Emission Factor Documentation for AP-42
Section 10.6.3

Medium Density Fiberboard Manufacturing

Final Report

For U. S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Emission Factor and Inventory Group

EPA Purchase Order 8D-1933-NANX

MRI Project No. 4945

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Attn: Mr. Dallas Safriet (MD-14)

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NOTICE

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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. 4604-05 and EPA Purchase Order No. 8D-1933-NANX. Mr. Dallas Safriet was the requester of the work.

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September, 1998

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1. INTRODUCTION

The document *Compilation of Air Pollutant Emission 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 is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. Emission factors usually are expressed as the weight of pollutant divided by the unit weight, volume, distance, or duration of the activity that emits the pollutant. The emission factors presented in AP-42 may be appropriate to use in a number of situations, such as making source-specific emission estimates for areawide inventories for dispersion modeling, developing control strategies, screening sources for compliance purposes, establishing operating permit fees, and making permit applicability determinations. The purpose of this report is to provide background information from test reports and other information to support preparation of AP-42 Section 10.6.3, Medium Density Fiberboard Manufacturing.

This background report consists of five sections. Section 1 includes the introduction to the report. Section 2 gives a description of the medium density fiberboard (MDF) manufacturing industry. It includes a characterization of the industry, a description of the different process operations, a characterization of emission sources and pollutants emitted, and a description of the technology used to control emissions resulting from these sources. Section 3 is a review of emission data collection (and emission measurement) 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 3 also discusses issues related to the testing and interpretation of emission data for wood products industry sources. Section 4 details how the new AP-42 section was developed. It includes the review of specific data sets and a description of how candidate emission factors were developed. Section 5 presents the AP-42 Section 10.6.3, Medium Density Fiberboard Manufacturing.

2. INDUSTRY DESCRIPTION[1,2]

The Composite Panel Association defines MDF as a dry-formed panel product manufactured from lignocellulosic fibers combined with a synthetic resin or other suitable binder. The panels are compressed to a density of from 496 to 801 kilograms per cubic meter (kg/m^3) (31 to 50 pounds per cubic foot [lb/ft^3]) in a hot press. The entire interfiber bond is formed by a synthetic resin or other suitable organic binder.

In contrast to particleboard, MDF has more uniform density throughout the board and has smooth, tight edges that can be machined. It can be finished to a smooth surface and grain printed, eliminating the need for veneers and laminates. Most of the thicker MDF panels (1.27 to 1.91 centimeters [cm]) (1/2 to 3/4 inch [in.]) are used as core material in furniture panels. Medium density fiberboard panels thinner than 1.27 cm (1/2 in.) typically are used for siding.

Medium density fiberboard manufacturing falls under Standard Industrial Classification (SIC) Code 24933, medium density fiberboard. The six-digit Source Classification Code (SCC) for MDF manufacturing operations is 3-07-009.

2.1 INDUSTRY CHARACTERIZATION[3]

Nineteen MDF plants were operating in the United States in 1996 according to the *1997 Directory of the Wood Products Industry*. Table 2-1 presents the name, location, and annual production capacity for the MDF plants listed in the *1997 Directory of the Wood Products Industry*. Board densities produced at these plants ranged from 689 to 961 kg/m^3 (43 to 60 lb/ft^3), with most being in the range of 769 to 785 kg/m^3 (48 to 49 lb/ft^3). Annual production capacity for these plants ranged from 2 to 11.6 million square meters (21 to 150 million square feet) on a 1.91-cm (3/4-in.) basis. South Carolina led the other states in MDF production with its production accounting for over 26 percent of the U.S. total.

2.2 PROCESS DESCRIPTION[2,4,5]

The general steps used to produce MDF include mechanical pulping of wood chips to fibers (refining), drying, blending fibers with resin and sometimes wax, forming the resinated material into a mat, and hot pressing. Figure 2-1 presents a process flow diagram for a typical MDF plant.

The furnish for MDF normally consists of wood chips. Wood chips typically are delivered by truck or rail from off-site locations such as sawmills, plywood plants, furniture manufacturing facilities, satellite chip mills, and whole tree chipping operations. If wood chips are prepared onsite, logs are debarked, cut to more manageable lengths, and then sent to chippers. If necessary, the chips are washed to remove dirt and other debris.

Clean chips are softened by steam and then sent to atmospheric or pressurized disk refiners, also known as attrition mills. The refiners use single or double revolving disks to mechanically pulp the chips to obtain fibers in a suitable form for making the board.

From the refiners, the fibers move to the drying and blending area. Tube dryers are typically used to reduce the moisture content of the fibers to desired levels. Heat is usually provided by the direct firing of propane, natural gas, or distillate oil. Two-stage dryers are used when the moisture content of the incoming furnish is highly variable. The first stage equalizes the moisture content in the furnish; the second stage is the main dryer.

TABLE 2-1. DOMESTIC PRODUCTION OF MDF IN 1996[a]

Mill name/location	Annual capacity, millions of ft^2, 3/4-in. basis
Louisiana-Pacific Corp., Clayton, AL	Not available
Temple-Inland Forest Products Corp., Monroeville, AL	108
Willamette Industries, Inc., Malvern, AR	125
International Paper, Chino, CA	Not available
Jeld-Wen Fiber Products of Iowa, Dubuque, IA	Not available
Plum Creek Manufacturing, L.P., Columbia Falls, MT	125
Medite of New Mexico, Las Vegas, NM	90
Norbord MDF, Deposit, NY	71
Jeld-Wen, Inc., Marion, NC	Not available
Weyerhaeuser Forest Products Corp., Moncure, NC	150
International Paper, Spring Hope, NC	67
Masonite Corp., Tarboro, NC	Not available
Medite Corp., Medford, OR	100
Color Lam, White City, OR	Not available
Willamette Industries, Inc., Bennettsville, SC	145
Georgia-Pacific Corp., Holly Hill, SC	100
Masonite Corp., Sellers, SC	60
Bassett Industries, Bassett, VA	21
Jeld-Wen Fiber of Washington, White Swan, WA	Not available
Total plant capacity[b]	1,162

[a] Reference 3.
[b] Total plant capacity, less the seven mills not reporting annual production capacity.

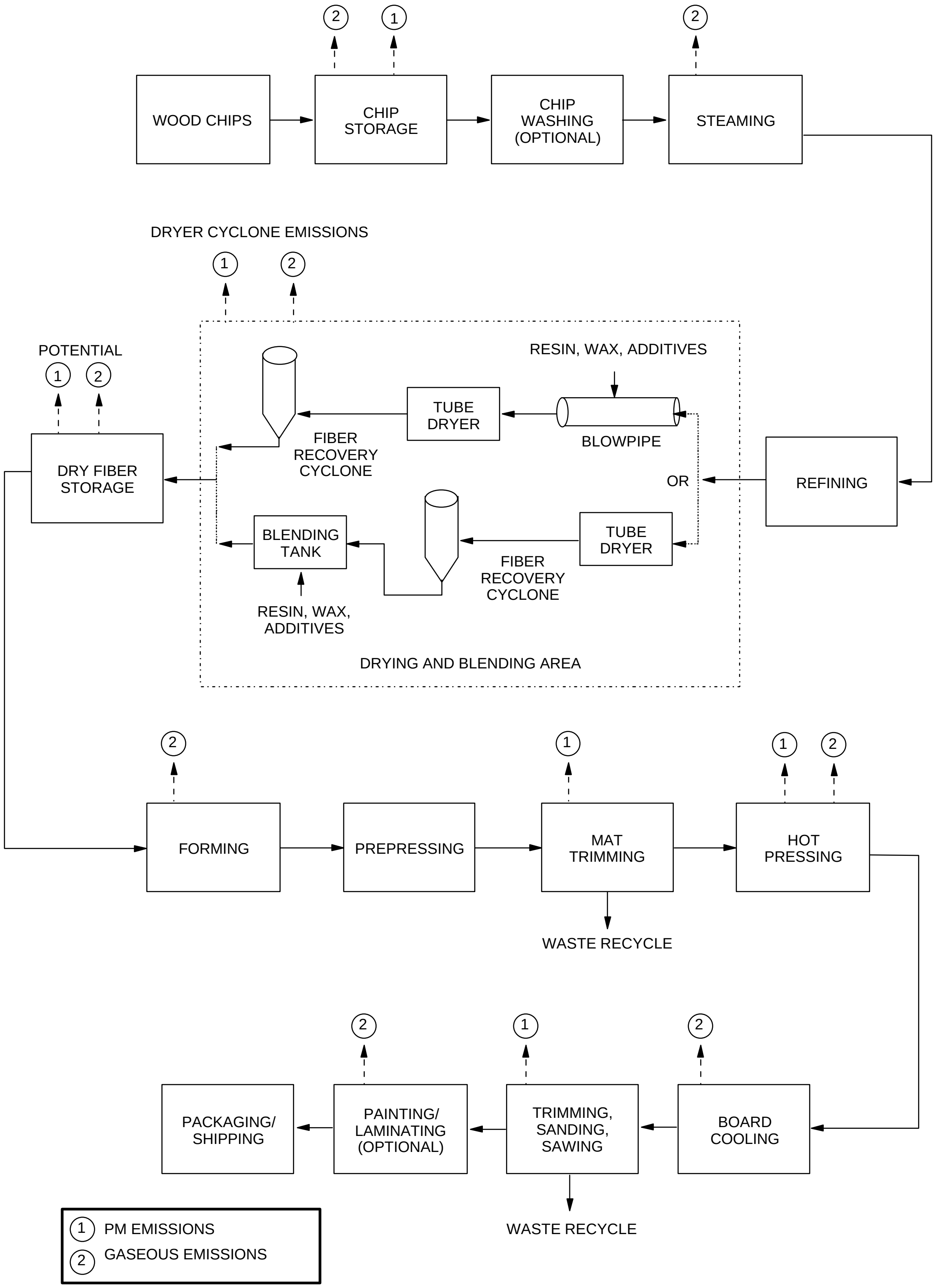

Figure 2-1. Typical process flow diagram for a medium density fiberboard (MDF) plant.

The sequence of the drying and blending operations depends on the method by which resins and other additives are blended with the fibers. Some plants inject resins into a short-retention blender, while others inject resin formulations into a blowline system. If resin is added in a separate blender, the fibers are first dried and separated from the gas stream by a primary cyclone, then conveyed to the blender. The fibers then are blended with resin, wax, and any other additives and conveyed to a dry fiber storage bin. Urea-formaldehyde (UF) resins are the most common resins used in the manufacture of MDF. Phenolic resins and melamine resins are also used.

If a blowline system is used, the fibers are first blended with resin, wax, and other additives in a blowpipe that discharges the resinated fibers to the dryer. After drying, the fibers are separated from the gas stream by a primary cyclone and then conveyed to a dry fiber storage bin.

Air conveys the resinated fibers from the dry storage bin to the forming machine, where they are deposited on a continuously moving screen system. The continuously formed mat must be prepressed before being loaded into the hot press. After prepressing, some pretrimming is done. The trimmed material is collected and recycled to the forming machine.

The prepressed and trimmed mats then are transferred to the hot press. The press applies heat and pressure to activate the resin and bond the fibers into a solid panel. The mat may be pressed in a continuous hot press, or the precompressed mat may be cut by a flying cutoff saw into individual mats that are then loaded into a batch-type hot press. Radio-frequency (RF) heating and steam heating of the press platens are common in domestic MDF plants. After pressing, the boards are cooled, sanded, trimmed to final dimensions, any other finishing operations are done, and the finished product is packaged for shipment.

2.3 EMISSIONS

The primary emission sources at MDF mills are fiber dryers and press vents. Other emission sources may include boilers, chip production operations, and finishing operations such as sanding, trimming, edge painting, and laminate application.

Although most MDF mills have chips delivered from offsite locations, in mills where chips are generated onsite, operations such as log debarking, sawing, chipping, and grinding generate particulate matter (PM) and PM less than 10 micrometers (PM-10) emissions in the form of sawdust and wood particles.

Emissions from dryers that are exhausted from the primary recovery cyclone include wood dust and other solid PM, volatile organic compounds (VOCs), condensible PM, and products of combustion such as carbon monoxide (CO), carbon dioxide (CO_2), and nitrogen oxides (NO_x), if direct-fired units are used. The condensible PM and a portion of the VOCs leave the dryer stack as vapor but condense at normal atmospheric temperatures to form liquid particles or mist that creates a visible blue haze. Both the VOCs and condensible PM are primarily compounds evaporated from the wood, with a minor constituent being combustion products. Quantities emitted are dependent on wood species, dryer temperature, fuel used, and other factors including season of the year, time between logging and processing, and chip storage time.

Emissions from board hot presses are dependent on the type and amount of resin used to bind the wood fibers together, as well as wood species, wood moisture content, wax and catalyst application rates, and press conditions. When the press opens, vapors that may include resin ingredients such as formaldehyde, phenol, and other VOCs are released. The rate at which formaldehyde is emitted during pressing and board cooling operations is a function of the amount of excess formaldehyde in the resin, board thickness, press temperature, press cycle time, and catalyst application rates.

Only limited data are available on emissions of the organic constituents included in the exhaust streams from MDF dryers and presses. However, speciated organic emission data for waferboard/oriented strandboard (WB/OSB) and particleboard may provide an indication of the types of organic compounds emitted from MDF dryers and presses. Emission factors for speciated organic emissions from WB/OSB and particleboard dryers and presses are included in AP-42 Sections 10.6.1 and 10.6.2, respectively.

Emissions from finishing operations for MDF are dependent on the type of products being finished. For most MDF products, finishing involves trimming to size and, in some cases, painting or coating the edges. Other products may require sanding or the application of laminate surfaces with spray adhesives. Trimming and sanding operations are sources of PM and PM-10 emissions. No data specific to MDF trimming or sawing are available. However, emission factors for general sawing operations may provide an order of magnitude estimate for similar MDF sawing and trimming operations, bearing in mind that the sawing of dry MDF panels may result in greater PM and PM-10 emissions than the sawing of green lumber. No data specific to MDF panel sanding are available. It is expected that water-based coatings are used to paint MDF edges, and the resultant VOC emissions are relatively small. Emissions from adhesives used in the application of laminate surfaces are likely to include VOCs.

