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MRI REPORT

Emission Factor Documentation for AP-42 Section 10.4

Paper-Making Processes

Final Draft Report

For U. S. Environmental Protection Agency
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PREFACE

This report was prepared by Midwest Research Institute (MRI) for the Office of Air Quality Planning and Standards (OAQPS), U. S. Environmental Protection Agency (EPA), under Contract No. 68-D2-0159, Work Assignment No. I-10. Mr. Dallas Safriet was the requester of the work. The report was prepared by David Bullock, Richard Marinshaw, and Dr. Dennis Wallace.

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EMISSION FACTOR DOCUMENTATION FOR AP-42 SECTION 10.4
Paper-Making Processes

1. INTRODUCTION

The document *Compilation of Air Pollutant Emissions Factors* (AP-42) has been published by the U. S. Environmental Protection Agency (EPA) since 1972. Supplements to AP-42 have been routinely published to add new emission source categories and to update existing emission factors. AP-42 is routinely updated by EPA to respond to new emission factor needs of EPA, State and local air pollution control programs, and industry.

An emission factor relates the quantity (weight) of pollutants emitted to a unit of activity of the source. The emission factors reported in AP-42 are used by air pollution professionals for widely varied purposes that include:

1. Estimating area-wide emissions;
2. Estimating emissions for a specific facility; and
3. Evaluating emissions relative to ambient air quality.

The purpose of this report is to provide background information from test reports and other information to support preparation of AP-42 Section 10.4, Paper-Making Processes.

This background report consists of five sections. Section 1 includes the introduction to the report. Section 2 gives a description of the paper-making industry. It includes a characterization of the industry, a description of emissions, and a description of the technology used to control emissions resulting from paper-making. Section 3 is a review of process/emissions data collection and laboratory analysis procedures. It describes the literature search, the screening of emission data reports, and the quality rating system for both emission data and emission factors. Section 4 details pollutant emission factor development, including the review of specific data sets and the results of data analysis. Section 5 presents the AP-42 Section 10.4, Paper-Making Processes.

2. INDUSTRY DESCRIPTION

One of the largest uses of pulp is in the manufacture of paper. Pulp, which may come from on-site production, from outside vendors, or from both, is made into paper stock through the addition of chemical additives, including dyes, clays, and adhesives, depending upon the desired characteristics of the final product.

Pulp and paper manufacturing facilities fall under the following general Standard Industrial Classification (SIC) codes: pulp mills (2611), paper mills (2621), and paperboard mills (2631). Pulp mills are defined as mills that are primarily engaged in the manufacture of pulp from wood, rags, linters, waste paper, and straw. Mills that produce both pulp and paper products are classified as paper mills if paper is the primary product shipped. Paperboard mills that make either paperboard from wood pulp and other fiber pulp, or converted paper products such as envelopes, food containers, and packaging paper are classified under separate SIC codes. The Source Classification Codes (SCC's) for specific paper-making processes fall under the general SCC code (3-07-004) for pulpboard manufacture.

2.1 CHARACTERIZATION OF THE INDUSTRY[1]

New York, Wisconsin, Pennsylvania, Michigan, and Massachusetts are the States with the largest number of paper mills. The concentration of paper mills in Wisconsin is due mainly to the number of pulp mills, while concentrations in the other three states are due to a pressing need for recycling in highly populated areas. The geographic distribution of U.S. paper mills is presented in Table 2-1.

Approximately 71 million megagrams (Mg) (78 million tons) of paper and paperboard were produced in the United States in 1990. The primary U.S. paper product is uncoated free sheets, which account for about 30 percent of total paper production. This is followed by coated papers, newsprint, tissues, groundwood paper, and thin paper, respectively. Estimates show that half of the paperboard production in the United States is unbleached kraft paperboard, 22 percent is combination furnish paperboard, 15 percent is semichemical paperboard, and 11 percent is solid paperboard.

