. The model BLO units were not used to assess the impact of this control option; the economic and environmental impacts, such as cost for equipment removal and the associated emission reduction, were included in the impacts for the DCE recovery furnace models.

The second control option to reduce gaseous organic HAP emissions from BLO units is to incinerate the BLO emissions, most likely in a power boiler. This control option reduces methanol emissions from the BLO unit by 98 percent and from the DCE recovery furnace system by 49 percent. The model BLO units analyzed for this control option are presented in Table 4-15.

4.2.4 Lime Kiln Control Options

One PM emission control option was evaluated that would reduce PM emissions from existing lime kilns to the NSPS PM limit. The control option would involve replacing the existing scrubber with a new ESP. Because lime kilns with ESP's are already achieving the NSPS PM level, they are not included under this control option. The model lime kilns analyzed for this control option are presented in Table 4-16.

A second PM emission control option was evaluated that would reduce PM emissions from lime kilns to a more stringent level of 0.023 g/dscm (0.010 gr/dscf). The control option would involve

TABLE 4-14a (METRIC). SMELT DISSOLVING TANK MODELS: PM CONTROL OPTIONS (0.06 KG/MG BLS)[a]

Model No.	Equivalent pulp production rate		Smelt flow rate, kg/d	PM emission control device	Control option PM emission control device	Inlet gas flow rate, m^3/sec actual	Moisture content, %	PM emissions, kg/Mg BLS	Controlled PM emissions, kg/Mg BLS
	ADMUP/d	ADMBP/d							
SDT-1	270	230	151,000	Wet scrubber	Wet scrubber	4.4	36	0.18	0.06
SDT-2	450	380	252,000	Wet scrubber	Wet scrubber	7.4	36	0.18	0.06
SDT-3	820	680	453,000	Wet scrubber	Wet scrubber	13.4	36	0.18	0.06
SDT-4	1,200	1,000	655,000	Wet scrubber	Wet scrubber	19.3	36	0.18	0.06
SDT-5	270	230	151,000	Mist eliminator	Wet scrubber	4.4	36	0.23	0.06
SDT-6	450	380	252,000	Mist eliminator	Wet scrubber	7.4	36	0.23	0.06
SDT-7	820	680	453,000	Mist eliminator	Wet scrubber	13.4	36	0.23	0.06

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-14b.

TABLE 4-14b (ENGLISH). SMELT DISSOLVING TANK MODELS: PM CONTROL OPTIONS (0.12 LB/TON BLS)

Model No.	Equivalent pulp production rate		Smelt flow rate, lb/d	PM emission control device	Control option PM emission control device	Inlet gas flow rate, acfm	Moisture content, %	PM emissions, lb/ton BLS	Controlled PM emissions, lb/ton BLS
	ADTUP/d	ADTBP/d							
SDT-1	300	250	333,000	Wet scrubber	Wet scrubber	9,400	36	0.37	0.12
SDT-2	500	420	555,000	Wet scrubber	Wet scrubber	15,700	36	0.37	0.12
SDT-3	900	750	999,000	Wet scrubber	Wet scrubber	28,300	36	0.37	0.12
SDT-4	1,300	1,100	1,443,000	Wet scrubber	Wet scrubber	40,900	36	0.37	0.12
SDT-5	300	250	333,000	Mist eliminator	Wet scrubber	9,400	36	0.46	0.12
SDT-6	500	420	555,000	Mist eliminator	Wet scrubber	15,700	36	0.46	0.12
SDT-7	900	750	999,000	Mist eliminator	Wet scrubber	28,300	36	0.46	0.12

TABLE 4-15a (METRIC). BLACK LIQUOR OXIDATION UNIT MODELS: METHANOL CONTROL OPTION (INCINERATION)[a]

Model No.	Equivalent black liquor firing rate, kg BLS/d	Equivalent pulp production rate		Methanol control device	Control option control device	Methanol emissions, kg/d	Controlled methanol emissions, kg/d
		ADMUP/d	ADMBP/d				
BLO-1	0.4 MM	270	230	Uncontrolled	Incineration	70.8	1.4
BLO-2	0.7 MM	450	380	Uncontrolled	Incineration	118	2.4
BLO-3	1.2 MM	820	680	Uncontrolled	Incineration	212	4.2

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-15b.