2.4 EMISSION CONTROL TECHNOLOGY[6-8]

In MDF mills where wood chips are generated onsite, PM and PM-10 emissions from log debarking, sawing, and grinding operations can be controlled through capture in an exhaust system connected to a sized cyclone and/or fabric filter collection system. These wood dust capture and collection systems are used not only to control atmospheric emissions, but also to collect the dust as a by-product fuel for a boiler or dryer.

A VOC control technology gaining popularity in the wood products industry for controlling both dryer and press exhaust gases is regenerative thermal oxidation. Thermal oxidizers destroy VOCs, CO, and condensible organics by burning them at high temperatures. Regenerative thermal oxidizers (RTOs) are designed to preheat the inlet emission stream with heat recovered from the incineration exhaust gases. Up to 98 percent heat recovery is possible, although 95 percent is typically specified. Gases entering an RTO are heated by passing through pre-heated beds packed with a ceramic media. A gas burner brings the preheated emissions up to an incineration temperature between 788° and 871°C (1450° and 1600°F) in a combustion chamber with sufficient gas residence time to complete the combustion. Combustion gases then pass through a cooled ceramic bed where heat is extracted. By reversing the flow through the beds, the heat transferred from the combustion exhaust air preheats the gases to be treated, thereby reducing auxiliary fuel requirements.

One manufacturer has six commercial scale units installed at two MDF manufacturing facilities in the U.S. These units include five RTOs controlling emissions from six MDF flash tube dryers, and one RTO controlling emissions from one MDF press. Design airflows are 120,000 dry standard cubic feet per minute (dscfm) per RTO for dryer emission control, and 90,000 dscfm per RTO for press emission control.

Vendor literature indicates that an RTO can achieve a VOC destruction efficiency of 99 percent. The literature further indicates that with a particulate prefilter to remove inorganic PM, an RTO system can achieve a PM control efficiency of 95 percent. Of the five RTOs that control MDF dryer exhaust, none requires further PM control than the primary product recovery cyclone. The RTO controlling only press vent emissions does not require the use of a particulate prefilter. Industry experience with OSB dryers and presses has shown that RTOs typically achieve 95 percent reduction for VOC (except at inlet concentrations below 20 parts per million by volume as carbon [ppm-vC]), 70 to 80 percent reduction for CO, and typical NO_x increase of 10 to 20 ppm.

Biofiltration systems can be used effectively for control of a variety of pollutants including organic compounds (including formaldehyde and benzene), NO_x, CO, and PM from both dryer and press exhaust streams. Data from pilot plant studies in U.S. OSB mills indicate that biofilters can achieve VOC control efficiencies of 70 to 90 percent, formaldehyde control efficiencies of 85 to 98 percent, CO control efficiencies of 30 to 50 percent, NO_x control efficiencies of 80 to 95 percent, and resin/fatty acid control efficiencies of 83 to 99 percent.

Fugitive emissions from road dust and uncovered bark and dust storage piles may be controlled in a number of different ways. These methods include enclosure, wet suppression systems, and chemical stabilization. Control techniques for these sources are discussed more fully in AP-42 Chapter 13, Miscellaneous Sources.

REFERENCES FOR SECTION 2

1. T. M. Maloney, *Modern Particleboard and Dry-Process Fiberboard Manufacturing*, Miller Freeman Publications, Inc., San Francisco, CA, 1977.

2. J. G. Haygreen and J. L. Bowyer, *Forest Products and Wood Science: An Introduction*, Second Edition, Iowa State University Press, Ames, IA, 1989.

3. P. R. Hereso, ed., *1997 Directory of the Wood Products Industry*, San Francisco, Miller Freeman, Inc., November 1996.

4. O. Suchsland, and G. E. Woodson, *Fiberboard Manufacturing Practices in the United States*, Agriculture Handbook No. 640, Forest Service, U.S. Department of Agriculture, 1986.

5. C. C. Vaught, *Evaluation of Emission Control Devices at Waferboard Plants*, EPA-450/3-90-002, Control Technology Center, Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 1990.

6. Written communication and attachments from T. A. Crabtree, Smith Engineering Company, Broomall, PA, to P. E. Lassiter, U. S. Environmental Protection Agency, Research Triangle Park, NC, July 26, 1996.

7. Technical Memorandum, Minutes of the October 12-13, 1993 BACT Technologies Workshop, Raleigh, NC, sponsored by the American Forest and Paper Association, K. D. Bullock, Midwest Research Institute, Cary, NC, October 1993.

8. A. E. Cavadeas, *RTO Experience in the Wood Products Industry*, presented at Environmental Challenges: What's New in the Wood Products Industry?, workshop sponsored by the American Forest and Paper Association, Research Triangle Park, NC, February 4-5, 1997.

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 Factor Information and Retrieval (FIRE), Crosswalk/Air Toxic Emission Factor Data Base Management System (XATEF) and VOC/PM Speciation Data Base Management System (SPECIATE) data bases 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 data bases.

Information on the industry, including number of plants, plant location, and annual production capacities, was obtained from the *1995 Directory of the Wood Products Industry*. A number of sources of information were investigated specifically for emission test reports and data. Searches of the Source Test Information Retrieval System (STIRS) and the Test Method Storage and Retrieval (TSAR) data bases were conducted to identify test reports for sources within the MDF industry. The EPA library was searched for additional test reports. In addition, the National Council of the Paper Industry for Air and Stream Improvement (NCASI), the American Forest and Paper Association, and other trade associations 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. Emission data must be from a primary reference:

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 should contain test results based on more than one test run. If results from only one run are presented, the emission factors must be down rated.

3. The report must contain sufficient data to evaluate the testing procedures and source operating conditions (e.g., 1-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 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 Emission Factor and Inventory Group (EFIG) for preparing AP-42 sections. The data were rated as follows:

A--Multiple test runs that were performed 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 unproven or new methodology or that lacked a significant amount of background information.

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 this occurred, an evaluation was made of the extent to which such alternative procedures could influence the test results.

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. 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 from A- and B-rated source 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- or 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 industries. The source category is specific enough so that variability within the source category population may be minimized.

C--Average: Developed only from A-, B-, and C-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-, B-, and C-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 footnoted.

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.

3.4 EMISSION TEST METHODS[2-4]

The primary air pollutants of concern from the manufacture of MDF and other reconstituted wood products are PM (or more specifically PM-10 and condensible PM) from drying operations, VOC from drying operations and hot presses, and formaldehyde from hot presses and some drying operations. Emission data for these pollutants have been obtained via a number of different methods, and these methods generate data that are not directly comparable. To facilitate interpretation of the data generated by different methods, the paragraphs below identify and briefly describe the procedures that have been used for measuring emissions of PM and related pollutants, VOCs, and formaldehyde from MDF dryers and presses.

Test methods for PM (both filterable and condensible) include the standard reference method (EPA Methods 1 through 5 with Method 5 being the primary PM procedure) and derivatives of Method 5. Other methods that have been used in the MDF industry are EPA Methods 201 and 201A for PM-10, EPA Method 202 for condensible PM, and the Oregon Department of Environmental Quality Method 8 (ODEQ-8) for filterable PM. The paragraphs below first describe the essential features of Method 5 and then describe how the other procedures differ from Method 5.

The primary components of the Method 5 train are the nozzle, the probe, a filter (which is maintained at 120°C [250°F] in a heated filter box), an impinger train that is kept in an ice bath to cool the gas stream to ambient temperature, a meter box, and a pump. The impinger train contains four impingers; the first two contain water, the third is dry, and the fourth contains silica gel to dry the gas stream before it enters the dry gas meter. The Method 5 train collects an integrated sample over one to several hours at sample points that span a cross-section of the exhaust duct or stack, typically on perpendicular traverses across the diameter of the stack. At each sampling point, a sample of the gas stream is collected isokinetically through the nozzle. The captured gas stream moves through the probe to the filter. Some particles are collected on the walls of the probe, and the remaining material that is in particle phase at 120°C (250°F) is collected on the filter. The gases that pass through the filter then go through the impinger train where any organic or inorganic materials that condense between 16° and 120°C (60° and 250°F) are collected. Typically, the material collected in the probe and filter (front half catch) is considered for regulatory purposes to be PM, and the material captured in the impingers (back half catch) is considered to be condensible PM. The procedures for Method 5 do not require the back half catch of the sampling train to be quantified. However, as explained below, the Method 5 train may be coupled with a Method 202 sampling train for measuring the condensible PM emission rate.

Oregon Department of Environmental Quality Method 8 is a high volume method of sampling filterable PM emissions, primarily designed for wood product handling cyclone and baghouse exhaust systems whose primary emissions are solid PM. The primary components of the ODEQ-8 train are the nozzle, the probe, a filter (unheated, outside stack), a meter box and a pump. One primary difference between EPA Method 5 and ODEQ-8 is in the collection temperature for the filter catch. In order to maintain a collection temperature of 120°C (250°F), the Method 5 train employs a heated probe and filter. In contrast, the ODEQ-8 train uses an unheated probe, and an unheated, out-of-stack filter, so the collection temperature is near the actual temperature of the stack gas. If the stack gas temperature is less than 120°C (250°F), than any material that condenses at temperatures between the stack gas temperature and 120°C (250°F) will be measured as filterable PM with ODEQ-8. However, in a Method 5 train, this material would pass through the front half of the train to the impingers and would not be quantified as filterable PM. The other major difference between EPA Method 5 and ODEQ-8 is that the Oregon method does not include a series of impingers, or back half, and, therefore, does not quantify condensible PM.

In 40 CFR Part 51, EPA has published two procedures for determining PM-10 emission rates (EPA Methods 201 and 201A) and a method for measuring condensible PM emission rates (EPA Method 202). Methods 201 and 201A are derivatives of Method 5 both of which include an in-stack cyclone to remove particles with an aerodynamic diameter greater than 10 micrometers (µm) from the gas stream followed by an in-stack filter to collect the remaining particles. The back half of the train is identical to the back half of the Method 5 train. Both methods require a traverse of the stack, but Method 201 uses isokinetic sampling with a recirculating system to maintain constant flow through the cyclone, while Method 201A uses a constant sampling rate. The PM-10 is determined gravimetrically from the material captured in the sample line between the cyclone and filter and on the filter. Neither of the two methods specify procedures for determining condensible PM, but both methods indicate that for applications such as inventories of sources contributing to ambient PM-10 levels, PM-10 should be the sum of condensible PM emissions and PM-10 emissions measured by the Method 201 or 201A procedures.

Condensible PM emissions can be determined by EPA Method 202. Method 202, which applies to determination of condensible PM from stationary sources, measures condensible PM as material that passes through the filter and is collected in the impingers of a PM train. The primary method specifies that condensible PM be based on the back-half catch of a Method 17 train (which uses an in-stack filter), but Method 5, 201, or 201A procedures are also acceptable. The method specifies that the impinger solution be extracted with methylene chloride, the inorganic and organic fractions be dried separately, the residues weighed, and the condensible PM be determined from the combination of both residues. Note that because the method allows the use of either a heated filter system or an in-stack filter system, some ambiguity in results can occur from test to test.

Total hydrocarbon or VOC emission estimates from MDF dryers and hot presses have been obtained primarily via one of two EPA methods--Method 25 and Method 25A. Method 25 measures VOC emissions as total gaseous nonmethane organics (TGNMO), and emission levels are typically reported as carbon concentrations or mass rates. Because organic PM interferes with the organic analysis, the sample is drawn through a heated filter for PM removal. The method currently requires that the filter be maintained at 121° ± 3°C (250° ± 5°F), but these filter requirements have evolved. Initially, the filter was optional, and temperature requirements have changed over the years. The sample is drawn from the filter through a condensate trap into an evacuated sample tank. The material in the trap and sample tank are recovered and analyzed separately, and the results are combined to determine total VOC. The organic material in the condensate trap is oxidized to CO_2 and collected in an evacuated vessel; then a portion of the CO_2 is reduced to methane (CH_4) and measured by flame ionization detector (FID). A portion of the gas collected in the sample tank is first passed through a gas chromatograph to separate CO, CO_2, and CH_4 from the remaining nonmethane organic material (NOM). The NOM is then oxidized to CO_2, reduced to CH_4, and measured by FID. This procedure essentially determines the number of carbon atoms present in the nonmethane volatile organic material and eliminates inconsistencies associated with the variable response of the FID to different organic compounds.

Method 25A is used to provide a continuous measure of the concentration of organic vapors consisting primarily of alkanes, alkenes, and aromatic hydrocarbons. The stack gas sample is collected through a heated sample line with either an in-stack or heated filter to remove PM. From the filter, the sample is directed to an FID, and the concentration of organic material in the gas stream is measured as calibration gas equivalents or as carbon equivalents. The results depend strongly on the particular constituents that make up the organic content of the gas stream because the FID has different response factors for different organic bond structures. In particular, the carbon/oxygen bond in formaldehyde provides a negative interference, so the response of the FID to formaldehyde is essentially zero, and responses for other aldehydes and ketones are diminished. Consequently, Method 25A does not include a measure of formaldehyde emissions and does not accurately quantify emissions of other aldehydes or ketones in the VOC estimate. Also Method 25A measures methane, which is not regulated as a VOC. This may result in the overestimation of VOC emissions from gas-fired dryers which can have significant methane emissions.

Because the resins used to bond MDF products are formaldehyde-based, the exhaust gases from the presses and from drying operations where resin is applied prior to drying are known to contain quantities of formaldehyde and may contain some amount of other aldehydes and ketones. The available data on aldehyde and ketone emissions from these operations have been obtained with EPA Method 0011. It is important to note that Method 0011 has not been validated for wood products industry emission sources. Method 0011 was developed specifically for formaldehyde emissions, but it has been applied to other aldehyde and ketone compounds. The procedure collects an integrated sample isokinetically at points along perpendicular traverses of the stack. The gaseous and particulate pollutants in the sample gas are collected in an impinger train that contains an aqueous acidic solution of dinitrophenyl-hydrazine. Formaldehyde reacts with the dinitrophenyl-hydrazine to form a formaldehyde dinitrophenylhydrazone derivative. This derivative is extracted, solvent exchanged, concentrated, and analyzed by high performance liquid chromatography.