TABLE 2-1. GEOGRAPHIC DISTRIBUTION OF U.S. PAPER MILLS[1]

State	Number of mills
Alabama	19
Arizona	2
Arkansas	9
California	33
Colorado	1
Connecticut	10
Delaware	3
Florida	10
Georgia	22
Idaho	2
Illinois	11
Indiana	13
Iowa	2
Kansas	2
Kentucky	5
Louisiana	13
Maine	20
Maryland	4
Massachusetts	36
Michigan	35
Minnesota	12
Mississippi	12
Missouri	5
Montana	1
New Hampshire	13
New Jersey	17
New Mexico	1
New York	53
North Carolina	16
Ohio	30
Oklahoma	8
Oregon	17
Pennsylvania	35
South Carolina	12
Tennessee	13
Texas	13
Vermont	6
Virginia	14
Washington	19
West Virginia	2
Wisconsin	47
Total United States	598

2.2 PROCESS DESCRIPTION[2]

The paper-making process is diagrammed in Figure 2-1. Stock from high-density pulp storage tanks is pumped to blending chests where it is blended to attain the proper consistency. Chemical additives may be added to the pulp, depending upon the kind of paper to be made. For book papers, fillers such as white clay and titanium oxide may be added to give opacity and extra whiteness. For tinted papers, dyes may be added. Other additives include waterproofing agents, preservatives, thickeners, wet-strength additives, and pH controls. The mixed pulp is sent to a set of mechanical beaters or "refiners" that further process the fibers as necessary for the desired finished-product characteristics. The prepared stock is then diluted to about 0.5 percent consistency (0.5 percent wood fiber by weight) and pumped into the paper machine head box.

The dilute pulp flows continuously from the head box and is uniformly distributed onto a moving continuous belt of fine-mesh screening (the "wire") where about 98 percent of the water is removed. As the wire moves forward it is shaken from side to side to help the water drain through. Near the end of the wire, suction boxes below the wire pull more water through, and a wire-mesh-covered cylinder presses on the pulp from above.

At the end of the wire, the web of pulp, still soft and wet, is lifted onto a continuous belt of wool felt and passed through the press section of the paper machine. Here, the new sheet passes through a series of rollers that remove more water and begin to smooth the sheet. The sheet then passes over a series of large, steam-heated, cast iron cylinders that evaporate the remaining moisture in the sheet.

After drying, surface coatings may be brushed or rolled on in liquid form. Surface coatings produce specific qualities such as finish (matte or glossy) and pigmentation. Other commonly used surface coatings include kaolin (clay), plastic pigments, calcium carbonate, as well as adhesives like latexes, glues, polyvinyl, and acrylics. Although most papers include sizing in the furnish, additional sizing may also be applied to the surface for a harder finish. After the coating or sizing is applied, the sheet again passes through a series of steam-heated rollers for drying.

After this final drying, the paper runs through a series of highly-polished metal rollers (calender rolls) that further compact the sheet and smooth the surface. The calender rolls are

