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Project Summary

Kraft Pulp Industry Particulate Emissions: Source Category Report

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The objective of this study was to develop particulate emission factors based on cutoff size for inhalable particles for the kraft pulp industry. After a review of available information characterizing particulate emissions from kraft pulp mills, the data were summarized and rated in terms of reliability. Size specific emission factors were developed from these data for the major processes used in the manufacture of kraft pulp. A detailed process description was presented with emphasis on factors affecting the generation of emissions. A replacement for Section 10.1 (Chemical Wood Pulping) of EPA report AP-42, A Compilation of Air Pollutant Emissions Factors, was prepared, containing the size specific emission factors developed during this program.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The purpose of this program was to summarize the best available information on emissions of inhalable particulate matter in the kraft pulp industry. The main objective of the program was to develop reliable size-specific emission factors for the various processes used in the production of kraft pulp. Both uncontrolled and controlled emission factors are presented in the report. The uncontrolled factors represent emissions which would result if the particulate control device (baghouse, scrubber, etc.) were bypassed, and the controlled factors represent emissions emanating from a particular type of control system. The size-specific emission factors are generally based on the results of simultaneous sampling at the inlet and outlet of the control device(s), utilizing a variety of particle sizing techniques. Other objectives of this program were to present current information on the kraft pulp industry as well as prepare a replacement for Section 10.1 in EPA report AP-42, "A Compilation of Air Pollutant Emissions Factors."

The above objectives were met by a thorough literature search which included:

- Data from the inhalable particulate characterization program,
- Fine Particle Emissions Inventory System (FPEIS),
- AP-42 background file at EPA's Office of Air Quality Planning and Standards (OAQPS),
- State and local air pollution control agencies, and
- Various industry sources (e.g., National Council of the Paper Industry for Air and Stream Improvement and Technical Association of the Pulp and Paper Industry).

The emission data contained in the reference documents were reviewed, analyzed, summarized, and ranked according to the criteria established by OAQPS as published in the EPA report, "Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections," April 1980. After ranking the data, emission factors were calculated using the highest quality data available. The quality of the data used to develop each emission factor is indicated by the emission factor rating.

Process control system operating data as well as general industry information were also obtained and summarized as general background information. It was not part of this program to provide detailed engineering analyses, product specifications, or a detailed evaluation of trends in the industry.

Summary of Results

Particulate emissions from the kraft process occur largely from the recovery furnace, the lime kiln, and the smelt dissolving tank. These emissions consist mainly of sodium salts with some calcium salts from the lime kiln. They are caused mostly by carryover of solids and sublimation and condensation of the inorganic chemicals.

Particulate control is provided on recovery furnaces in a variety of ways. In mills with either a cyclonic scrubber or cascade evaporator as the direct contact evaporator, further control is necessary (these devices are generally only 20 to 50 percent efficient for particulates). Most often in these cases, an electrostatic precipitator is employed after the direct contact evaporator for an overall particulate control efficiency of 85 to ≥99 percent particulate control. Auxiliary scrubbers may be included after the precipitator or the venturi scrubber to provide additional control of particulates. Particulate from lime kilns is generally controlled by scrubbers. Smelt dissolving tanks are commonly controlled by mesh pads, but they have scrubbers when further control is needed.

The total mass controlled and uncontrolled emission factors for kraft pulp manufacturing are presented in Table 1. The size-specific controlled and uncontrolled emission factors for recovery boilers are presented in Tables 2 and 3. The size-specific controlled and uncontrolled emission factors for lime kilns are presented in Tables 4 and 5. The size-specific controlled and uncontrolled emission factors for smelt dissolving tanks are presented in Tables 6 and 7.