TABLE 4-15b (ENGLISH). BLACK LIQUOR OXIDATION UNIT MODELS: METHANOL CONTROL OPTION (INCINERATION)

Model No.	Equivalent black liquor firing rate, lb BLS/d	Equivalent pulp production rate		Methanol control device	Control option methanol control device	Methanol emissions, lb/d	Controlled methanol emissions, lb/d
		ADTUP/d	ADTBP/d				
BLO-1	0.9 MM	300	250	Uncontrolled	Incineration	156	3.1
BLO-1	1.5 MM	500	420	Uncontrolled	Incineration	260	5.2
BLO-1	2.7 MM	900	750	Uncontrolled	Incineration	467	9.3

TABLE 4-16a (METRIC). LIME KILN MODELS: PM CONTROL OPTIONS (0.15 G/DSCM)[a]

Model No.	Equivalent pulp production rate, ADMP/d	CaO production rate, Mg/d	Length, m	Diameter, m	PM emission control device	Control option PM emission control device	PM emissions, g/dscm	Controlled PM emissions, g/dscm @ 10% O_2
LK-1	320	90	61	2.7	Venturi scrubber	ESP	0.27	0.15
LK-2	680	180	84	3.0	Venturi scrubber	ESP	0.27	0.15
LK-3	1,000	270	107	3.7	Venturi scrubber	ESP	0.27	0.15

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-16b.

TABLE 4-16b (ENGLISH). LIME KILN MODELS: PM CONTROL OPTIONS (0.067 GR/DSCF)

Model No.	Equivalent pulp production rate, ADTP/d	CaO production rate, ton/d	Length, ft	Diameter, ft	PM emission control device	Control option PM emission control device	PM emissions. gr/dscf	Controlled PM emissions, gr/dscf @ 10% O_2
LK-1	350	100	200	9.0	Venturi scrubber	ESP	0.12	0.067
LK-2	750	200	275	10	Venturi scrubber	ESP	0.12	0.067
LK-3	1,100	300	350	12	Venturi scrubber	ESP	0.12	0.067

(1) replacing the existing scrubber with an ESP, (2) upgrading the existing ESP, or (3) installing a new ESP. The more stringent PM control option is applicable to both new and existing lime kilns. The model lime kilns that were analyzed for this control option are presented in Table 4-17.

4.3 ENHANCED MONITORING OPTIONS

The practice of enhanced monitoring allows a facility to demonstrate continuous compliance with the emission limits established by the emission standard. The most direct means of monitoring compliance is the use of continuous emission monitors (CEM's) to measure the emissions of each pollutant on a continuous basis. In the event that CEM's for specific pollutants are not applicable because of cost and/or technology constraints, alternative approaches to ensure continuous compliance can be adopted. The best alternative approach is to use CEM's to monitor surrogate pollutants with emission profiles that closely match those of the pollutants of concern. Where CEM's are not applicable for surrogate pollutants, the next best option is to use process monitors to measure those process or add-on control device operating parameters that impact emissions of the pollutants of concern. In some cases, the very presence of specific processing equipment will ensure continuous compliance with the emission standard. Pollutant emissions can also be tested on a periodic basis (e.g., semiannually).

The following sections describe how the approach described above was used to develop the enhanced monitoring options for combustion sources in the pulp and paper industry. Table 4-18 summarizes the enhanced monitoring options for recovery furnaces, SDT's, BLO units, and lime kilns, based on the control options presented in Section 4.2. Enhanced monitoring options were not developed for control options other than those developed in Section 4.2; if a CEM is not applicable, facilities that choose to meet the emission limits through the application of other control options must develop an enhanced monitoring plan that demonstrates the ability of the selected parameter to gauge a change in emissions.

TABLE 4-17a (METRIC). LIME KILN MODELS: PM CONTROL OPTIONS (0.023 G/DSCM)[a]

Model No.	Equivalent pulp production rate, ADMP/d	CaO production rate, Mg/d	Length, m	Diameter, m	PM emission control device	Control option PM emission control device	PM emissions, g/dscm	Controlled PM emissions, g/dscm @ 10% O_2
LK-1	320	90	61	2.7	Venturi scrubber	ESP	0.27	0.023
LK-2	680	180	84	3.0	Venturi scrubber	ESP	0.27	0.023
LK-3	1,000	270	107	3.7	Venturi scrubber	ESP	0.27	0.023
LK-4	320	90	61	2.7	ESP	ESP	0.15	0.023
LK-5	680	180	84	3.0	ESP	ESP	0.15	0.023
LK-6	1,000	270	107	3.7	ESP	ESP	0.15	0.023

[a]Metric equivalents in this table were converted from the calculated English unit values given in Table 4-17b.