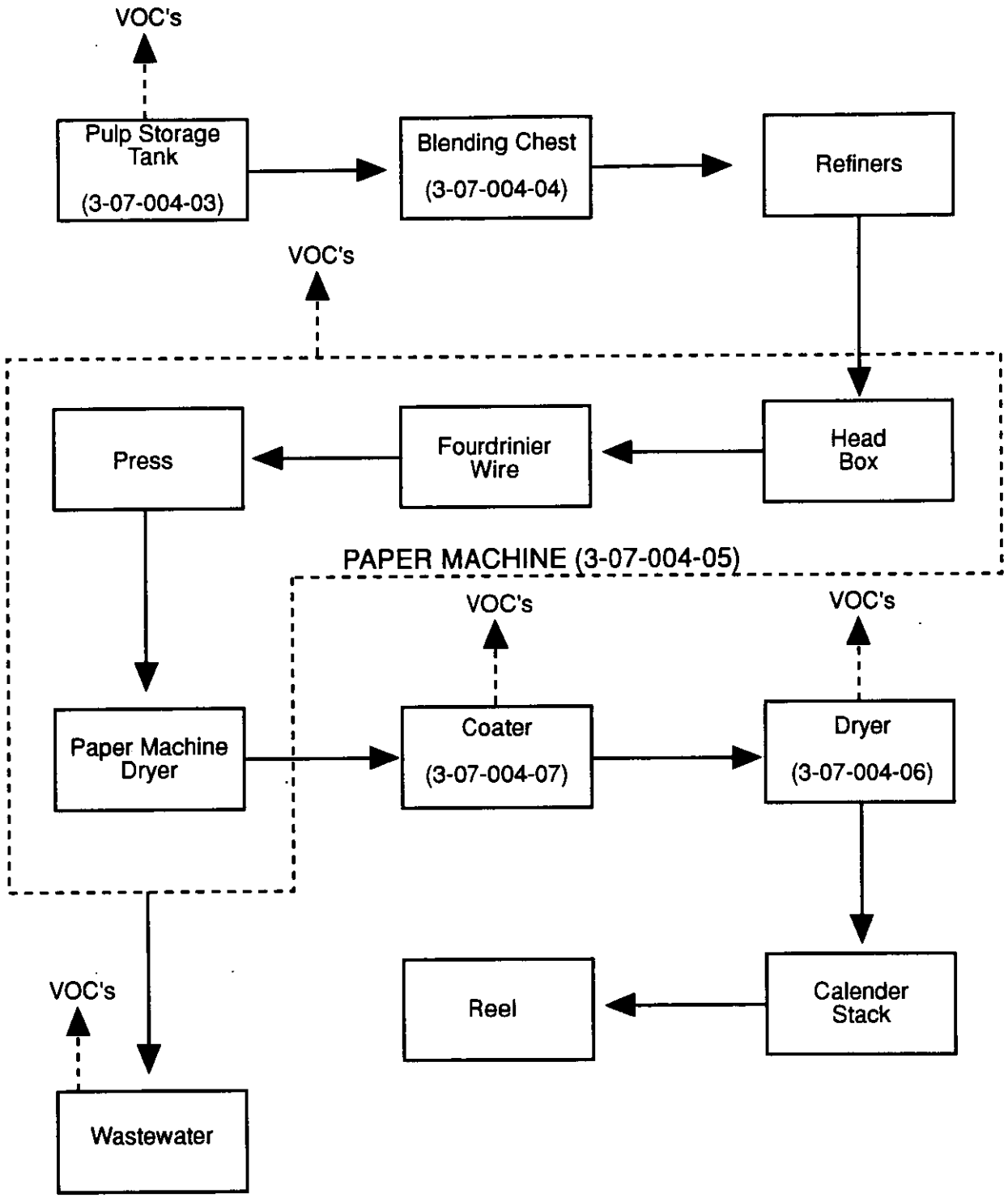

Figure 2-1. General paper-making process diagram.

arranged in pairs, with one roll of each pair running at a slightly different speed from the other, thus tending to polish the paper as it passes between them. Depending upon how much, if any, calendering the paper is subjected to, a variety of finishes can be obtained. Finally, the finished sheet is wound onto a large reel, ready for shipment.

2.3 EMISSIONS[2]

Water vapor is the primary emission from the paper machine. However, the potential exists for other air emissions to be vented during the paper manufacturing process. Chemicals can be added to the pulp to give the paper the desired qualities, such as color or strength. Some amount of these chemicals may be emitted to the atmosphere during paper production. Chemical additives include resins, dyes and pigments, defoamers, and slimicides. The composition of these additives varies greatly, and some additives may include hazardous air pollutant (HAP) compounds. Inks may include HAP's such as cyanide compounds; strength additives may include xylene; and defoamers and slimicides may include formaldehyde, styrene, or chlorinated organics. Other potential emissions include epichlorohydrin, ethylene glycol, methanol, and phenol.

Paper coating can also be a source of air emissions. Some potential pollutants are formaldehyde, latexes, acrylics, synthetic polymers, and cellulose derivatives. Emissions may also occur from solvents such as methanol, toluene, xylene, and methyl ethyl ketone used in converting operations. Emissions from paper-making are typically vented through building exhaust.

Emissions from blending and refining are expected to be negligible. Emissions from other sources are covered in other sections of AP-42. These other sources include power boilers (Chapter 1), storage tank vents (Chapter 12), wastewater (Chapter 4, Section 4.13), and solid waste (Chapter 2). These sources are not discussed further in Section 10.4.

2.4 CONTROL TECHNOLOGY[2]

Because of high moisture content, large exhaust gas volume, and minimal pollutant concentrations, control devices for paper machine vents are considered impractical. Waste minimization techniques and process modifications, including the type, mode, and location of chemical addition, may be considered on a site-specific basis.