Table 1. *Emission Factors for Sulfite Pulping*[a]

Emission Factor Rating: A

Source	Type of control	Particulate		Sulfur dioxide (SO_2)		Carbon monoxide (CO)		Hydrogen Sulfide (S^m)		RSH, RSR, RSSR (S^m)[b]	
		kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
Digester relief and blow tank	Untreated[b]	—	—	—	—	—	—	0.02	0.03	0.6	1.2
Brown stock washer	Untreated[b]	—	—	—	—	—	—	0.01	0.02	0.2[c]	0.4[c]
Multiple effect evaporator	Untreated[b]	—	—	—	—	—	—	0.55	1.1	0.05	0.1
Recovery boiler and direct evaporator	Untreated[e]	90	180	3.5	7	5.5	11	6[f]	12[f]	1.5[f]	3[f]
	Venturi scrubber[g]	24	48	3.5	7	5.5	11	6[f]	12[f]	1.5[f]	3[f]
	ESP	1	2	3.5	7	5.5	11	6[f]	12[f]	1.5[f]	3[f]
	Auxiliary scrubber	1.5–7.5[f]	3–15[f]					6[f]	12[f]	1.5[f]	3[f]
Noncontact recovery boiler without direct contact evaporator	Untreated	115	230	—	—	5.5	11	0.05[j]	0.1[j]	—	—
	ESP	1	2	—	—	5.5	11	0.05[j]	0.1[j]	—	—
Smelt dissolving tank	Untreated	3.5	7	0.1	0.2	—	—	0.1[k]	0.2[k]	0.15[k]	0.3[k]
	Mesh pad	0.5	1	0.1	0.2	—	—	0.1[k]	0.2[k]	0.15[k]	0.3[k]
	Scrubber	0.1	0.2	—	—	—	—	0.1[k]	0.2[k]	0.15[k]	0.3[k]
Lime kiln	Untreated	28	56	0.15	0.3	0.05	0.1	0.25[m]	0.5[m]	0.1[m]	0.2[m]
	Scrubber or ESP	0.25	0.5	—	—	0.05	0.1	0.25[m]	0.5[m]	0.1[m]	0.2[m]
Turpentine condenser	Untreated	—	—	—	—	—	—	0.005	0.01	0.25	0.5
Miscellaneous[d]	Untreated	—	—	—	—	—	—	—	—	0.25	0.5

[a]*Factors expressed in unit weight of air dried unbleached pulp (ADP). RSH = Methyl mercaptan. RSR = Dimethyl sulfide. RSSR = Dimethyl disulfide. ESP = Electrostatic precipitator.*

[b]*If noncondensable gases from these sources are vented to lime kiln, recovery furnace, or equivalent, the reduced sulfur compounds are destroyed.*

[c]*Apply with system using condensate as washing medium. When using fresh water, emissions are 0.05 (0.1).*

[d]*Includes knotter vents, brownstock seal tanks, etc. When black liquor oxidation is included, emissions are 0.3 (0.6).*

[e]*Apply when cyclonic scrubber or cascade evaporator is used for direct contact evaporation, with no further controls.*

[f]*Usually reduced by 50% with black liquor oxidation and can be cut 95 - 99% when oxidation is complete and recovery furnace is operated optimally.*

[g]*Apply when venturi scrubber is used for direct contact evaporation, with no further controls.*

[h]*Use 7.5 (15) when auxiliary scrubber follows venturi scrubber, and 1.5 (3) when it follows ESP.*

[j]*Apply when recovery furnace is operated optimally to control total reduced sulfur (TRS) compounds.*

[k]*Usually reduced to 0.01 g/kg (0.02 lb/ton) ADP when water low in sulfides is used in smelt dissolving tank and associated scrubber.*

[m]*Usually reduced to 0.015 g/kg (0.03 lb/ton) ADP with efficient mud washing, optimal kiln operation, and added caustic in scrubbing water. With only efficient mud washing and optimal process control, TRS compounds reduced to 0.04 g/kg (0.08 lb/ton) ADP.*

Table 2. *Cumulative Particle Size Distribution and Size Specific Emission Factors for a Recovery Boiler with a Direct Contact Evaporator and an ESP*

Emission Factor Rating: C

Particle size (μm)	Cumulative mass % ≤ stated size		Cumulative emission factor (kg/Mg of air dried pulp)	
	Uncontrolled	Controlled	Uncontrolled	Controlled
15	95.0	—	86	—
10	93.5	—	84	—
6	92.2	68.2	83	0.7
2.5	83.5	53.8	75	0.5
1.25	56.5	40.5	51	0.4
1.00	45.3	34.2	41	0.3
0.625	26.5	22.2	24	0.2
Total	100	100	90	1.0