TABLE 4-17b (ENGLISH). LIME KILN MODELS: PM CONTROL OPTIONS (0.010 GR/DSCF)

Model No.	Equivalent pulp production rate, ADTP/d	CaO production rate, ton/d	Length, ft	Diameter, ft	PM emission control device	Control option control device	PM emissions, gr/dscf	Controlled PM emissions, gr/dscf @ 10% O_2
LK-1	350	100	200	9.0	Venturi scrubber	ESP	0.12	0.010
LK-2	750	200	275	10	Venturi scrubber	ESP	0.12	0.010
LK-3	1,100	300	350	12	Venturi scrubber	ESP	0.12	0.010
LK-4	350	100	200	9.0	ESP	ESP	0.067	0.010
LK-5	750	200	275	10	ESP	ESP	0.067	0.010
LK-6	1,100	300	350	12	ESP	ESP	0.067	0.010

TABLE 4-18. ENHANCED MONITORING OPTIONS

Emission source	Pollutants controlled	Control equipment	Enhanced monitoring options
Recovery furnace	PM/PM HAP's	ESP	Opacity monitor
			Monitoring of ESP operating parameters according to a monitoring plan prepared by the mill
		Wet scrubber[a]	Monitoring of scrubber operating parameters (i.e., pressure drop and scrubber liquid flow rate)
		Other[a]	Monitoring of selected parameter according to a monitoring plan prepared by the mill
		All	Periodic EPA Method 5, Method 29, or Method 17 tests
	Gaseous organic HAP's	NDCE recovery furnace with dry ESP system	Equipment in place
		Other[a]	Methanol CEM (e.g., FTIR)
	HCl	Packed-bed scrubber	HCl CEM
			Monitoring of scrubber operating parameters (i.e., scrubber liquid pH and flow rate)
		Other[a]	HCl CEM
			Monitoring of selected parameter according to a monitoring plan prepared by the mill
			Periodic EPA Method 26 tests
SDT	PM/PM HAP's	Wet scrubber	Monitoring of scrubber operating parameters (i.e., pressure drop and scrubber liquid flow rate)
		Other[a]	Monitoring of selected parameter according to a monitoring plan prepared by the mill
		All	Periodic EPA Method 5, Method 29, or Method 17 tests
BLO unit	Gaseous organic HAP's	NDCE recovery furnace with dry ESP system	Equipment in place
		Incineration	Equipment in place
			Incinerator temperature monitor
		Other[a]	Methanol CEM (e.g., FTIR)
Lime kiln	PM/PM HAP's	ESP	Opacity monitor
			Monitoring of ESP operating parameters according to a monitoring plan prepared by the mill
		Wet scrubber[a]	Monitoring of scrubber operating parameters (i.e., pressure drop and scrubber liquid flow rate)
		Other[a]	Monitoring of selected parameter according to a monitoring plan prepared by the mill
		All	Periodic EPA Method 5, Method 29, or Method 17 tests

[a]The emission source can comply with the applicable emission limit by another method or with existing equipment.

4.3.1 Recovery Furnace Enhanced Monitoring

Enhanced monitoring options that can be used to demonstrate compliance with recovery furnace emission limits for PM or PM HAP's, total gaseous organic HAP's, and HCl are presented in the following sections.

4.3.1.1 Enhanced Monitoring for PM or PM HAP's Controlled with an ESP. Because opacity is the surrogate measurement that best characterizes the level of recovery furnace PM emissions, installation of an opacity monitor after the ESP is one option being considered as a means of demonstrating compliance with a PM or PM HAP emission limit for recovery furnaces. For those recovery furnaces with a wet scrubber following the ESP, an opacity monitor must be located after the ESP but prior to the scrubber. Method 5, Method 29, or Method 17 compliance tests could be performed periodically as a substitute for an opacity monitor.