REFERENCES FOR SECTION 2

1. *1991 Lockwood-Post's Directory for the Pulp, Paper, and Allied Trades*, Miller Freeman Publications, 1990.

2. A. V. Someshwar and J. E. Pinkerton, Paper and Paperboard Manufacture, in *Air Pollution Engineering Manual*, AP-40, Third Edition, A. J. Buonicore and W. T. Davis (eds.) Air and Waste Management Association, Van Nostrand Reinhold, NY, 1992.

3. GENERAL DATA REVIEW AND ANALYSIS

3.1 LITERATURE SEARCH AND SCREENING

Data for this investigation were obtained from a number of sources within the Office of Air Quality Planning and Standards (OAQPS) and from outside organizations. The Crosswalk/Air Toxic Emission Factor Data Base Management System (XATEF) and VOC/PM Speciation Data Base Management System (SPECIATE) were searched by SCC code for identification of the potential pollutants emitted and emission factors for those pollutants. A general search of the Air CHIEF CD-ROM also was conducted to supplement the information from these two data bases.

Information on the industry, including number of plants, plant location, and annual production capacities was obtained from the *1991 Lockwood-Post's Directory for the Pulp, Paper, and Allied Trades* and the *1987 Census of Manufactures*.

Numerous sources of information were investigated specifically for emission test reports and data. A search of the Test Method Storage and Retrieval (TSAR) data base was conducted to identify test reports for sources within the paper-making industry. The EPA library was searched for additional test reports. Using this information and information obtained on plant location from the 1991 Lockwood-Post's Directory for the Pulp, Paper, and Allied Trades and the 1987 Census of Manufactures, State and Regional air offices were contacted about the availability of test reports. Publications lists from the Office of Research and Development (ORD) and Control Technology Center (CTC) were also searched for reports on emissions from the paper-making industry. In addition, representative trade associations, including the National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI), were contacted for assistance in obtaining information about the industry and emissions.

To screen out unusable test reports, documents, and information from which emission factors could not be developed, the following general criteria were used:

1. Emissions data must be from a primary reference or traceable to facility-specific test data.

a. Source testing must be from a referenced study that does not reiterate information from previous studies.

b. The document must constitute the original source of test data. For example, a technical paper was not included if the original study was contained in the previous document. If the exact source of the data could not be determined, the document was eliminated.

2. The referenced study must contain test results based on more than one test run.

3. The report must contain sufficient data to evaluate the testing procedures and source operating conditions (e.g., one-page reports were generally rejected).

A final set of reference materials was compiled after a thorough review of the pertinent reports, documents, and information according to these criteria.

3.2 EMISSION DATA QUALITY RATING SYSTEM[1]

As part of the analysis of the emission data, the quantity and quality of the information contained in the final set of reference documents were evaluated. The following data were excluded from consideration:

1. Test series averages reported in units that cannot be converted to the selected reporting units;

2. Test series representing incompatible test methods (i.e., comparison of EPA Method 5 front half with EPA Method 5 front and back half);

3. Test series of controlled emissions for which the control device is not specified;

4. Test series in which the source process is not clearly identified and described; and

5. Test series in which it is not clear whether the emissions were measured before or after the control device.

Test data sets that were not excluded were assigned a quality rating. The rating system used was that specified by EIB for preparing AP-42 sections. The data were rated as follows.

A--Multiple tests that were performed on the same source using sound methodology and reported in enough detail for adequate validation. These tests do not necessarily conform to the methodology specified in EPA reference test methods, although these methods were used as a guide for the methodology actually used.

B--Tests that were performed by a generally sound methodology but lack enough detail for adequate validation.

C--Tests that were based on an untested or new methodology or that lacked a significant amount of background data.

D--Tests that were based on a generally unacceptable method but may provide an order-of-magnitude value for the source.

The following criteria were used to evaluate source test reports for sound methodology and adequate detail:

1. Source operation. The manner in which the source was operated is well documented in the report. The source was operating within typical parameters during the test.

2. Sampling procedures. The sampling procedures conformed to a generally acceptable methodology. If actual procedures deviated from accepted methods, the deviations are well documented. When such deviations occurred, the extent to which such alternative procedures could influence the test results was evaluated.