3.5 EMISSION TESTING ISSUES

Many of the difficulties encountered in developing VOC and PM-10 emission factors for the MDF industry dryers and hot presses arise because of the chemical composition of the organic materials found in the emission streams from these processes and the use of different test methods described above to collect and analyze these organic compounds for the historical data base. Also, the chemical and physical characteristics of these emission streams, particularly the moisture content and temperature variations, complicate sampling and analysis and data reduction. Particular issues of concern are complications associated with high moisture in exhaust streams, differing VOC and PM-10 results from different procedures and associated concerns with the condensible PM-10 as measured by Method 202, and the interrelationship between the estimates of VOC and PM-10 emissions. The paragraphs below first discuss the characteristics of the organic material in wood products exhaust streams and then address the issues outlined above.

3.5.1 Organic Emissions from Dryers and Presses

As green wood is subjected to heat in MDF dryers, some of the organic material in the wood is volatilized and carried off with the exhaust stream. These organic materials that emanate from the wood are the primary VOCs and condensible organic PM in the dryer exhaust. Consequently, the organic compounds found in wood products dryer emissions typically include terpenes, terpene-like materials, resins, and fatty acids comparable to those found in wood. The boiling points of many of these materials are in the range of 155° to 370°C (310° to 700°F). These temperatures are greater than typical dryer temperatures, but the compounds exhibit significant vapor pressures at dryer temperatures. Consequently, some of these organic compounds are at saturation levels in the gas streams and will condense as the gas stream cools.

3.5.2 Moisture Content of Dryer Exhaust

The inherent moisture contents of wood products dryer exhaust streams complicate measurement of PM-10 emissions in these streams. This problem is most prevalent for wood products facilities that have wet control devices such as wet electrostatic precipitators (ESPs) or ionizing wet scrubbers. Because the exhaust from these systems is saturated, moisture condensation downstream from the control device is common. The PM-10 procedures described above prescribe an in-stack filter that operates at stack temperatures. If the gas stream does contain water droplets, sample train filter blinding (blockage of gas flow through the filter) is likely to preclude PM-10 sampling. This problem has been encountered during EPA tests conducted on wet ESP-controlled OSB dryers as a part of the program to develop emission factors for the wood products industry.

One solution to this problem is to use a heated filter rather than an in-stack filter in the Method 201 or 201A train. As a part of the testing, Method 202 could be used to determine condensible PM emissions from the back half of the Method 201 or 201A train. The total PM-10 emissions could be estimated as the sum of the PM-10 emissions obtained from Method 201 or 201A and the condensible PM emissions obtained from Method 202. This solution will eliminate the moisture problem, but it does have two drawbacks. First, since this procedure is different from the procedure used for dry control systems, the results will not be directly comparable. Second, this procedure exacerbates the problems related to the interrelationship of VOC and PM-10 emissions discussed below.

3.5.3 VOC and PM-10 Measurements

As suggested by the characteristics of the organic emissions from wood products dryers described above, the dryer exhaust gas contains a substantial amount of organic material that is condensible in the range of 50° to 120° C (120° to 250°F). Because all of the test methods described earlier contain a filter to collect PM, the amount of this material that remains on that filter and the amount that will be measured downstream from the filter depend on the operating temperature of the filter. Consequently, the material classified as PM-10, condensible PM, and VOC differs, depending on filter temperature. The situation related to VOC emissions is further complicated by the presence of aldehydes and ketones in the exhaust streams from dryers and presses. Because these compounds are treated differently by Methods 25 and 25A, results obtained by these two methods are not directly comparable. The paragraphs below first address the PM-10 issues and then the VOC issues.

The applicability sections for EPA Methods 201 and 201A indicate that if PM-10 results are to be used for purposes such as inventories then the PM-10 results from those methods should be added to condensible PM results from Method 202 to obtain total PM-10 emissions. Because the primary purpose of AP-42 is to aid in preparing emission inventories, such a combination appears to be appropriate for developing AP-42 emission factors. However, condensible PM emissions can be determined via Method 202 in conjunction with a variety of trains. The available data base on condensible PM emissions from the wood products industry has been obtained using a Method 202 train following EPA Method 5 and Method 201A trains. Because these trains operate at different filter temperatures, they can generate different measures of condensible PM emissions for the same facility. Furthermore, because Method 201A operates with an in-stack filter, the distribution of filterable and condensible fractions will vary from site to site depending on stack gas temperatures. In addition, measurements of filterable PM by Method 5 and PM-10 by Methods 201 or 201A on the same stack gas can result in a PM-10 emission rate that is higher than the filterable PM emission rate because of the differences in sampling train filter temperatures. Such differences complicate averaging results across facilities to develop emission factors.

As noted in the discussion of Method 25 above, the protocol concerning the Method 25 particulate prefilter has changed over time. Data collected during the last several years are based on the organic material that passes through a 120°C (250°F) filter. However, some of the historical VOC data for the wood products industry were based on Method 25 trains with in-stack filters or with heated filters operating at 88°C (190°F). Because available data from NCASI testing indicate that substantial quantities of the organic material in wood products dryers may condense at temperatures between 77°C (170°F) and 120°C (250°F), the results from the historical tests with different filter temperatures cannot be combined consistently.

Development of VOC emission factors is further complicated by the differences between Method 25 and Method 25A results. First, Method 25A allows the use of an in-stack particulate filter in lieu of a heated filter, so the organic material that is subjected to analysis via the two methods is not equivalent. More importantly, the analytical methods are quite different. Method 25 collects an integrated sample over time and essentially counts the number of carbon atoms in the volatile fraction of the organic material collected. Consequently, irrespective of the structure of the organic compounds in the emission stream, the method measures the moles of carbon contained in those compounds. In contrast, Method 25A provides a continuous measure of the organic material present by measuring the response of an FID to that material relative to the response of the FID to a calibration gas. If the organic compounds in the exhaust gas are primarily aliphatic and aromatic hydrocarbons, the two methods provide reasonably comparable measures, but if the exhaust contains substantial quantities of oxygenated compounds such as aldehydes and ketones, the results will differ substantially. This difference is a consequence of the diminished response of the FID to aldehydes and ketones. Because the hot press exhaust and some dryer exhaust streams are known to contain quantities of aldehydes and ketones, the two methods are not expected to produce comparable results for those operations. However, Method 25 was not used in any of the emission tests documented for this AP-42 section; all VOC data were the results of Method 25A testing.

3.5.4 Interrelationship of PM/PM-10 and VOC Emissions

Due to source characteristics there is an interrelationship between PM/PM-10 and VOC emissions. Because of this interrelationship, the differences in the test methods described above can result in measuring some fraction of the organic constituents in the exhaust stream as both PM-10 and VOC emissions.

Available test data for wood products dryer emissions indicate that irrespective of filter temperature, essentially all of the condensible PM that passes through the filter and is collected in the back half of a PM or PM-10 train is organic material. Also, any organic material that passes through an in-stack filter used with Method 25A or that passes through a heated filter at 120°C (250°F) as used with Method 25 will be measured as VOC. At the same time, organic material that condenses between the stack temperature and 120°C (250°F) will be measured as PM-10 by Methods 201 and 201A. Furthermore, material that condenses in the back half of an EPA Method 5 train will be classified as condensible PM by EPA Method 202.

An overlap in the measured PM-10 and VOC emissions in the historical data base may have resulted in two instances. First, if the recommendations of Methods 201 and 201A related to including condensible PM in estimating total PM-10 emissions are followed, condensible PM will be measured as both VOC and PM-10. Second, some fraction of the organic material retained on the Method 201 or 201A filter and measured as PM-10 may also be counted as VOC via Method 25 because the filter temperatures in the Method 25 train can be higher than that of the PM-10 train for these emission sources.

3.5.5 Summary

Several general conclusions can be made regarding the measurement of PM-10 and VOC emissions from wood products industry sources. First, the source characteristics result in an interrelationship between PM/PM-10 and VOC. The constituent organic pollutants emitted act as both PM and VOC. When an in-stack filter is used during sampling the measured filterable PM, condensible PM, and VOC will be affected by the stack gas temperature. Consequently, these measurements should be made under normal operating conditions; ideally simultaneous measurements should be taken.

Second, the PM-10 and VOC test methods should be conducted to minimize the amount of overlap in their measurement. Use of Methods 201/201A for filterable PM-10 in conjunction with Method 202 for condensible PM-10 will provide total PM-10 results on the same basis (distribution of emissions between the filterable and condensible fraction will be dependent upon stack gas temperature because the 201/201A train uses an in-stack filter). Use of Method 25A with an in-stack filter will provide VOC data on the same basis as the PM-10 measurements. In this case, the condensible organic PM-10 fraction measured using Method 202 will also be measured as VOC by Method 25A. However, the amount of measurement overlap can be estimated.

Finally, Method 25A has a very low response to formaldehyde, and a reduced response to other aldehydes, and ketones; consequently, the VOC emissions measured by Method 25A will be biased low in cases where these compounds are present. A separate measurement method (e.g., Method 0011) should be used to quantify these compounds when they are expected to be present in the emissions; for example, in the exhaust gases from the presses and from drying operations where formaldehyde-based resin is applied prior to drying.

REFERENCES FOR SECTION 3

1. *Procedures for Preparing Emission Factor Documents*, EPA-454/R-95-015, U. S. Environmental Protection Agency, Research Triangle Park, NC, May 1997.

2. Code of Federal Regulations, Title 40, Part 60, Appendix A-Reference Methods.

3. Code of Federal Regulations, Title 40, Part 51, Requirements for Preparation, Adoption, and Submittal of Implementation Plans.

4. *Source Sampling Manual Volume I*, State of Oregon, Department of Environmental Quality, Air Quality Division, January 1992.

4. AP-42 SECTION DEVELOPMENT

4.1 INTRODUCTION

This section describes how the AP-42 section was developed. First, descriptions of the data sets that were reviewed for this report are presented in Section 4.2. Section 4.3 explains how the candidate emission factors for MDF manufacturing were developed.

4.2 REVIEW OF SPECIFIC DATA SETS

A total of seven references were reviewed in the preparation of the AP-42 section on MDF manufacturing. References 1, 2, and 4 through 7 are emission test reports. The emission data from both References 1 and 2 are included in Reference 3, which is the National Council of the Paper Industry for Air and Stream Improvement (NCASI) Technical Bulletin No. 693 and the associated data base (hereafter referred to as the NCASI data base). The following sections provide brief descriptions of these references.

4.2.1 Reference 1

This report presents the results of testing conducted March 10-21, 1992, on the dryers and presses at the Louisiana-Pacific Corporation MDF mill located in Clayton, Alabama. The Clayton facility has four wood-fired tube fiber dryers (direct-fired) and operates two press lines: a 16-opening fixed press line, and a continuous press line. Two of the dryers (a surface material dryer and a core material dryer) service the fixed press line and two of the dryers (Dryer 1 and Dryer 2) service the continuous press line. The dryers process a mixture of raw green wood chips and dry planer shavings at a ratio of 3:2. The wood species being dried is Southern yellow pine. Wax and resin are applied upstream from the dryers. Exhaust from the dryers passes through product recovery cyclones and is discharged to the atmosphere. Emissions from the fixed press and the continuous press each are vented by six press vents. Axial fans in the ducts above the roof provide the air movement. The data from this test are included in the NCASI data base.

Filterable PM emissions were tested in accordance with Methods 2 through 5, and condensible PM emissions were measured using Method 202. Emissions of PM-10 were quantified using Method 201A. Formaldehyde emissions were measured in accordance with Method 0011. Total gaseous hydrocarbon (THC) concentrations were determined instrumentally using Method 25A with a J.U.M. Engineering Model VE-7 heated flame ionization detector and reported as propane. Carbon monoxide determinations were made in accordance with Method 10, and concentrations were determined using a non-dispersive infrared (NDIR) continuous emission monitor (CEM).

Three PM, condensible PM, CO, formaldehyde, and THC runs were performed on each of Dryer No. 2, the core dryer, the surface dryer, and on the press vents for both press lines. Three PM-10 runs were performed on Dryer No. 2, the core dryer, and the surface dryer. Two PM, PM-10, CO, formaldehyde, and THC runs were performed on Dryer No. 1.

The quality ratings for these emission data are described in the discussion of Reference 3.

4.2.2 Reference 2

The purpose of this test program was to assist EPA in developing emission factors for selected hazardous air pollutants emitted for several processes associated with the wood products industry.

Uncontrolled emissions of filterable PM, condensible PM, PM-10, THC, volatile organics, semivolatile organics, and formaldehyde and other aldehydes and ketones were measured at the outlet of the cyclone serving the MDF tube dryer. Uncontrolled emissions of total PM, condensible PM, PM-10, THC, formaldehyde and other aldehydes and ketones also were measured from the MDF press. The data from this test are included in the NCASI data base.

Filterable PM and condensible PM were measured using Methods 5 and 202. Measurements of PM-10 were made with Method 201A. Total hydrocarbon emissions were measured by Method 25A. Speciated VOC emissions were determined with Method 0030, and speciated semivolatile organic emissions were determined with Method 0010. Aldehyde/ketone emissions were measured with Method 0011. Carbon monoxide and NO_x emissions were measured with Methods 10 and 7E, respectively.

The MDF mill uses almost exclusively whole tree hardwood chips consisting of 50 percent hardwoods, such as oak and hickory, and 50 percent soft hardwoods, such as poplar, maple, beech, birch, gum, sweetgum, and sycamore. The MDF fibers are dried in a 137-cm (54-in.) diameter steam- and thermal oil-heated tube dryer. At this facility, wax, urea-formaldehyde resin, and formaldehyde scavenger are applied to the wood chips in the blow pipes that feed the dryer.

The emission factors developed for the press are based on the combined emissions from all five vents. For the aldehyde-ketone test, emission data were not available for Vent 2, Run 3 and for Vent 4, Run 1. For these runs, the emission rates for each aldehyde or ketone were estimated using the average concentrations of the same pollutant for the other two runs and the volumetric flow rate through the vent for the run for which emission data were not available.

The quality ratings for these emission data are described below in the discussion of Reference 3.