Another option being considered is for the facility to develop a monitoring plan that specifies ESP operating parameters to be monitored. Operating parameters for the ESP would be site-specific and would be based on the parameters measured during a three-run, EPA Method 5, Method 29, or Method 17 compliance test that showed the facility to be in compliance with the applicable PM or PM HAP emission limit. Under this option, operation outside the ranges of the ESP operating parameters would not represent noncompliance with the applicable emission limit but instead would require the facility to take corrective actions, if necessary, to return the ESP parameters to the levels established during the compliance test. The corrective action procedures would be documented in the facility's startup, shutdown, and malfunction plan.

4.3.1.2 Enhanced Monitoring for PM or PM HAP's Controlled with a Wet Scrubber. For those recovery furnaces that can comply with a PM or PM HAP emission limit with existing wet scrubbers, the use of an opacity monitor to demonstrate compliance with the PM or PM HAP emission limit may be inappropriate. The exhaust from the recovery furnace wet scrubber will have a high moisture content and will interfere with the readings from an opacity monitor. Monitoring scrubber operating parameters (i.e., pressure drop and scrubber liquid flow rate) is an alternative enhanced monitoring option for showing compliance with a PM or PM HAP emission limit for recovery furnaces. The pressure drop and liquid flow rate are indirect measurements of the performance of the scrubber. Pressure drop and scrubber liquid flow rate levels would be site-specific and would be based on the operating parameters measured during a three-run, EPA Method 5, Method 29, or Method 17 compliance test that showed the facility to be in compliance with the applicable PM or PM HAP emission limit. Method 5, Method 29, or Method 17 compliance tests could also be performed periodically as a substitute for monitoring scrubber operating parameters.

4.3.1.3 Enhanced Monitoring for Gaseous Organic HAP's. Control of gaseous organic HAP emissions from recovery furnaces can be achieved by using NDCE recovery furnaces equipped with dry ESP systems. Therefore, enhanced monitoring for recovery furnace gaseous organic HAP emissions can be achieved simply by confirming that the recovery furnace is an NDCE recovery furnace with a dry ESP system. If the recovery furnace is a DCE recovery furnace or an NDCE recovery furnace equipped with a wet ESP system, the facility could measure methanol emissions with a methanol CEM (e.g., a fourier transform infrared [FTIR] spectroscopy monitoring system).

4.3.1.4 Enhanced Monitoring for HCl. Hydrochloric acid emissions can be measured directly using an HCl CEM. An HCl CEM could be installed after the packed-bed scrubber to demonstrate continuous compliance with an HCl emission standard. An HCl CEM could also be used after the ESP for those recovery furnaces that could comply with an HCl emission limit without a packed-bed scrubber. The feasibility of using HCl CEM's to demonstrate compliance with an HCl standard has not been determined. The low HCl concentrations and high moisture content associated with the recovery furnace flue gas may make the use of HCl CEM's more difficult. However, additional information is needed before an HCl CEM can be definitively ruled out for recovery furnaces.

Because HCl emissions can be controlled with a packed-bed scrubber, monitoring scrubber operating parameters is another monitoring option being considered for those recovery furnaces that comply with an HCl emission limit using a packed-bed scrubber. The scrubber operating parameters to be monitored are the scrubber liquid pH and scrubber liquid flow rate. Scrubber liquid flow rate and pH levels would be site-specific and would be based on the operating parameters measured during a three-run, EPA Method 26 HCl compliance test that showed the facility to be in compliance with an HCl emission limit.

Alternative enhanced monitoring options are also available to demonstrate compliance for those recovery furnaces that could comply with an HCl emission limit without a packed-bed scrubber. One option would require the facility to develop a monitoring plan that specifies operating parameters to be monitored. The operating parameters would be site-specific and would be based on the parameters measured during a three-run, EPA Method 26 HCl compliance test that showed the facility to be in compliance with an HCl emission limit. Under this option, operating outside the ranges of the operating parameters would not represent noncompliance with the applicable emission limit but instead would require the facility to take corrective actions, if necessary, to return the parameters to the levels established during the compliance test. The corrective action procedures would be documented in the facility's startup, shutdown, and malfunction plan. A second option would require periodic Method 26 HCl compliance tests to demonstrate compliance.

4.3.2 Smelt Dissolving Tank Enhanced Monitoring

This section presents the enhanced monitoring options that can be used to demonstrate compliance with an SDT emission limit for PM or PM HAP's.