3. Sampling and process data. Adequate sampling and process data are documented in the report, and any variations in the sampling and process operation are noted. If a large spread between

test results cannot be explained by information contained in the test report, the data are suspect and are given a lower rating.

4. Laboratory analysis and calculations. The test reports contain original raw data sheets. The nomenclature and equations used were compared to those (if any) specified by EPA to establish equivalency. The depth of review of the calculations was dictated by the reviewer's confidence in the ability and conscientiousness of the tester, which in turn was based on factors such as consistency of results and completeness of other areas of the test report.

3.3 EMISSION FACTOR QUALITY RATING SYSTEM[1]

The quality of the emission factors developed from analysis of the test data was rated using the following general criteria:

A--Excellent: Developed only from A-rated test data taken from many randomly chosen facilities in the industry population. The source category is specific enough so that variability within the source category population may be minimized.

B--Above average: Developed only from A-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industries. The source category is specific enough so that variability within the source category population may be minimized.

C--Average: Developed only from A- and B-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. In addition, the source category is specific enough so that variability within the source category population may be minimized.

D--Below average: The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there is reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of the emission factor are noted in the emission factor table.

E--Poor: The emission factor was developed from C- and D-rated test data, and there is reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of these factors are always noted.

The use of these criteria is somewhat subjective and depends to an extent upon the individual reviewer. Details of the rating of each candidate emission factor are provided in Section 4 of this report.

REFERENCES FOR SECTION 3

1. *Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections*, EPA-454/B-93-050, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 1993.

4. AP-42 SECTION DEVELOPMENT

4.1 DEVELOPMENT OF SECTION NARRATIVE

The draft AP-42 section is a new section addressing paper-making processes. The new section is based on information gathered from the references cited, and includes a description of the industry, process flow diagram, and potential emissions for specific process emission points.

Occurring simultaneously with the revision of AP-42 Chapter 10, the Chemicals and Petroleum Branch (CPB) is developing maximum achievable control technology (MACT) standards for the pulp and paper industry. As part of the MACT development effort, EPA is conducting tests of various sources within the pulping and pulp bleaching industries. When these new data become available, they could be incorporated into the appropriate sections of AP-42. Additionally, since the new data gathered for the MACT standards will be forthcoming, only those data readily available were evaluated.

4.2 POLLUTANT EMISSION FACTOR DEVELOPMENT

A single reference was documented and reviewed in the attempt to develop emission factors for paper-making processes. The reference could not be used to develop emission factors.

4.2.1 Review of Specific Data Sets

4.2.1.1 Reference 1. This information document provides background information on the pulp and paper industry for assisting EPA/OAQPS in evaluating the need for standards or guidelines addressing air emissions from pulp and paper manufacturing processes. The document focuses on HAP and VOC emissions and control technologies.

This document includes emission rates for a number of HAP's and VOC's from a number of paper-making process emission sources. The document does not include emission factors or process data from which emission factors could be calculated. The data in the document do, however, provide a list of potential emissions from paper-making processes. This list of pollutants has been incorporated into AP-42 Section 10.4.

4.2.2 Review of XATEF and SPECIATE Data Base Emission Factors

A search of the XATEF data base revealed no emission factors for paper-making processes. However, chloroform emission factors for wastewater from integrated pulp and paper mills (both kraft and sulfite mills) during and after wastewater treatment are presented under SIC 2621, paper mills. Because these emission factors are not specific to the paper-making process, they were not incorporated into AP-42 Section 10.4.

The SPECIATE data base includes emission factors for speciated VOC emissions from paper coating and glazing (extrusion coating line with solvent-free resin/wax), miscellaneous paper products (shredding newspaper for insulation manufacturing), and pulpboard manufacture (paperboard: general). However, the emission factors are all surrogates, which are based on averages for the wood products industry as a whole. For that reason, these emission factors have not been incorporated into AP-42 Section 10.4.

The SPECIATE data base includes emission factors for speciated PM emissions from paper coating and glazing (extrusion coating line with solvent-free resin/wax) and miscellaneous paper products (shredding newspaper for insulation manufacturing). However, the emission factors are all surrogates, which are based on averages for the wood products industry as a whole. For that reason, these emission factors have not been incorporated into AP-42 Section 10.4. The SPECIATE data base includes no emission factors for speciated PM emissions from pulpboard manufacture (paperboard: general).