4.2.3 Reference 3

As indicated previously, this reference consists of a technical bulletin and the associated data base. The data base includes data on emission source design and operating parameters, emission test parameters, and emission measurements for a total of approximately 40 emission tests conducted at 6 MDF manufacturing facilities. Because of the extent of the data presented in the data base, a narrative description of the emission tests addressed is not practical for this report. Instead, the data are summarized in a series of tables. Table 4-1, Table 4-2, and Table 4-3 present data related to the sampling of criteria pollutants and other pollutants from MDF dryers. Table 4-1 presents data on dryer design and operating parameters, including dryer type, type of firing, dryer capacity, emission control device, form of wood materials dried, and the hot air source. Table 4-2 summarizes the emission data for MDF dryers. The table presents for each emission test, the test method, number of runs, volumetric flow rate, stack gas temperature and moisture, pollutant concentration, emission rate, process operating rate, and emission factor. Table 4-3 presents a summary of the other operating data that are likely to affect dryer emission levels. The table includes data on firing type, fuel type, wood species dried, inlet and outlet moisture contents of the wood furnish, dryer inlet and outlet temperatures, emission control device, number of test runs, emission factor, and data rating. The data in Table 4-1, Table 4-2, and Table 4-3 are ordered by pollutant and primary emission control device. The dryer test code and unit code for each test are provided in the first two columns of each of the tables. The dryer and parameter codes presented in these tables, as well as the other tables developed from the NCASI data base, are identical to the codes used in the NCASI data base. The footnotes at the end of each table define the relevant parameter codes that appear in the table.

TABLE 4-1. SUMMARY OF MDF DRYER DESIGN DATA FROM NCASI DATA BASE[a]

Test code	Unit code	Pollutant[b]	Dryer type[c]	Firing type[d]	Dryer capacity	Emission control device[e]	Core/ surface/ both[f]	Wood material form[g]		Hot air source[h]			
										Primary		Secondary	
								Primary	Secondary	Source	%	Source	%
121-062889A	1D121	PM	TUBE	DFIRE	19 ODTH	CYC	S	PSHAV	LOG	SUSP BU	50	GAS B	50
121-062989A	2D121	PM	TUBE	DFIRE	19 ODTH	CYC	C	PSHAV	LOG	SUSP BU	50	GAS B	50
173-092592A	1D173	PM	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
192-050492A	1D192	PM	TUBE	IHEAT	16 ODTH	CYC	NS	PSHAV	SAWD	IHEAT	100	NA	
227-031192A	4D227	PM	TUBE	DFIRE	NS	CYC	S	SHAV	NS	SUSP BU	100	NA	
227-031292A	3D227	PM	TUBE	DFIRE	NS	CYC	C	SHAV	NS	SUSP BU	100	NA	
227-031392A	2D227	PM	TUBE	DFIRE	NS	CYC	NS	SHAV	NS	SUSP BU	100	NA	
227-031492A	1D227	PM	TUBE	DFIRE	NS	CYC	NS	SHAV	NS	SUSP BU	100	NA	
121-062889A	1D121	PM10	TUBE	DFIRE	19 ODTH	CYC	S	PSHAV	LOG	SUSP BU	50	GAS B	50
121-062989A	2D121	PM10	TUBE	DFIRE	19 ODTH	CYC	C	PSHAV	LOG	SUSP BU	50	GAS B	50
173-092592B	1D173	PM10	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
227-031192A	4D227	PM10	TUBE	DFIRE	NS	CYC	S	SHAV	NS	SUSP BU	100	NA	
227-031292A	3D227	PM10	TUBE	DFIRE	NS	CYC	C	SHAV	NS	SUSP BU	100	NA	
227-031392A	2D227	PM10	TUBE	DFIRE	NS	CYC	NS	SHAV	NS	SUSP BU	100	NA	
227-031492A	1D227	PM10	TUBE	DFIRE	NS	CYC	NS	SHAV	NS	SUSP BU	100	NA	
121-062889A	1D121	CPM	TUBE	DFIRE	19 ODTH	CYC	S	PSHAV	LOG	SUSP BU	50	GAS B	50
121-062989A	2D121	CPM	TUBE	DFIRE	19 ODTH	CYC	C	PSHAV	LOG	SUSP BU	50	GAS B	50
173-092592A	1D173	CPM	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
227-031192A	4D227	CPM	TUBE	DFIRE	NS	CYC	S	SHAV	NS	SUSP BU	100	NA	
227-031292A	3D227	CPM	TUBE	DFIRE	NS	CYC	C	SHAV	NS	SUSP BU	100	NA	
227-031392A	2D227	CPM	TUBE	DFIRE	NS	CYC	NS	SHAV	NS	SUSP BU	100	NA	
227-031492A	1D227	CPM	TUBE	DFIRE	NS	CYC	NS	SHAV	NS	SUSP BU	100	NA	
121-052688A	1D121	PM&CPM	TUBE	DFIRE	19 ODTH	CYC	S	PSHAV	LOG	SUSP BU	50	GAS B	50
121-052788A	2D121	PM&CPM	TUBE	DFIRE	19 ODTH	CYC	C	PSHAV	LOG	SUSP BU	50	GAS B	50
121-062889A	1D121	PM&CPM	TUBE	DFIRE	19 ODTH	CYC	S	PSHAV	LOG	SUSP BU	50	GAS B	50
121-062989A	2D121	PM&CPM	TUBE	DFIRE	19 ODTH	CYC	C	PSHAV	LOG	SUSP BU	50	GAS B	50
173-092592A	1D173	PM&CPM	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
227-031192A	4D227	PM&CPM	TUBE	DFIRE	NS	CYC	S	SHAV	NS	SUSP BU	100	NA	

TABLE 4-1. (continued)

Test code	Unit code	Pollutant[b]	Dryer type[c]	Firing type[d]	Dryer capacity	Emission control device[e]	Core/ surface/ both[f]	Wood material form[g]		Hot air source[h]			
										Primary		Secondary	
								Primary	Secondary	Source	%	Source	%
227-031292A	3D227	PM&CPM	TUBE	DFIRE	NS	CYC	C	SHAV	NS	SUSP BU	100	NA	
227-031392A	2D227	PM&CPM	TUBE	DFIRE	NS	CYC	NS	SHAV	NS	SUSP BU	100	NA	
227-031492A	1D227	PM&CPM	TUBE	DFIRE	NS	CYC	NS	SHAV	NS	SUSP BU	100	NA	
121-062889A	1D121	PM10&CPM	TUBE	DFIRE	19 ODTH	CYC	S	PSHAV	LOG	SUSP BU	50	GAS B	50
121-062989A	2D121	PM10&CPM	TUBE	DFIRE	19 ODTH	CYC	C	PSHAV	LOG	SUSP BU	50	GAS B	50
227-031992A	2D227	CO	TUBE	DFIRE	NS	CYC	NS	SHAV	NS	SUSP BU	100	NA	
227-032092A	3D227	CO	TUBE	DFIRE	NS	CYC	C	SHAV	NS	SUSP BU	100	NA	
227-032092B	4D227	CO	TUBE	DFIRE	NS	CYC	S	SHAV	NS	SUSP BU	100	NA	
227-032192A	1D227	CO	TUBE	DFIRE	NS	CYC	NS	SHAV	NS	SUSP BU	100	NA	
173-092592C	1D173	VOC	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
192-020194B	1D192	VOC	TUBE	IHEAT	16 ODTH	CYC	NS	PSHAV	SAWD	IHEAT	100	NA	
192-020194C	2D192	VOC	TUBE	IHEAT	16 ODTH	CYC	NS	PSHAV	SAWD	IHEAT	100	NA	
227-031992A	2D227	VOC	TUBE	DFIRE	NS	CYC	NS	SHAV	NS	SUSP BU	100	NA	
227-032092A	3D227	VOC	TUBE	DFIRE	NS	CYC	C	SHAV	NS	SUSP BU	100	NA	
227-032092B	4D227	VOC	TUBE	DFIRE	NS	CYC	S	SHAV	NS	SUSP BU	100	NA	
227-032192A	1D227	VOC	TUBE	DFIRE	NS	CYC	NS	SHAV	NS	SUSP BU	100	NA	
173-092692A	1D173	2-5-DMBENZ	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692A	1D173	ACETALD	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
192-020194B	1D192	ACETALD	TUBE	IHEAT	16 ODTH	CYC	NS	PSHAV	SAWD	IHEAT	100	NA	
192-020194C	2D192	ACETALD	TUBE	IHEAT	16 ODTH	CYC	NS	PSHAV	SAWD	IHEAT	100	NA	
173-092692A	1D173	ACETONE	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	ACETONE	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	ACETPH	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692A	1D173	ACROLEIN	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	A-PINENE	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	A-PINENE	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	A-TERPENE	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692A	1D173	BENZALD	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	

TABLE 4-1. (continued)

Test code	Unit code	Pollutant[b]	Dryer type[c]	Firing type[d]	Dryer capacity	Emission control device[e]	Core/ surface/ both[f]	Wood material form[g]		Hot air source[h]			
										Primary		Secondary	
								Primary	Secondary	Source	%	Source	%
173-092692B	1D173	BIS-2EH-PH	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	BUTBENPHTH	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692A	1D173	BUTYLALDEH	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	B-PINENE	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	B-PINENE	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	CHLOROMET	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692A	1D173	CROTONALDE	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	D-N-BUT-PH	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
093-063088A	1D093	FOR	NS	IHEAT	21,000 lb/hr	MCLO	NS	LOG	NS	IHEAT	100	NA	
173-092692A	1D173	FOR	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
192-020194B	1D192	FOR	TUBE	IHEAT	16 ODTH	CYC	NS	PSHAV	SAWD	IHEAT	100	NA	
192-020194C	2D192	FOR	TUBE	IHEAT	16 ODTH	CYC	NS	PSHAV	SAWD	IHEAT	100	NA	
227-031992A	2D227	FOR	TUBE	DFIRE	NS	CYC	NS	SHAV	NS	SUSP BU	100	NA	
227-032092A	3D227	FOR	TUBE	DFIRE	NS	CYC	C	SHAV	NS	SUSP BU	100	NA	
227-032092B	4D227	FOR	TUBE	DFIRE	NS	CYC	S	SHAV	NS	SUSP BU	100	NA	
227-032192A	1D227	FOR	TUBE	DFIRE	NS	CYC	NS	SHAV	NS	SUSP BU	100	NA	
173-092692A	1D173	HEXALD	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	ISOOCTANE	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692A	1D173	ISOVALALD	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692A	1D173	MEK	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	METHENECHL	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	NAPHTHALENE	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	N-HEXANE	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692A	1D173	O-TOLALD	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	PHENOL	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692A	1D173	PROPIONALD	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	P-CYMEME	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	P-CYMEME	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	

TABLE 4-1. (continued)

Test code	Unit code	Pollutant[b]	Dryer type[c]	Firing type[d]	Dryer capacity	Emission control device[e]	Core/ surface/ both[f]	Wood material form[g]		Hot air source[h]			
										Primary		Secondary	
								Primary	Secondary	Source	%	Source	%
173-092692B	1D173	P-CYMEME	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692A	1D173	P-TOLALD	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692B	1D173	T-FL-METH	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	
173-092692A	1D173	VALALD	TUBE	IHEAT	21,000 lb/hr	CYC	NS	DCHP	NS	IHEAT	100	NA	

[a]Reference 3. NS = not specified. NA = not applicable. ODTH = oven-dried tons per hour.
[b]Pollutant codes are identified in Table 4-4.
[c]Dryer types: TUBE = tube dryer.
[d]Firing types: DFIRE = direct firing, IHEAT = indirect heat.
[e]Emission control devices: CYC = cyclone. MCLO = multiclone.
[f]Core/surface/both: C = core material dryer; S = surface material dryer; B = combination of core and surface material dryer.
[g]Wood material forms: DCHP = debarked chips; TRIM = trim; LOG = logs; PSHAV = planer shavings; SAWD = sawdust.
[h]Hot air sources: SUSP BU = suspension burner; IHEAT = unspecified type of direct heat; GAS B = gas burner.

TABLE 4-2. SUMMARY OF EMISSION DATA FOR MDF DRYERS FROM NCASI DATA BASE[a]

Test code	Unit code	Pollutant[b]	No. of runs	Test method[c]	Stack gas parameters: Flow, dscfm	Stack gas parameters: Temp., °F	Stack gas parameters: Moisture, %	Pollutant concentration: ppm	Pollutant concentration: gr/dscf	Emission rate, lb/hr	Process rate, ODTH	Emission factor, lb/ODT
121-062889A	1D121	PM	3	M5	44,189	135	14.3			16.6	16.50	1.02
121-062989A	2D121	PM	3	M5	43,717	121	11.7			25.7	6.00	5.27
173-092592A	1D173	PM	3	M5	91,998	158	10.1		0.0171	13.5	8.72	1.50
192-050492A	1D192	PM	3	OD8	103,541	135	7.6		0.023	20.3	14.90	1.36
227-031192A	4D227	PM	3	M5	65,887	131	7.6		0.0466	26.3	8.56	3.14
227-031292A	3D227	PM	3	M5	62,976	138	8.0		0.131	70.8	8.20	8.95
227-031392A	2D227	PM	3	M5	102,908	120	5.4		0.084	73.9	5.55	13.7
227-031492A	1D227	PM	2	M5	94,390	128	6.2		0.118	95.5	6.02	15.8
121-062889A	1D121	PM10	3	M201/201A	44,189	135	14.3			8.3	16.50	0.52
121-062989A	2D121	PM10	3	M201/201A	43,717	121	11.7			9.4	6.00	1.90
173-092592B	1D173	PM10	3	M201A	99,370	151	10.4	0.0027		2.3	8.54	0.28
227-031192A	4D227	PM10	3	M201A	65,887	131	7.6		0.0060	3.3	8.56	0.40
227-031292A	3D227	PM10	3	M201A	62,976	138	8.0		0.011	6.9	8.20	0.87
227-031392A	2D227	PM10	3	M201A	102,908	120	5.4		0.017	14.3	5.55	2.71
227-031492A	1D227	PM10	2	M201A	94,390	128	6.2		0.019	14.1	6.02	2.33
121-062889A	1D121	CPM	3	M202	44,189	135	14.3			1.4	16.50	0.086
121-062989A	2D121	CPM	3	M202	43,717	121	11.7			7.1	6.00	1.21
173-092592A	1D173	CPM	3	M202	91,998	158	10.1		0.008	6.5	8.72	0.73
227-031192A	4D227	CPM	3	M202	65,887	131	7.6		0.005	2.9	8.56	0.34
227-031292A	3D227	CPM	3	M202	62,976	138	8.0		0.008	4.3	8.20	0.55
227-031392A	2D227	CPM	3	M202	102,908	120	5.4		0.004	3.4	5.55	0.63
227-031492A	1D227	CPM	2	M202	94,390	128	6.2		0.0065	5.2	6.02	0.86
121-052688A	1D121	PM&CPM	3	M5/202	82,809	142	27.0		0.037	26.2	13.70	1.91
121-052788A	2D121	PM&CPM	3	M5/202	82,695	150	26.0		0.034	24.2	9.50	2.54
121-062889A	1D121	PM&CPM	3	M5/202	44,189	135	14.3			17.9	16.50	1.11
121-062989A	2D121	PM&CPM	3	M5/202	43,717	121	11.7			29.4	6.00	6.47
173-092592A	1D173	PM&CPM	3	M5/202	91,998	158	10.1		0.025	20.0	8.72	2.22
227-031192A	4D227	PM&CPM	3	M5/202	65,887	131	7.6		0.052	29.1	8.56	3.48
227-031292A	3D227	PM&CPM	3	M5/202	62,976	138	8.0		0.139	75.1	8.20	9.50
227-031392A	2D227	PM&CPM	3	M5/202	102,908	120	5.4		0.088	77.3	5.55	14.3