4.3.2.1 Enhanced Monitoring for PM or PM HAP's Controlled with a Wet Scrubber. Because the exhaust from the SDT wet scrubber will have a high moisture content and will interfere with the readings from an opacity monitor, the use of an opacity monitor to demonstrate compliance with a PM or PM HAP emission limit for SDT's may be inappropriate. Monitoring scrubber operating parameters (i.e., pressure drop and scrubber liquid flow rate) is an alternative enhanced monitoring option for showing compliance with a PM or PM HAP emission limit for SDT's. The pressure drop and liquid flow rate are indirect measurements of the performance of the scrubber. Pressure drop and scrubber liquid flow rate levels would be site-specific and would be based on the operating parameters measured during a three-run, EPA Method 5, Method 29, or Method 17 compliance test that showed the facility to be in compliance with the applicable PM or PM HAP emission limit. Method 5, Method 29, or Method 17 compliance tests could also be performed periodically as a substitute for monitoring scrubber operating parameters.

4.3.3 Black Liquor Oxidation Unit Enhanced Monitoring

This section presents the enhanced monitoring options that can be used to demonstrate compliance with a total gaseous organic HAP emission limit for DCE recovery furnace systems (which include the BLO unit).

One control option presented for the BLO unit involves the removal of this piece of equipment from the chemical recovery process by converting a DCE recovery furnace to an NDCE recovery furnace equipped with a dry ESP system. Demonstrating that this conversion has been completed assures compliance with the applicable total gaseous organic HAP emission limit.

A second control option involves incineration of the BLO emissions. Enhanced monitoring for BLO incineration could be achieved simply by affirming that the BLO control equipment is in place. Another enhanced monitoring option would be for the facility to monitor the temperature of the power boiler or other incineration device.

4.3.4 Lime Kiln Enhanced Monitoring

Enhanced monitoring options that can be used to demonstrate compliance with a lime kiln emission limit for PM or PM HAP's are presented in the following sections.

4.3.4.1 Enhanced Monitoring for PM or PM HAP's Controlled with an ESP. Because opacity is the surrogate measurement that best characterizes the level of lime kiln PM emissions, installation of an opacity monitor after the ESP is one option being considered as a means of demonstrating compliance with a PM or PM HAP emission limit for lime kilns controlled with ESP's. For those lime kilns with a wet scrubber following the ESP, an opacity monitor must be located after the ESP but prior to the scrubber. Method 5, Method 29, or Method 17 compliance tests could be performed periodically as a substitute for an opacity monitor.

Another option being considered is for the facility to develop a monitoring plan that specifies ESP parameters to be monitored. Operating parameters for the ESP would be site-specific and would be based on the parameters measured during a three-run, EPA Method 5, Method 29, or Method 17 compliance test that showed the facility to be in compliance with the applicable PM or PM HAP emission limit. Under this option, operation outside the ranges of the ESP operating parameters would not represent noncompliance with the applicable emission limit but instead would require the facility to take corrective actions, if necessary, to return the ESP parameters to the levels established during the compliance test. The corrective action procedures would be documented in the facility's startup, shutdown, and malfunction plan.

4.3.4.2 Enhanced Monitoring for PM or PM HAP's Controlled with a Wet Scrubber. For those lime kilns that can comply with a lime kiln PM or PM HAP emission limit with existing wet scrubbers, the use of an opacity monitor to demonstrate compliance with a PM or PM HAP emission limit may be inappropriate. The exhaust from the lime kiln wet scrubber will have a high moisture content and will interfere with the readings from an opacity monitor. Monitoring scrubber operating parameters (i.e., pressure drop and scrubber liquid flow rate) is an alternative enhanced monitoring option for showing compliance with the applicable PM or PM HAP emission limit for lime kilns.

The pressure drop and liquid flow rate are indirect measurements of the performance of the scrubber. Pressure drop and scrubbing liquid flow rate levels would be site-specific and would be based on the operating parameters measured during a three-run, EPA Method 5, Method 29, or Method 17 compliance test that showed the facility to be in compliance with the applicable PM or PM HAP emission limit. Method 5, Method 29, or Method 17 compliance tests could also be performed periodically as a substitute for monitoring scrubber operating parameters.

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