4.2.3 Results of Data Analysis

No emission data were found that were suitable for developing emission factors for the paper-making process.

No emission factors were developed for the paper-making process. However, the data in Reference 1 provide a list of potential pollutant emissions from specific paper-making process emission sources. This list of pollutants and sources as presented in Reference 1 is shown in Table 4-1. Emission factors for these pollutants may be developed on a site-specific basis using

material balance approaches, or in the case of storage tank vents, by using equations found in AP-42 Chapter 12.

TABLE 4-1. POTENTIAL POLLUTANT EMISSIONS FROM SOURCES WITHIN THE PAPER-MAKIING PROCESS[a]

Source (SCC)	Pollutant	
	CASRN[b]	Name
Pulp storage tanks (3-07-004-03)		ND
Paper machine vents (3-07-004-05)	50-00-0 108-78-1 7664-41-7	Formaldehyde Melamine Ammonia
Coater vents (3-07-004-07)	50-00-0 108-78-1 7664-41-7	Formaldehyde Melamine Ammonia
Coated paper dryer vents (3-07-004-06)	50-00-0 108-78-1 7664-41-7	Formaldehyde Melamine Ammonia
Wastewater and sludges	75-09-2 87-86-5 100-42-5 108-78-1 7664-41-7	Dichloromethane Pentachlorophenol Styrene Melamine Ammonia

[a]Reference 1.
[b]CASRN = Chemical Abstracts Service Registry Number.
ND = No data available.

REFERENCES FOR SECTION 4

1. *General Information Document for the Pulp and Paper Industry, Draft*, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, March 1991.

5. DRAFT AP-42 SECTION 10.4

10.4 PAPER-MAKING PROCESSES

10.4.1 General

One of the largest uses of pulp is in the manufacture of paper. Pulp, which may come from on-site production, from outside vendors, or from both, is made into paper stock through the addition of chemical additives, including dyes, clays, and adhesives, depending upon the desired characteristics of the final product.

10.4.2 Process Description[1,2]

The paper-making process is diagramed in Figure 10.4-1. Stock from high-density pulp storage tanks is pumped to blending chests where it is blended to attain the proper consistency. Chemical additives may be added to the pulp, depending upon the kind of paper to be made. For book papers, fillers such as white clay and titanium oxide may be added to give opacity and extra whiteness. For tinted papers, dyes may be added. Other additives include waterproofing agents, preservatives, thickeners, wet-strength additives, and pH controls. The mixed pulp is sent to a set of mechanical beaters or "refiners" that further process the fibers as necessary for the desired finished-product characteristics. The prepared stock is then diluted to about 0.5 percent consistency (0.5 percent wood fiber by weight) and pumped into the paper machine head box.

The dilute pulp flows continuously from the head box and is uniformly distributed onto a moving continuous belt of fine-mesh screening (the "wire") where about 98 percent of the water is removed. As the wire moves forward it is shaken from side to side to help the water drain through. Near the end of the wire, suction boxes below the wire pull more water through, and a wire-mesh-covered cylinder presses on the pulp from above.

At the end of the wire, the web of pulp, still soft and wet, is lifted onto a continuous belt of wool felt and passed through the press section of the paper machine. Here, the new sheet passes through a series of rollers that remove more water and begin to smooth the sheet. The sheet then passes over a series of large, steam-heated, cast iron cylinders that evaporate the remaining moisture in the sheet.