TABLE 4-2. (continued)

Test code	Unit code	Pollutant[b]	No. of runs	Test method[c]	Stack gas parameters: Flow, dscfm	Temp., °F	Moisture, %	Pollutant concentration: ppm	gr/dscf	Emission rate, lb/hr	Process rate, ODTH	Emission factor, lb/ODT
227-031492A	1D227	PM&CPM	2	M5/202	94,390	128	6.2		0.1245	100.7	6.02	16.6
121-062889A	1D121	PM10&CPM	3	M201A/202	44,189	135	14.3			9.7	16.50	0.60
121-062989A	2D121	PM10&CPM	3	M201A/202	43,717	121	11.7			16.4	6.00	3.11
227-032192A	1D227	CO	2	M10	86,950	124	5.2	11.750		4.5	5.14	0.88
227-031992A	2D227	CO	3	M10	90,333	135	7.3	29.267		11.4	5.39	2.06
227-032092A	3D227	CO	3	M10	64,600	137	8.8	192.333		54.1	8.97	6.06
227-032092B	4D227	CO	3	M10	62,267	136	10.6	216.667		58.9	8.86	6.86
173-092592C	1D173	VOC	3	M25A	92,667	NS	NS	35.900		6.2	8.72	0.69
192-020194B	1D192	VOC	3	M25A	111,133	125	6.4		199	41.2	15.10	2.80
192-020194C	2D192	VOC	3	M25A	97,667	139	7.3		315	57.5	12.83	4.57
227-031992A	2D227	VOC	3	M25A	90,333	135	7.3	163.333		29.8	5.39	5.38
227-032092A	3D227	VOC	3	M25A	64,600	137	8.8	318.667		42.4	8.97	4.76
227-032092B	4D227	VOC	3	M25A	62,267	136	10.6	306.000		39.8	8.86	4.63
227-032192A	1D227	VOC	2	M25A	86,950	124	5.2	135.000		23.3	5.14	4.53
173-092692A	1D173	2-5-DMBENZ	3	M0011	92,660	155	9.6	0.002		0.0034	8.72	0.00038
173-092692A	1D173	ACETALD	3	M0011	92,660	155	9.6	0.183		0.116	8.72	0.0130
192-020194C	2D192	ACETALD	3	M0011	97,667	139	7.3		0.00028	0.237	12.83	0.0188
192-020194B	1D192	ACETALD	3	M0011	111,133	125	6.4		0.00011	0.105	15.10	0.0071
173-092692A	1D173	ACETONE	3	M0011	92,660	155	9.6	0.043		0.036	8.72	0.0040
173-092692B	1D173	ACETONE	3	M0030	88,758	150	10.1	0.011		0.0088	8.54	0.0011
173-092692B	1D173	ACETPH	3	M0010	88,758	150	10.1	0.001		0.0019	8.54	0.00024
173-092692A	1D173	ACROLEIN	3	M0011	92,660	155	9.6	0.024		0.020	8.72	0.0022
173-092692B	1D173	A-PINENE	3	M0010	88,758	150	10.1	0.026		0.048	8.54	0.0065
173-092692B	1D173	A-PINENE	3	M0030	88,758	150	10.1	0.026		0.048	8.54	0.0059
173-092692B	1D173	B-PINENE	3	M0010	88,758	150	10.1	0.027		0.052	8.54	0.0067
173-092692B	1D173	B-PINENE	3	M0030	88,758	150	10.1	0.026		0.049	8.54	0.0061
173-092692B	1D173	CHLOROMET	3	M0030	88,758	150	10.1	0.017		0.012	8.54	0.0015
173-092692A	1D173	CROTONALDE	3	M0011	92,660	155	9.6	0.017		0.017	8.72	0.0019
173-092692B	1D173	D-N-BUT-PH	3	M0010	88,758	150	10.1	0.000		0.0014	8.54	0.00018
093-063088A	1D093	FOR	3	M0011	94,928	122	7.9	3.067		1.4	15.21	0.0896
173-092692A	1D173	FOR	3	M0011	92,660	155	9.6	29.200		12.6	8.72	1.40

TABLE 4-2. (continued)

Test code	Unit code	Pollutant[b]	No. of runs	Test method[c]	Stack gas parameters: Flow, dscfm	Stack gas parameters: Temp., °F	Stack gas parameters: Moisture, %	Pollutant concentration: ppm	Pollutant concentration: gr/dscf	Emission rate, lb/hr	Process rate, ODTH	Emission factor, lb/ODT
192-020194B	1D192	FOR	3	M0011	111,133	125	6.4		0.0042	3.7	15.10	0.25
192-020194C	2D192	FOR	3	M0011	97,667	139	7.3		0.0039	3.3	12.83	0.26
227-031992A	2D227	FOR	3	M0011	90,333	135	7.3	15.967		6.7	5.39	1.20
227-032092A	3D227	FOR	3	M0011	64,600	137	8.8	12.433		3.7	8.97	0.42
227-032092B	4D227	FOR	3	M0011	62,267	136	10.6	14.733		4.3	8.86	0.50
227-032192A	1D227	FOR	2	M0011	86,950	124	5.2	16.750		6.8	5.14	1.32
173-092692A	1D173	HEXALD	3	M0011	92,660	155	9.6	0.016		0.024	8.72	0.0026
173-092692B	1D173	ISOOCTANE	3	M0030	88,758	150	10.1	0.003		0.0049	8.54	0.00062
173-092692A	1D173	ISOVALALD	3	M0011	92,660	155	9.6	0.014		0.017	8.72	0.0019
173-092692A	1D173	MEK	3	M0011	92,660	155	9.6	0.055		0.0571	8.72	0.0063
173-092692B	1D173	METHENECHL	3	M0030	88,758	150	10.1	0.020		0.023	8.54	0.0029
173-092692B	1D173	A-TERPENE	3	M0010	88,758	150	10.1	0.008		0.018	8.54	0.0022
173-092692A	1D173	BENZALD	3	M0011	92,660	155	9.6	0.015		0.023	8.72	0.0026
173-092692B	1D173	BIS-2EH-PH	3	M0010	88,758	150	10.1	0.000		0.0021	8.54	0.00027
173-092692B	1D173	BUTBENPHTH	3	M0010	88,758	150	10.1	0.001		0.0019	8.54	0.00024
173-092692A	1D173	BUTYLALDEH	3	M0011	92,660	155	9.6	0.024		0.025	8.72	0.0028
173-092692B	1D173	NAPHTHALENE	2	M0010	90,461	151	9.9	0.003		0.0050	7.41	0.00066
173-092692B	1D173	N-HEXANE	3	M0030	88,758	150	10.1	0.009		0.011	8.54	0.0014
173-092692A	1D173	O-TOLALD	3	M0011	92,660	155	9.6	0.004		0.0067	8.72	0.00074
173-092692B	1D173	PHENOL	2	M0010	90,461	151	9.9	0.001		0.0015	7.41	0.00020
173-092692A	1D173	PROPIONALD	3	M0011	92,660	155	9.6	0.011		0.00955	8.72	0.0011
173-092692B	1D173	P-CYMEME	2	M0010	88,305	147	10.1	0.0008		0.0018	7.41	0.00024
173-092692B	1D173	P-CYMEME	3	M0010	85,351	150	10.7	0.0007		0.0012	8.54	0.00014
173-092692B	1D173	P-CYMEME	3	M0010	88,758	150	10.1	0.0007		0.0014	8.54	0.00018
173-092692A	1D173	P-TOLALD	3	M0011	92,660	155	9.6	0.019		0.033	8.72	0.0036
173-092692B	1D173	T-FL-METH	3	M0030	88,758	150	10.1	0.008		0.0149	8.54	0.0014
173-092692A	1D173	VALALD	3	M0011	92,660	155	9.6	0.015		0.0189	8.72	0.0021

[a]Reference 3. NS = not specified. ODTH = oven-dried tons per hour. Lb/ODT = pounds of pollutant per oven-dried ton of wood material out of dryer.
[b]Pollutant codes are identified in Table 4-4. Factors for VOC on a carbon basis.
[c]Test methods: M0010 = EPA Method 0010; M0011 = EPA Method 0011; M0030 = EPA Method 0030; M201A = EPA Method 201A; M202 = EPA Method 202; M201/201A = modification of EPA Method 201A; M5 = EPA Method 5; M10 = EPA Method 10; M25A = EPA Method 25A; OD8 = Oregon Department of Environmental Quality Method 8.

TABLE 4-3. SUMMARY OF EMISSION FACTORS FOR MDF DRYERS FROM NCASI DATA BASE[a]

Test code	Unit code	Pollutant[b]	Firing type[c]	Fuel type[d]	Wood species[e]				Moisture content, %		Temp., °F		Emission control device[f]	No. of runs	Emission factor, lb/ODT	Data rating
					Primary	%	Secondary	%	Inlet	Outlet	Inlet	Outlet				
121-062889A	1D121	PM	DFIRE	TRIM	SWOOD	100	NA	NA	NS	NS	NS	NS	CYC	3	1.02	A
121-062989A	2D121	PM	DFIRE	TRIM	SWOOD	100	NA	NA	NS	NS	NS	NS	CYC	3	5.27	A
173-092592A	1D173	PM	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	1.50	A
192-050492A	1D192	PM	IHEAT	NS	PINE SP	100	NA	NA	NS	12.1	NS	130	CYC	3	1.36	A
227-031192A	4D227	PM	DFIRE	SDUST	PINE SP	100	NA	NA	32	10.0	150	124	CYC	3	3.14	A
227-031292A	3D227	PM	DFIRE	SDUST	PINE SP	100	NA	NA	26	9.6	160	121	CYC	3	8.95	A
227-031392A	2D227	PM	DFIRE	SDUST	PINE SP	100	NA	NA	46	13.0	169	104	CYC	3	13.7	A
227-031492A	1D227	PM	DFIRE	SDUST	PINE SP	100	NA	NA	56	12.5	187	112	CYC	2	15.8	B
121-062889A	1D121	PM10	DFIRE	TRIM	SWOOD	100	NA	NA	NS	NS	NS	NS	CYC	3	0.516	A
121-062989A	2D121	PM10	DFIRE	TRIM	SWOOD	100	NA	NA	NS	NS	NS	NS	CYC	3	1.90	A
173-092592B	1D173	PM10	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.275	A
227-031192A	4D227	PM10	DFIRE	SDUST	PINE SP	100	NA	NA	32	10.0	150	124	CYC	3	0.397	A
227-031292A	3D227	PM10	DFIRE	SDUST	PINE SP	100	NA	NA	26	9.6	160	121	CYC	3	0.873	A
227-031392A	2D227	PM10	DFIRE	SDUST	PINE SP	100	NA	NA	46	13.0	169	104	CYC	3	2.71	A
227-031492A	1D227	PM10	DFIRE	SDUST	PINE SP	100	NA	NA	56	12.5	187	112	CYC	2	2.33	B
121-062889A	1D121	CPM	DFIRE	TRIM	SWOOD	100	NA	NA	NS	NS	NS	NS	CYC	3	0.0857	A
121-062989A	2D121	CPM	DFIRE	TRIM	SWOOD	100	NA	NA	NS	NS	NS	NS	CYC	3	1.21	A
173-092592A	1D173	CPM	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.726	A
227-031192A	4D227	CPM	DFIRE	SDUST	PINE SP	100	NA	NA	32	10.0	150	124	CYC	3	0.340	A
227-031292A	3D227	CPM	DFIRE	SDUST	PINE SP	100	NA	NA	26	9.6	160	121	CYC	3	0.547	A
227-031392A	2D227	CPM	DFIRE	SDUST	PINE SP	100	NA	NA	46	13.0	169	104	CYC	3	0.630	A
227-031492A	1D227	CPM	DFIRE	SDUST	PINE SP	100	NA	NA	56	12.5	187	112	CYC	2	0.860	B
121-052688A	1D121	PM&CPM	DFIRE	TRIM	SWOOD	100	NA	NA	NS	12.6	322	141	CYC	3	1.91	A
121-052788A	2D121	PM&CPM	DFIRE	TRIM	SWOOD	100	NA	NA	NS	NS	NS	NS	CYC	3	2.54	A

TABLE 4-3. (continued)