Table 3. *Cumulative Particle Size Distribution and Size Specific Emission Factors for a Recovery Boiler without a Direct Contact Evaporator but with and ESP*

Emission Factor Rating: C

Particle size (μm)	Cumulative mass % ≤ stated size		Cumulative emission factor (kg/Mg of air dried pulp)	
	Uncontrolled	Controlled	Uncontrolled	Controlled
15	—	78.8	—	0.8
10	—	74.8	—	0.7
6	—	71.9	—	0.7
2.5	78.0	67.3	90	0.6
1.25	40.0	51.3	46	0.5
1.00	30.0	42.4	35	0.4
0.625	17.0	29.6	20	0.3
Total	100	100	115	1.0

Table 4. *Cumulative Particle Size Distribution and Size Specific Emission Factors for a Lime Kiln with a Venturi Scrubber*

Emission Factor Rating: C

Particle size (μm)	Cumulative mass % ≤ stated size		Cumulative emission factor (kg/Mg of air dried pulp)	
	Uncontrolled	Controlled	Uncontrolled	Controlled
15	27.7	98.9	7.8	0.24
10	16.8	98.3	4.7	0.24
6	13.4	98.2	3.8	0.24
2.5	10.5	96.0	2.9	0.24
1.25	8.2	85.0	2.3	0.21
1.00	7.1	78.9	2.0	0.20
0.625	3.9	54.3	1.1	0.14
Total	100	100	28.0	0.25

Table 5. *Cumulative Particle Size Distribution and Size Specific Emission Factors for a Lime Kiln with an ESP*

Emission Factor Rating: C

Particle size (μm)	Cumulative mass % ≤ stated size		Cumulative emission factor (kg/Mg of air dried pulp)	
	Uncontrolled	Controlled	Uncontrolled	Controlled
15	27.7	91.2	7.8	0.23
10	16.8	88.5	4.7	0.22
6	13.4	86.5	3.8	0.22
2.5	10.5	83.0	2.9	0.21
1.25	8.2	70.2	2.3	0.18
1.00	7.1	62.9	2.0	0.16
0.625	3.9	46.9	1.1	0.12
Total	100	100	28.0	0.25

Table 6. *Cumulative Particle Size Distribution and Size Specific Emission Factors for a Smelt Dissolving Tank with a Packed Tower*

Emission Factor Rating: C

Particle size (μm)	Cumulative mass % ≤ stated size		Cumulative emission factor (kg/Mg of air dried pulp)	
	Uncontrolled	Controlled	Uncontrolled	Controlled
15	90.0	95.3	3.2	0.48
10	88.5	95.3	3.1	0.48
6	87.0	94.3	3.0	0.47
2.5	73.0	85.2	2.6	0.43
1.25	47.5	63.8	1.7	0.32
1.00	40.0	54.2	1.4	0.27
0.625	25.5	34.2	0.9	0.17
Total	100	100	3.5	0.50

Table 7. *Cumulative Particle Size Distribution and Size Specific Emission Factors for a Smelt Dissolving Tank with a Venturi Scrubber*

Emission Factor Rating: C

Particle size (μm)	Cumulative mass % ≤ stated size		Cumulative emission factor (kg/Mg of air dried pulp)	
	Uncontrolled	Controlled	Uncontrolled	Controlled
15	90.0	89.9	3.2	0.09
10	88.5	89.5	3.1	0.09
6	87.0	88.4	3.0	0.09
2.5	73.0	81.3	2.6	0.08
1.25	47.5	63.5	1.7	0.06
1.00	54.0	54.7	1.4	0.06
0.625	25.5	38.7	0.9	0.04
Total	100	100	3.5	0.09

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***Dale L. Harmon** is the EPA Project Officer (see below).*
The complete report, entitled "Kraft Pulp Industry Particulate Emissions: Source Category Report," (Order No. PB 87-169 603/AS; Cost: $18.95, subject to change) will be available only from:
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