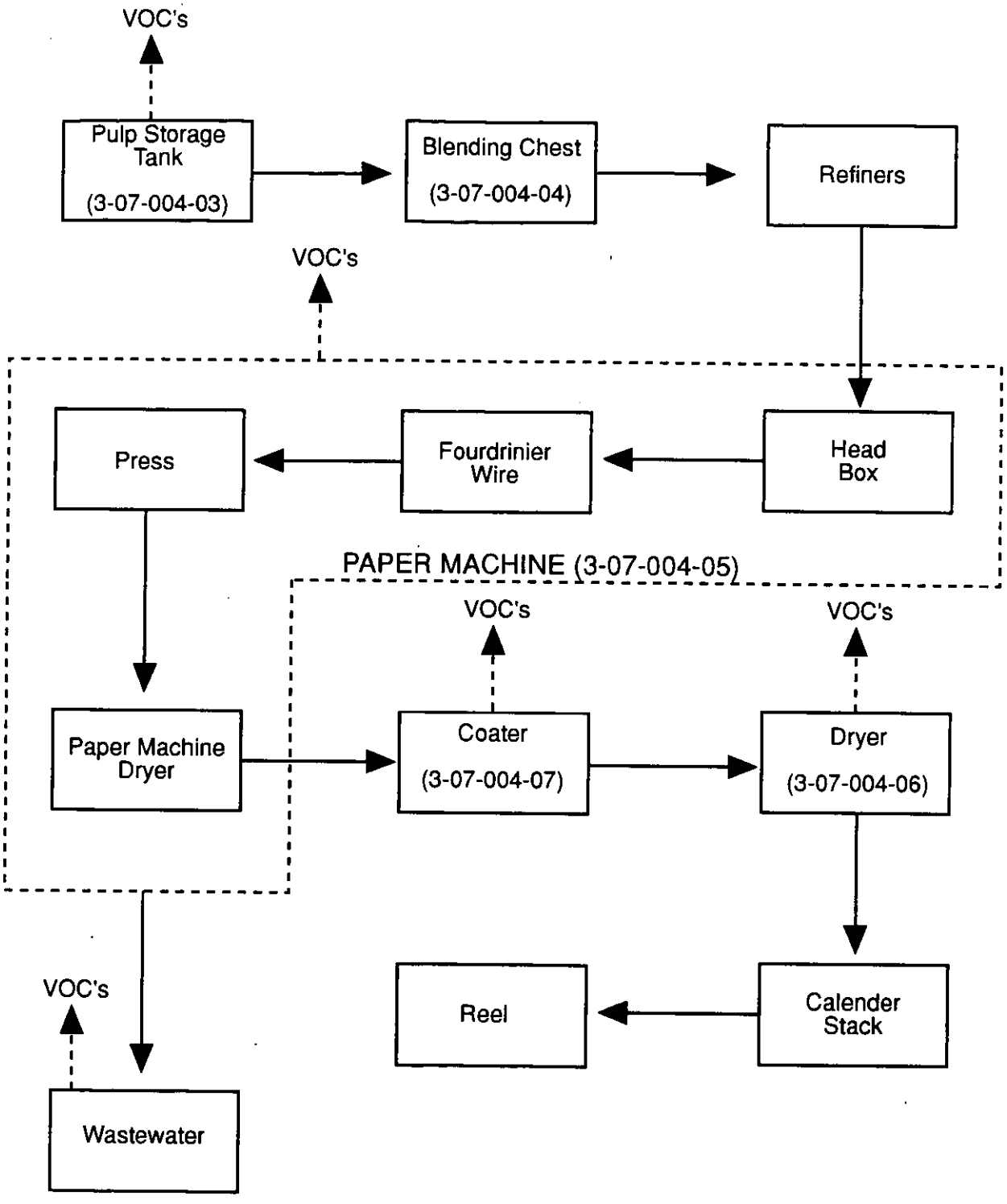

Figure 10.4-1. General paper-making process diagram.

After drying, surface coatings may be brushed or rolled on in liquid form. Surface coatings produce specific qualities such as finish (matte or glossy) and pigmentation. Other commonly used surface coatings include kaolin (clay), plastic pigments, calcium carbonate, as well as adhesives like latexes, glues, polyvinyl, and acrylics. Although most papers include sizing in the furnish, additional sizing may also be applied to the surface for a harder finish. After the coating or sizing is applied, the sheet again passes through a series of steam-heated rollers for drying.

After this final drying, the paper runs through a series of highly-polished metal rollers (calender rolls) that further compact the sheet and smooth the surface. The calender rolls are arranged in pairs, with one roll of each pair running at a slightly different speed from the other, thus tending to polish the paper as it passes between them. Depending upon how much, if any, calendering the paper is subjected to, a variety of finishes can be obtained. Finally, the finished sheet is wound onto a large reel, ready for shipment.