Test code	Unit code	Pollutant[b]	Firing type[c]	Fuel type[d]	Wood species[e] Primary	%	Secondary	%	Moisture content, % Inlet	Outlet	Temp., °F Inlet	Outlet	Emission control device[f]	No. of runs	Emission factor, lb/ODT	Data rating
121-062889A	1D121	PM&CPM	DFIRE	TRIM	SWOOD	100	NA	NA	NS	NS	NS	NS	CYC	3	1.11	A
121-062989A	2D121	PM&CPM	DFIRE	TRIM	SWOOD	100	NA	NA	NS	NS	NS	NS	CYC	3	6.47	A
173-092592A	1D173	PM&CPM	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	2.22	A
227-031192A	4D227	PM&CPM	DFIRE	SDUST	PINE SP	100	NA	NA	32	10.0	150	124	CYC	3	3.48	A
227-031292A	3D227	PM&CPM	DFIRE	SDUST	PINE SP	100	NA	NA	26	9.6	160	121	CYC	3	9.50	A
227-031392A	2D227	PM&CPM	DFIRE	SDUST	PINE SP	100	NA	NA	46	13.0	169	104	CYC	3	14.3	A
227-031492A	1D227	PM&CPM	DFIRE	SDUST	PINE SP	100	NA	NA	NS	12.5	187	112	CYC	2	16.6	B
121-062889A	1D121	PM10&CPM	DFIRE	TRIM	SWOOD	100	NA	NA	NS	NS	NS	NS	CYC	3	0.603	A
121-062989A	2D121	PM10&CPM	DFIRE	TRIM	SWOOD	100	NA	NA	NS	NS	NS	NS	CYC	3	3.11	A
227-031992A	2D227	CO	DFIRE	SDUST	PINE SP	100	NA	NA	66.3	12.6	214	117	CYC	3	2.06	A
227-032092A	3D227	CO	DFIRE	NS	HWOOD	100	NA	NA	25	11.0	177	129	CYC	3	6.06	A
227-032092B	4D227	CO	DFIRE	NS	HWOOD	100	NA	NA	26	11.6	212	129	CYC	3	6.86	A
227-032192A	1D227	CO	DFIRE	SDUST	PINE SP	100	NA	NA	57.2	12.5	163	106	CYC	2	0.875	B
173-092592C	1D173	VOC	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.687	A
192-020194B	1D192	VOC	IHEAT	NS	HWOOD	100	NA	NA	NS	9.3	199	160	CYC	3	2.80	A
192-020194C	2D192	VOC	IHEAT	NS	HWOOD	100	NA	NA	NS	9.8	235	140	CYC	3	4.57	A
227-031992A	2D227	VOC	DFIRE	SDUST	PINE SP	100	NA	NA	66.3	12.6	214	117	CYC	3	5.38	A
227-032092A	3D227	VOC	DFIRE	NS	HWOOD	100	NA	NA	25	11.0	177	129	CYC	3	4.76	A
227-032092B	4D227	VOC	DFIRE	NS	HWOOD	100	NA	NA	26	11.6	212	129	CYC	3	4.63	A
227-032192A	1D227	VOC	DFIRE	SDUST	HWOOD	100	NA	NA	57.2	12.5	163	106	CYC	2	4.53	B
173-092692A	1D173	2-5-DMBENZ	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00038	A
173-092692A	1D173	ACETALD	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.0130	A
192-020194C	2D192	ACETALD	IHEAT	NS	HWOOD	100	NA	NA	NS	9.8	235	140	CYC	3	0.0188	A
192-020194B	1D192	ACETALD	IHEAT	NS	HWOOD	100	NA	NA	NS	9.3	199	160	CYC	3	0.00707	A

TABLE 4-3. (continued)

Test code	Unit code	Pollutant[b]	Firing type[c]	Fuel type[d]	Wood species[e] Primary	%	Secondary	%	Moisture content, % Inlet	Outlet	Temp., °F Inlet	Outlet	Emission control device[f]	No. of runs	Emission factor, lb/ODT	Data rating
173-092692A	1D173	ACETONE	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00397	A
173-092692B	1D173	ACETONE	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00113	A
173-092692B	1D173	ACETPH	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00024	A
173-092692A	1D173	ACROLEIN	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00220	A
173-092692B	1D173	A-PINENE	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00651	A
173-092692B	1D173	A-PINENE	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00587	A
173-092692B	1D173	A-TERPENE	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00225	A
173-092692A	1D173	BENZALD	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00258	A
173-092692B	1D173	BIS-2EH-PH	IHEAT	SDUST	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00027	A
173-092692B	1D173	BUTBENPHTH	IHEAT	SDUST	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00024	A
173-092692A	1D173	BUTYLALDEH	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00282	A
173-092692B	1D173	B-PINENE	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00673	A
173-092692B	1D173	B-PINENE	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00614	A
173-092692B	1D173	CHLOROMET	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00151	A
173-092692A	1D173	CROTONALDE	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00189	A
173-092692B	1D173	D-N-BUT-PH	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00018	A
093-063088A	1D093	FOR	IHEAT	NS	HWOOD	100	NA	NA	NS	NS	NS	NS	MCLO	3	0.0896	A
173-092692A	1D173	FOR	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	1.40	A
192-020194B	1D192	FOR	IHEAT	NS	HWOOD	100	NA	NA	NS	9.3	199	160	CYC	3	0.253	A
192-020194C	2D192	FOR	IHEAT	NS	HWOOD	100	NA	NA	NS	9.8	235	140	CYC	3	0.260	A
227-031992A	2D227	FOR	DFIRE	NS	HWOOD	100	NA	NA	66	12.6	214	117	CYC	3	1.20	A
227-032092A	3D227	FOR	DFIRE	NS	HWOOD	100	NA	NA	25	11.0	177	129	CYC	3	0.420	A
227-032092B	4D227	FOR	DFIRE	NS	HWOOD	100	NA	NA	26	11.6	212	129	CYC	3	0.497	A
227-032192A	1D227	FOR	DFIRE	NS	HWOOD	100	NA	NA	57	12.5	163	106	CYC	2	1.32	B
173-092692A	1D173	HEXALD	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00262	A

TABLE 4-3. (continued)

Test code	Unit code	Pollutant[b]	Firing type[c]	Fuel type[d]	Wood species[e]				Moisture content, %		Temp., °F		Emission control device[f]	No. of runs	Emission factor, lb/ODT	Data rating
					Primary	%	Secondary	%	Inlet	Outlet	Inlet	Outlet				
173-092692B	1D173	ISOOCTANE	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00062	A
173-092692A	1D173	ISOVALALD	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00188	A
173-092692A	1D173	MEK	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00634	A
173-092692B	1D173	METHENECHL	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00287	A
173-092692B	1D173	NAPHTHALENE	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	2	0.00066	B
173-092692B	1D173	N-HEXANE	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00139	A
173-092692A	1D173	O-TOLALD	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00074	A
173-092692B	1D173	PHENOL	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	2	0.00020	B
173-092692A	1D173	PROPIONALD	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00106	A
173-092692B	1D173	P-CYMEME	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	2	0.00024	B
173-092692B	1D173	P-CYMEME	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00014	A
173-092692B	1D173	P-CYMEME	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00018	A
173-092692A	1D173	P-TOLALD	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00363	A
173-092692B	1D173	T-FL-METH	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00138	A
173-092692A	1D173	VALALD	IHEAT	NS	HWOOD	50	SWOOD	50	100	9.9	302	148	CYC	3	0.00210	A

[a]Reference 3. NS = not specified; NA = not applicable. lb/ODT = pounds of pollutant per oven-dried ton of wood material out of dryer.
[b]Pollutant codes identified in Table 4-4. Factors for VOC on a carbon basis.
[c]Firing types: DFIRE = direct firing; IHEAT = indirect heat.
[d]Fuel types: SDUST = sawdust; TRIM = trim.
[e]Wood species: PINE SP = unknown pine species; SWOOD = unspecified softwood; HWOOD = unspecified hardwood.
[f]Emission control devices: CYC = cyclone; MCLO = multiclone.

Table 4-4 defines the pollutant codes used in Tables 4-1 to 4-3 and in Tables 4-5 to 4-8. These pollutant codes match those used in the NCASI data base and throughout this section.

Table 4-5 and Table 4-6 present a summary of the data on MDF presses. Table 4-5 includes press design and operating data and emission test parameters including press size, number of vents, test method, number of runs, stack parameters, pollutant concentration, emission rate, process rate, and emission factor. Table 4-6 presents other data that are likely to have a significant effect on emissions, including press temperature, cycle time, board thickness and density, moisture content, wood species, type of resin, resin application rate, the use of catalysts or scavengers, wax application rate, pollutant, and emission factor.

Table 4-7 summarizes the emission data for MDF board coolers. The table presents for each emission test, the pollutant, number of runs, test method, stack parameters, pollutant concentration, the use of catalysts or scavengers, emission rate, production rate, and emission factor.

Table 4-8 summarizes the emission data for miscellaneous equipment. The table presents for each emission test, emission control device, wood species, pollutant, number of runs, test method, pollutant concentration, emission rate, production rate, and emission factor.

The quality ratings for the emission data presented in Tables 4-1 to 4-3 and 4-5 to 4-8 take into account the number of test runs, test method, and any other indication that the test results may be suspect. Generally, data based on 3 or more test runs were assigned a rating of A, 2-run data were assigned a rating of B, and single-run data were assigned a rating of D. If there were indications of other reasons for questioning the data, the rating was further lowered.

4.2.4 Reference 4

This report presents the results of RTO control efficiency tests performed on January 18-21, 1994, at the Louisiana-Pacific MDF plant located in Urania, Louisiana. Pollutants tested include PM, VOC, formaldehyde, NO_x, and CO.

The Urania plant utilizes two direct-heated wood-fired dryers and one continuous press. The exhaust from each dryer is directed to two primary cyclones. The exhausts are then combined in a common header leading to a knockout box. The gas is then equally distributed to two Smith Engineering Company RTOs which exhaust to the atmosphere. The press area is enclosed and under vacuum such that essentially all emissions are collected and ducted to a Smith Engineering Company RTO which exhausts to the atmosphere. Urea formaldehyde resin was used in production throughout the test program.

Particulate matter and condensible PM emissions were tested in accordance with Methods 5 and 202, respectively. Method 5 and 202 results are reported as front half and back half organic and inorganic fractions. Volatile organic compounds were tested in accordance with Method 25A; results are reported on an as-carbon basis. Formaldehyde emissions were tested in accordance with Method 0011. Nitrogen oxides emissions were measured in accordance with Method 7E. Carbon monoxide emissions were tested in accordance with Method 10.

Because this report does not contain sufficient data to evaluate the dryer operating conditions during the test, the dryer emission data are not incorporated into AP-42 Section 10.6.3, and are not addressed further in this background report.

TABLE 4-4. POLLUTANT CODES

Code	Pollutant
2-5-DMBENZ	2,5 Dimethyl benzaldehyde
A-PINENE	Alpha pinene
A-TERPENE	Alpha terpeneol
ACETALD	Acetaldehyde
ACETONE	Acetone
ACETPH	Acetophenone
ACROLEIN	Acrolein
B-PINENE	Beta pinene
BENZALD	Benzaldehyde
BIS-2EH-PH	Bis-(2-ethylhexyl phthalate)
BUTBENPHTH	Butylbenzyl phthalate
BUTYLALDEH	Butylaldehyde
CHLOROMET	Chloromethane
CO	Carbon monoxide
CO2	Carbon dioxide
CPM	Condensible PM
CROTONALDE	Crotonaldehyde
D-N-BUT-PH	Di-n-butyl phthalate
FOR	Formaldehyde
HEXALD	Hexaldehyde
ISOOCTANE	Isooctane
ISOVALALD	Isovaleraldehyde
MEK	Methyl ethyl ketone
METHENECHL	Methylene chloride
N-HEXANE	n-Hexane
NAPHTHALENE	Naphthalene
NOX	Nitrogen oxides
O-TOLALD	o-Tolualdehyde
P-CYMEME	p-Cymene
P-TOLALD	p-Tolualdehyde
PHENOL	Phenol
PM	Filterable particulate matter
PM10	PM-10, PM less than 10 micrometers
PM10&CPM	PM-10 and condensible PM
PROPIONALD	Propionaldehyde
SO2	Sulfur dioxide
T-FL-METH	Trichlorofluoromethane
VALALD	Valeraldehyde
VOC	Volatile organic compounds

TABLE 4-5. SUMMARY OF MDF PRESS DESIGN AND EMISSION DATA FROM NCASI DATA BASE[a]