10.4.3 Emissions[1-5]

Water vapor is the primary emission from the paper machine. However, the potential exists for other air emissions to be vented during the paper manufacturing process. Chemicals can be added to the pulp to give the paper the desired qualities, such as color or strength. Some amount of these chemicals may be emitted to the atmosphere during paper production. Chemical additives include resins, dyes and pigments, defoamers, and slimicides. The composition of these additives varies greatly, and some additives may include hazardous air pollutant (HAP) compounds. Inks may include HAP's such as cyanide compounds; strength additives may include xylene; and defoamers and slimicides may include formaldehyde, styrene, or chlorinated organics. Table 10.4-1 presents potential pollutant emissions from paper manufacture. Other potential emissions include epichlorohydrin, ethylene glycol, methanol, and phenol.

Paper coating can also be a source of air emissions. Some potential pollutants are formaldehyde, latexes, acrylics, synthetic polymers, and cellulose derivatives. Emissions may also occur from solvents such as methanol, toluene, xylene, and methyl ethyl ketone used in converting operations. Emissions from paper-making are typically vented through building exhaust.

Emissions from blending and refining are expected to be negligible. Emissions from other sources are covered in other sections of AP-42. These other sources include power boilers

Table 10.4-1. EMISSION FACTORS FOR ORGANIC AND INORGANIC POLLUTANT EMISSIONS FROM PAPER-MAKING PROCESSES

Source (SCC)	Pollutant		Emission factor		Rating	Ref.
	CASRN[a]	Name	kg/Mg	lb/ton		
Pulp storage tanks (3-07-004-03)		ND	ND	ND		
Paper machine vents (3-07-004-05)	50-00-0	Formaldehyde	ND	ND	N/A	1
	108-78-1	Melamine	ND	ND	N/A	1
	7664-41-7	Ammonia	ND	ND	N/A	1
Coater vents (3-07-004-07)	50-00-0	Formaldehyde	ND	ND	N/A	1
	108-78-1	Melamine	ND	ND	N/A	1
	7664-41-7	Ammonia	ND	ND	N/A	1
Coated paper dryer vents (3-07-004-06)	50-00-0	Formaldehyde	ND	ND	N/A	1
	108-78-1	Melamine	ND	ND	N/A	1
	7664-41-7	Ammonia	ND	ND	N/A	1
Wastewater and sludges	75-09-2	Dichloromethane	ND	ND	N/A	1
	87-86-5	Pentachlorophenol	ND	ND	N/A	1
	100-42-5	Styrene	ND	ND	N/A	1
	108-78-1	Melamine	ND	ND	N/A	1
	7664-41-7	Ammonia	ND	ND	N/A	1

[a]CASRN = Chemical Abstracts Service Registry Number.
N/A = Not applicable.
SCC = Source Classification Code, in parentheses immediately following classified sources.
ND = No data available; emissions of this pollutant from this source may not be negligible.
kg/Mg = kg of pollutant per Mg of paper produced.
lb/ton = lb of pollutant per ton of paper produced.

(Chapter 1), storage tank vents (Chapter 12), wastewater (Chapter 4, Section 4.13), and solid waste (Chapter 2). These sources are not further discussed in Section 10.4.

10.4.4 Controls[2]

Because of high moisture content, large exhaust gas volume, and minimal pollutant concentrations, control devices for paper machine vents are considered impractical. Waste minimization techniques and process modifications, including the type, mode and location of chemical addition, may be considered on a site-specific basis.

References For Section 10.4

1. *General Information Document for the Pulp and Paper Industry, Draft*, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, March 1991.

2. A. V. Someshwar and J. E. Pinkerton, Paper and Paperboard Manufacture, in *Air Pollution Engineering Manual*, AP-40, Third Edition, A. J. Buonicore and W. T. Davis, Editors, Air and Waste Management Association, Van Nostrand Reinhold, NY, 1992.

3. G. A. Smook, *Handbook for Pulp and Paper Technologists*, TAPPI, Atlanta, Georgia, 1987.

4. Dr. Isaiah Gellman, Memo to Corporate Correspondents—CC 88-24, SARA Section 313 Technical Session Attendees, Regional Managers. Subject: EPA—SARA Title III—Revised Chemical Specific Information Sheets for Estimating Releases, March 1989.

5. *Environmental Pollution Control, Pulp and Paper Industry, Part I, Air*, EPA-625/7-76-001, U. S. Environmental Protection Agency, Cincinnati, OH, October 1976.