Test code	Unit code	Pollutant[b]	Press size: Dim., ft	Press size: No. of open.	No. of vents	Test method[c]	No. of runs	Stack parameters: Flow, dscfm	Stack parameters: Temp., °F	Stack parameters: Moist., %	Pollutant concentration: ppm	Pollutant concentration: gr/dscf	Emission rate, lb/hr	Process rate	Emission factor, lb/MSF 3/4
027-051893A	1P027	PM	8x26	6	2	M5	2	50,285	114	4	NS	NS	2.83	14.39 MSF 3/4/hr	0.197
173-091092G	1P173	PM	5x24	8	5	M5	3	23,782	121	3.6	NS	NS	2.07	12.9 MSF 3/4/hr	0.160
227-031592A	2P227	PM	NS	16	5	M5	3	169,826	85	1.53	NA	0.0024	3.44	21.07 TFP/hr	ND
227-031792A	1P227	PM	Cont.	NA	4	M5	3	150,042	95	1.3	NA	0.0021	2.68	13.93 TFP/hr	ND
027-051893A	1P027	PM10	8x26	6	2	M201A	2	50,285	114	4	NS	NS	3.265	14.39 MSF 3/4/hr	0.227
173-091092G	1P173	PM10	5x24	8	5	M201A	3	23,782	121	3.6	NA	0.004	0.967	12.9 MSF 3/4/hr	0.075
173-091092G	1P173	PM10&CPM	5x24	8	5	M201A/202	3	23,782	121	3.6	NA	0.015	3.72	12.9 MSF 3/4/hr	0.288
027-051793A	1P027	PM&CPM	8x26	6	2	M5/202	2	18,856	90	NS	NS	NS	3.352	13.80 MSF 3/4/hr	0.243
027-051893A	1P027	PM&CPM	8x26	6	2	M5/202	2	50,285	114	4	NS	NS	6.564	14.39 MSF 3/4/hr	0.456
227-031592A	2P227	PM&CPM	NS	16	5	M5/202	3	169,826	85	1.53	NA	0.0044	6.47	21.07 TFP/hr	ND
227-031792A	1P227	PM&CPM	Cont.	NA	4	M5/202	3	150,042	95	1.3	NA	0.0042	5.35	13.93 TFP/hr	ND
027-051893A	1P027	CPM	8x26	6	2	M202	2	50,285	114	4	NS	NS	3.73	14.39 MSF 3/4/hr	0.259
227-031592A	2P227	CPM	NS	16	5	M202	3	169,826	85	1.53	NA	0.0020	3.0	21.07 TFP/hr	ND
227-031792A	1P227	CPM	Cont.	NA	4	M202	3	150,042	95	1.3	NA	0.002	2.7	13.93 TFP/hr	ND
027-051893A	1P027	CO	8x26	6	2	M10	2	50,285	114	4	NS	NS	0.48	14.39 MSF 3/4/hr	0.034
227-031692A	2P227	CO	NS	16	5	M10	3	186,167	75	1.2	2.16	NA	1.71	19.75 TFP/hr	ND
227-031892A	1P227	CO	Cont.	NA	4	M10	3	186,033	79	1	2.7	NA	2.51	13.64 TFP/hr	ND
027-051893A	1P027	NOX	8x26	6	2	M7E	2	50,285	114	4	NS	NS	0.43	14.39 MSF 3/4/hr	0.030
027-051893A	1P027	VOC	8x26	6	2	M25A	2	50,285	114	4	NS	NS	4.785	14.39 MSF 3/4/hr	0.333
173-091192H	1P173	VOC	5x24	8	5	M25A	3	23,867	NS	NS	74.1	NA	4.68	12.3 MSF 3/4/hr	0.380
227-031692A	2P227	VOC	NS	16	5	M25A	3	186,167	75	1.2	15.7	NA	5.52	19.75 TFP/hr	ND
227-031892A	1P227	VOC	Cont.	NA	4	M25A	3	186,033	79	1	18.6	NA	5.57	13.64 TFP/hr	ND
173-091192G	1P173	2-5-DMBENZ	5x24	8	5	M0011	2	23,572	116	3.3	0.0207	NA	0.020	12.5 MSF 3/4/hr	0.0025
173-091192G	1P173	ACETALD	5x24	8	5	M0011	2	23,572	116	3.3	0.274	NA	0.0634	12.5 MSF 3/4/hr	0.0051
173-091192G	1P173	ACETONE	5x24	8	5	M0011	2	23,572	116	3.3	0.090	NA	0.0389	12.5 MSF 3/4/hr	0.0031
173-091192G	1P173	ACROLEIN	5x24	8	5	M0011	2	23,572	116	3.3	0.0445	NA	0.0151	12.5 MSF 3/4/hr	0.0012

TABLE 4-5. (continued)

Test code	Unit code	Pollutant[b]	Press size: Dim., ft	Press size: No. of open.	No. of vents	Test method[c]	No. of runs	Stack parameters: Flow, dscfm	Stack parameters: Temp., °F	Stack parameters: Moist., %	Pollutant concentration: ppm	Pollutant concentration: gr/dscf	Emission rate, lb/hr	Process rate	Emission factor, lb/MSF 3/4
173-091192G	1P173	BENZALD	5x24	8	5	M0011	2	23,572	116	3.3	0.006	NA	0.0070	12.5 MSF 3/4/hr	0.00055
173-091192G	1P173	BUTYLALDEH	5x24	8	5	M0011	2	23,572	116	3.3	0.047	NA	0.0293	12.5 MSF 3/4/hr	0.0024
173-091192G	1P173	CROTONALDE	5x24	8	5	M0011	2	23,572	116	3.3	0.023	NA	0.0136	12.5 MSF 3/4/hr	0.0011
027-052593A	1P027	FOR	8x26	6	2	M0011	2	46,152	99	2	NS	NS	0.4150	15.19 MSF 3/4/hr	0.027
093-063088B	1P093	FOR	5x18	14	2	M0011	2	68,037	88	0.84	5.30	NA	1.69	9.24 MSF 3/4/hr	0.183
173-091192G	1P173	FOR	5x24	8	5	M0011	3	23,775	116	3.0	48.3	NA	6.42	12.6 MSF 3/4/hr	0.56
227-031692A	2P227	FOR	NS	16	5	M0011	3	186,167	75	1.2	14.7	NA	12.7	19.75 TFP/hr	ND
227-031892A	1P227	FOR	Cont.	NA	4	M0011	3	186,033	79	1	21.6	NA	14	13.64 TFP/hr	ND
173-091192G	1P173	HEXALD	5x24	8	5	M0011	2	23,572	116	3.3	0.0268	NA	0.0364	12.5 MSF 3/4/hr	0.0029
173-091192G	1P173	ISOVALALD	5x24	8	5	M0011	2	23,572	116	3.3	0.022	NA	0.0170	12.6 MSF 3/4/hr	0.0014
173-091192G	1P173	MEK	5x24	8	5	M0011	2	23,572	116	3.3	0.0259	NA	0.0075	12.6 MSF 3/4/hr	0.00059
173-091192G	1P173	O-TOLALD	5x24	8	5	M0011	2	23,572	116	3.3	0.0086	NA	0.0089	12.6 MSF 3/4/hr	0.00070
173-091192G	1P173	PROPIONALD	5x24	8	5	M0011	2	23,572	116	3.3	0.0161	NA	0.00666	12.6 MSF 3/4/hr	0.00054
173-091192G	1P173	P-TOLALD	5x24	8	5	M0011	2	23,572	116	3.3	0.0186	NA	0.0127	12.6 MSF 3/4/hr	0.0010
173-091192G	1P173	VALALD	5x24	8	5	M0011	2	23,572	116	3.3	0.034	NA	0.0295	12.6 MSF 3/4/hr	0.0024

[a]Reference 3. NS = not specified; NA = not applicable; ND = insufficient data. MSF = thousand square feet. TFP = ton of finished product. LB/MSF 3/4 = pounds of pollutant per thousand square feet of 3/4-in. thick panel.
[b]Pollutant codes are identified in Table 4-4. Factors for VOC on a carbon basis.
[c]Test methods: M201A = EPA Method 201A; M202 = EPA Method 202; M25A = EPA Method 25A; M5 = EPA Method 5; M10 = EPA Method 10; M7E = EPA Method 7E; M0011 = BIF Method 0011 (aldehydes and ketones).

TABLE 4-6. SUMMARY OF MDF PRESS EMISSION FACTORS FROM NCASI DATA BASE[a]

Test code	Unit code	Pollutant[b]	Press		Board		Moist. cont., %	Wood species[c]				Adhesive/resin[d]		Cat/ Scav.?[e]	Wax applic. rate	Emission factor, lb/MSF 3/4	Data rating
			Temp., °F	Cycle, min	Thick., in.	Density, lb/ft^3		Primary	%	Second.	%	Type	Applic. rate				
027-051893A	1P027	PM	380	4.5	7/16-1.5	47	8.5	PINE SP	100	NA		UF	213 lb/MSF	Y	12 lb/MSF	0.197	B
173-091092G	1P173	PM	NS	3.13	0.625	48.6	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	321 lb/hr	0.160	A
227-031592A	2P227	PM	295	NS	NS	NS	NS	SY PINE	100	NA		UF	NS	NS	NS	ND	NR
227-031792A	1P227	PM	NS	NS	NS	NS	NS	SY PINE	100	NA		UF	NS	NS	NS	ND	NR
027-051893A	1P027	PM10	380	4.5	7/16-1.5	47	8.5	PINE SP	100	NA		UF	213 lb/MSF	Y	12 lb/MSF	0.227	B
173-091092G	1P173	PM10	NS	3.13	0.625	48.6	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	321 lb/hr	0.0748	A
173-091092G	1P173	PM10&CPM	NS	3.13	0.625	48.6	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	321 lb/hr	0.288	A
027-051793A	1P027	PM&CPM	380	4.5	7/16-1.5	47	8.5	PINE SP	100	NA		UF	213 lb/MSF	Y	12 lb/MSF	0.243	B
027-051893A	1P027	PM&CPM	380	4.5	7/16-1.5	47	8.5	PINE SP	100	NA		UF	213 lb/MSF	Y	12 lb/MSF	0.456	B
227-031592A	2P227	PM&CPM	295	NS	NS	NS	NS	SY PINE	100	NA		UF	NS	NS	NS	ND	NR
227-031792A	1P227	PM&CPM	NS	NS	NS	NS	NS	SY PINE	100	NA		UF	NS	NS	NS	ND	NR
027-051893A	1P027	CPM	380	4.5	7/16-1.5	47	8.5	PINE SP	100	NA		UF	213 lb/MSF	Y	12 lb/MSF	0.259	B
227-031592A	2P227	CPM	295	NS	NS	NS	NS	SY PINE	100	NA		UF	NS	NS	NS	ND	NR
227-031792A	1P227	CPM	NS	NS	NS	NS	NS	SY PINE	100	NA		UF	NS	NS	NS	ND	NR
027-051893A	1P027	CO	380	4.5	7/16-1.5	47	8.5	PINE SP	100	NA		UF	213 lb/MSF	Y	12 lb/MSF	0.034	B
227-031692A	2P227	CO	295	NS	NS	NS	NS	SY PINE	100	NA		UF	NS	NS	NS	ND	NR
227-031892A	1P227	CO	NS	NS	NS	NS	NS	SY PINE	100	NA		UF	NS	NS	NS	ND	NR
027-051893A	1P027	NOX	380	4.5	7/16-1.5	47	8.5	PINE SP	100	NA		UF	213 lb/MSF	Y	12 lb/MSF	0.030	B
027-051893A	1P027	VOC	380	4.5	7/16-1.5	47	8.5	PINE SP	100	NA		UF	213 lb/MSF	Y	12 lb/MSF	0.333	B
173-091192H	1P173	VOC	NS	3.55	0.71	47.6	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	333 lb/hr	0.380	A
227-031692A	2P227	VOC	295	NS	NS	NS	NS	SY PINE	100	NA		UF	NS	NS	NS	ND	NR
227-031892A	1P227	VOC	NS	NS	NS	NS	NS	SY PINE	100	NA		UF	NS	NS	NS	ND	NR
173-091192G	1P173	2-5-DMBENZ	NS	3.44	0.69	47.8	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	327 lb/hr	0.00247	B
173-091192G	1P173	ACETALD	NS	3.44	0.69	47.8	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	327 lb/hr	0.00508	B
173-091192G	1P173	ACETONE	NS	3.44	0.69	47.8	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	327 lb/hr	0.00314	B
173-091192G	1P173	ACROLEIN	NS	3.44	0.69	47.8	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	327 lb/hr	0.0012	B
173-091192G	1P173	BENZALD	NS	3.44	0.69	47.8	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	327 lb/hr	0.000553	B
173-091192G	1P173	BUTYLALDEH	NS	3.44	0.69	47.8	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	327 lb/hr	0.00236	B

TABLE 4-6. (continued)

Test code	Unit code	Pollutant[b]	Press		Board		Moist. cont., %	Wood species[c]				Adhesive/resin[d]		Cat/ Scav.?[e]	Wax applic. rate	Emission factor, lb/MSF 3/4	Data rating
			Temp., °F	Cycle, min	Thick., in.	Density, lb/ft^3		Primary	%	Second.	%	Type	Applic. rate				
173-091192G	1P173	CROTONALDE	NS	3.44	0.69	47.8	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	327 lb/hr	0.00111	B
027-052593A	1P027	FOR	380	4.5	7/16-1.5	47	8.5	PINE SP	100	NA		UF	213 lb/MSF	Y	12 lb/MSF	0.027	B
093-063088B	1P093	FOR	NS	32.7	3/4	48.9	NS	HWOOD	100	NA		UF	NS	NS	NS	0.183	A
173-091192G	1P173	FOR	NS	3.55	0.71	47.6	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	329 lb/hr	0.56	A
227-031692A	2P227	FOR	295	NS	NS	NS	NS	SY PINE	100	NA		UF	NS	NS	NS	ND	NR
227-031892A	1P227	FOR	NS	NS	NS	NS	NS	SY PINE	100	NA		UF	NS	NS	NS	ND	NR
173-091192G	1P173	HEXALD	NS	3.44	0.69	47.8	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	327 lb/hr	0.00291	B
173-091192G	1P173	ISOVALALD	NS	3.44	0.69	47.8	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	327 lb/hr	0.00138	B
173-091192G	1P173	MEK	NS	3.44	0.69	47.8	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	327 lb/hr	0.000588	B
173-091192G	1P173	O-TOLALD	NS	3.44	0.69	47.8	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	327 lb/hr	0.00070	B
173-091192G	1P173	PROPIONALD	NS	3.44	0.69	47.8	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	327 lb/hr	0.000540	B
173-091192G	1P173	P-TOLALD	NS	3.44	0.69	47.8	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	327 lb/hr	0.00102	B
173-091192G	1P173	VALALD	NS	3.44	0.69	47.8	8.5	HWOOD	50	SWOOD	50	UF	7.8%	Y	327 lb/hr	0.00238	B

[a]Reference 3. NS = not specified; NA = not applicable; NR = not rated; ND = insufficient data. MSF = thousand square feet. LB/MSF 3/4 = pounds of pollutant per thousand square feet of 3/4-in. thick panel.
[b]Pollutant codes are identified in Table 4-4. Factors for VOC on a carbon basis.
[c]Wood species: SY PINE = Southern yellow pine; PINE SP = unknown pine species; HWOOD = unspecified hardwood; SWOOD = unspecified softwood.
[d]Adhesive/resin type: UF = urea formaldehyde.
[e]Cat/Scav.? = Y indicates either a catalyst or formaldehyde scavenger was used.

TABLE 4-7. SUMMARY OF EMISSION FACTORS FOR MDF BOARD COOLERS FROM NCASI DATA BASE[a]

					Stack gas parameters			Pollutant concentration						
Test code	Unit code	Pollutant[b]	No. of runs	Test method[c]	Flow, dscfm	Temp., °F	Moist., %	ppm	gr/dcsf	Adhesive/ resin type[d]	Emission rate, lb/hr	Production rate, MSF 3/4/hr	Emission factor, Lb/MSF 3/4	Data rating
173-091092C	1C173	PM	3	M5	30862	98	2.5	NS	NS	UF	0.408	11.5	0.0364	A
173-091192F	1C173	PM	2	M5	27700	NS	NS	NA	17.10	UF	0.888	12.5	0.0714	B
173-091092C	1C173	PM10	3	M201A	30862	98	2.5	NA	0.000155	UF	0.041	11.5	0.00376	A
173-091092C	1C173	PM10&CPM	3	M201A/202	30862	98	2.5	NA	0.00227	UF	0.600	11.5	0.0556	A
173-091192F	1C173	VOC	3	M25A	27333	NS	NS	17.35	NS	UF	0.889	12.3	0.0726	A
173-091192E	1C173	2-5-DMBENZ	2	M0011	27995	92	1.9	0.00367	NS	UF	0.0021	11.9	0.00019	B
173-091192E	1C173	ACETALD	2	M0011	27995	92	1.9	0.06045	NS	UF	0.012	11.9	0.0010	B
173-091192E	1C173	ACETONE	2	M0011	27995	92	1.9	0.09915	NS	UF	0.025	11.9	0.0021	B
173-091192E	1C173	ACROLEIN	2	M0011	27995	92	1.9	0.01065	NS	UF	0.0026	11.9	0.000221	B
173-091192E	1C173	BENZALD	2	M0011	27995	92	1.9	0.0025	NS	UF	0.0012	11.9	0.000099	B
173-091192E	1C173	BUTYLALDEH	2	M0011	27995	92	1.9	0.05045	NS	UF	0.016	11.9	0.00141	B
173-091192E	1C173	CROTONALDE	2	M0011	27995	92	1.9	0.00969	NS	UF	0.0029	11.9	0.000255	B
173-091192E	1C173	FOR	2	M0011	27995	92	1.9	10.41	NS	UF	1.355	11.9	0.1140	B
173-091192E	1C173	HEXALD	2	M0011	27995	92	1.9	0.01715	NS	UF	0.0075	11.9	0.000647	B
173-091192E	1C173	ISOVALALD	2	M0011	27995	92	1.9	0.0079	NS	UF	0.0030	11.9	0.00025	B
173-091192E	1C173	MEK	2	M0011	27995	92	1.9	0.00403	NS	UF	0.0013	11.9	0.000110	B
173-091192E	1C173	O-TOLALD	2	M0011	27995	92	1.9	0.00147	NS	UF	0.0008	11.9	0.000065	B
173-091192E	1C173	P-TOLALD	2	M0011	27995	92	1.9	0.00375	NS	UF	0.0020	11.9	0.000169	B
173-091192E	1C173	VALALD	2	M0011	27995	92	1.9	0.0148	NS	UF	0.0055	11.9	0.000478	B

[a]Reference 3. NS = not specified; NA = not applicable. MSF 3/4/hr = thousand square feet of 3/4-in. thick panel per hour. LB/MSF 3/4 = pounds of pollutant per thousand square feet of 3/4-in. thick panel.
[b]Pollutant codes are identified in Table 4-4. Factors for VOC on a carbon basis.
[c]Test methods: M201A = EPA Method 201A; M202 = EPA Method 202; M25A = EPA Method 25A; M5 = EPA Method 5; M0011 = BIF Method 0011 (aldehydes and ketones).
[d]Adhesive/resin type: UF = urea formaldehyde.

TABLE 4-8. SUMMARY OF EMISSION FACTORS FOR MDF FROM NCASI DATA BASE -- MISCELLANEOUS EQUIPMENT[a]

Test code	Unit code	Pollutant[b]	Description	Emission control[c]	Wood species[d]	No of runs	Test method[e]	Pollutant concentration		Emission rate, lb/hr	Production rate	Emission factor, Lb/MSF 3/4	Data rating
								ppm	gr/dscf				
093-063088C	1U093	FOR	Hot press unloader	NS	HWOOD	3	M0011	3.98	NS	1.19	9.24 MSF 3/4/hr	0.13	A
192-050592B	1Z192	PM	Refiner reject cyclone	CYC	PINE SP	1	OD8	NS	3.92	2.2	9,000 lb/hr	ND[f]	NR
192-050592C	2Z192	PM	Mat reject cyclone	CYC	PINE SP	3	OD8	NS	0.14	32.53	27,700 lb/hr	ND[f]	NR
192-050592D	1F192	PM	Former vacuum cyclone	CYC	PINE SP	3	OD8	NS	0.0047	0.33	53,098 lb/hr	ND[f]	NR
227-031292B	1F227	PM	Former stack #1	NS	NS	3	M5	NS	1.06	77.73	NS	ND	NR
227-031292B	1F227	CPM	Former stack #1	NS	NS	3	M202	NS	0.0059	0.43	NS	ND	NR
227-031292B	1F227	PM&CPM	Former stack #1	NS	NS	3	M5/202	NS	1.06	78.17	NS	ND	NR

[a]Reference 3. NS = not specified; NA = not applicable; NR = not rated; ND = insufficient data. Lb/MSF 3/4 = pounds of pollutant per thousand square feet of 3/4-in. thick panel.
[b]Pollutant codes are identified in Table 4-4.
[c]Control devices: CYC = cyclone.
[d]Wood species: HWOOD = unspecified hardwood; PINE SP = unknown pine species.
[e]Test methods: M0011 = BIF Method 0011 (aldehydes and ketones); OD8 = Oregon Department of Environmental Quality Method 8; M5 = EPA Method 5; M202 = EPA Method 202.
[f]Because the production rate is in units of lb/hr of material collected by the cyclone and cannot be related to the process rate for the operation served by the cyclone, these factors are not incorporated in the AP-42 section.

The press RTO achieved a control efficiency of 93 percent for VOC, 99 percent for formaldehyde, 77 percent for filterable PM, and 89 percent for condensible PM. A rating of A was assigned to the press PM data. The press NO_x, CO, and VOC data were downrated to B because the methods used in calibration and testing were questionable and do not meet the criteria specified in Methods 7E, 10, and 25A. The emission data from Reference 4 are summarized in Table 4-9.

4.2.5 Reference 5

This report presents the results of testing performed on Boilers No. 4 and No. 5 at the Louisiana-Pacific MDF plant in Oroville, California, to determine compliance with regulatory limits and to certify the continuous emissions monitor system. The tests were performed on May 3-5, 1994.

Emissions from wood combustion in boilers are addressed in AP-42 Section 1.6, Wood Waste Combustion In Boilers. Because this test report does not contain emissions data for other MDF sources, these data are not incorporated into AP-42 Section 10.6.3, and are not addressed further in this background report.

4.2.6 Reference 6

This report presents the results of testing performed on June 7-20, 1994, on the No. 2 line at the Louisiana-Pacific plant in Oroville, California. Pollutants tested include PM, VOC, formaldehyde, NO_x, and CO.

The Louisiana-Pacific facility in Oroville consists of a fiberboard plant (hardboard and MDF production lines), a sawmill, a planer mill, and a dry kiln. The MDF line, No. 2, was added in 1985. Emissions from the line are controlled by cyclones, filter boxes, and baghouses.

Because this report does not contain sufficient data to evaluate the source operating conditions during the test (no process rates), these emission data are not incorporated into AP-42 Section 10.6.3, and are not addressed further in this background report.

4.2.7 Reference 7

This report presents the results of RTO control efficiency testing performed on June 6 and 7, 1995, at the Louisiana-Pacific MDF plant located in Clayton, Alabama. Pollutants tested include PM, VOC, formaldehyde, NO_x, and CO.

The Clayton plant operates two pairs of MDF dryers (two line 1 dryers and two line 2 dryers) which collectively exhaust to a common equalization chamber. The chamber distributes the exhaust to three Smith Engineering Company RTOs for emission control. The presses associated with each line vent through the same equalization chamber by way of the dryers.

Particulate matter and condensible PM emissions were tested in accordance with Methods 5 and 202, respectively. Method 5 and 202 results are reported as front half and back half organic and inorganic fractions. Volatile organic compounds were tested in accordance with Method 25A; results are reported on an as-carbon basis. Formaldehyde emissions were tested in accordance with Method 0011. Nitrogen oxides emissions were measured in accordance with Method 7E. Carbon monoxide emissions were tested in accordance with Method 10.

TABLE 4-9. SUMMARY OF MDF PRESS EMISSION FACTORS FROM REFERENCE 4[a]

Test code	Unit code	Pollutant[b]	Emission control device[c]	Press		Board		Moist. cont., %	Wood species		Adhesive/resin[d]		Wax applic. rate	Emission factor, lb/MSF 3/4	Data rating
				Temp., °F	Cycle, min	Thick, in.	Density, lb/ft^3		Primary	%	Type	Applic. rate			
4	4-1	PM	None	391	NS	0.25	53.8	NS	NS	NS	UF	10.8 gal/min	0.5 gal/min	0.17	A
4	4-1	CPM	None	391	NS	0.25	53.8	NS	NS	NS	UF	10.8 gal/min	0.5 gal/min	0.14	A
4	4-1	VOC	None	396	NS	0.375	51.0	NS	NS	NS	UF	11.7 gal/min	0.5 gal/min	0.26	B
4	4-1	FOR	None	396	NS	0.375	51.0	NS	NS	NS	UF	11.7 gal/min	0.5 gal/min	1.1	B
4	4-1	PM	RTO	391	NS	0.25	53.8	NS	NS	NS	UF	10.8 gal/min	0.5 gal/min	0.040	A
4	4-1	CPM	RTO	391	NS	0.25	53.8	NS	NS	NS	UF	10.8 gal/min	0.5 gal/min	0.016	A
4	4-1	VOC	RTO	396	NS	0.375	51.0	NS	NS	NS	UF	11.7 gal/min	0.5 gal/min	0.019	B
4	4-1	FOR	RTO	396	NS	0.375	51.0	NS	NS	NS	UF	11.7 gal/min	0.5 gal/min	0.0091	B
4	4-1	NO_x	RTO	391	NS	0.25	53.8	NS	NS	NS	UF	10.8 gal/min	0.5 gal/min	0.51	B
4	4-1	CO	RTO	391	NS	0.25	53.8	NS	NS	NS	UF	10.8 gal/min	0.5 gal/min	0.085	B

[a]NS = not specified. Lb/MSF 3/4 = pounds of pollutant per thousand square feet of 3/4-inch thick panel.
[b]Pollutant codes are identified in Table 4-4. Factors for VOC on a carbon basis.
[c]Emission control device: RTO = regenerative thermal oxidizer.
[d]Adhesive/resin type: UF = urea formaldehyde.

Since the emissions from the presses pass through the dryers and are controlled by the same control equipment, it is impossible to develop process-specific emission factors from this data. Because the emission data in this report could not be used to develop source specific emission factors, these emission data are not incorporated into AP-42 Section 10.6.3, and are not addressed further in this background report.

4.2.8 Review of XATEF and SPECIATE Data Base Emission Factors

A search of the XATEF and SPECIATE data bases revealed no emission factors for MDF manufacturing.

4.3 DEVELOPMENT OF CANDIDATE EMISSION FACTORS

As explained previously, Tables 4-1 through 4-8 summarize the data taken from the NCASI data base on emissions from MDF manufacturing. Table 4-9 summarizes the data taken from Reference 4. The candidate emission factors for emissions from MDF dryers are presented in Table 4-10. Table 4-11 includes the candidate emission factors for emissions from MDF batch and continuous presses. Table 4-12 summarizes the candidate factors for emissions from MDF board coolers. Tables 4-10 through 4-12 include the number of tests on which the factors are based, the range of the factors (minimum and maximum values), and the emission factor ratings. Appendix A presents a series of tables that show which data sets were used to develop each of the factors presented in Tables 4-10 through 4-12. The following paragraphs describe the general approach used to develop the emission factors presented in Tables 4-10 through 4-12. After the discussion of the general approach, the factors for individual sources and pollutants are described.

4.3.1 General Approach to Developing Emission Factors

The emission factors were developed by grouping the data by pollutant, control device, and other parameters that could significantly impact emissions. In this study, the parameters for which separate emission factors were developed for MDF dryers are dryer firing type and wood species. Although data were available for other parameters, emission factors are not presented separately for these other parameters because either only a single category was reported or the categories were not exclusive of one another. An example of a parameter for which the categories were not exclusive of one another is wood material form. In some cases, wood material form was reported as shavings, and other dryers used debarked chips, or planer shavings, which also could have been classified as shavings. For MDF presses, emission factors were differentiated only by press type. All press emission data are for presses using UF resins.

Emission data for a blend of 50 percent hardwood and 50 percent softwood species are included in this report. Emission factors for specific mixes of wood species may be calculated by combining emission factors for individual wood species in the ratio specific to a given application, as emission data for those species become available.

In a few cases, the data available for some of the specific emission factors developed included the results of multiple tests on the same emission source. In such cases, the test-specific emission factors for the same source were averaged first, and that average emission factor then was averaged with the factors for the other sources to yield the candidate emission factors for AP-42.

The NCASI data base included the results of several measurements of combined emissions of filterable PM and condensible PM and combined filterable PM-10 and condensible PM. These data were not used to develop separate factors for these combined emissions. However, the separate factors for filterable PM and condensible PM from the AP-42 section may be summed as appropriate to determine a factor for total PM. In addition, factors for VOC emissions are presented in the NCASI data base and in Tables 4-2, 4-

3, 4-5, 4-6, and 4-7 on a carbon basis. However, for the purposes of AP-42, the VOC factors were converted to a propane basis.

The ratings assigned to the candidate emission factors generally are largely a function of the data ratings and the number of data sets upon which the specific factors are based. However, because all the MDF data presented in this report are rated either A or B, emission factor ratings were a function only of the number of data sets for a specific category of emission factor. Factors based on a single data set were rated E. Factors based on 2 or more data sets were rated D. All of the emission factors developed in this report are rated D or E, and are based on no more than four emission tests. In addition, nearly all of the data were from only two of the seven MDF plants for which emissions data were available, providing further reason to rate the resultant emission factors no higher than D. Factors for speciated organics were assigned lower ratings due to the inconsistency and sparsity of the data.

4.3.2 MDF Dryers

The candidate emission factors for MDF dryers are presented in Table 4-10. Generally, dryer emission data were available for the criteria pollutants (with the exception of SO_2 and NO_x). Data were available for uncontrolled emissions only (emissions from the primary product recovery cyclone). Dryer emission data were available for few wood species including pines, softwoods, hardwoods, or a mix of hardwoods and softwoods. Data were available for direct-fired tube dryers and indirect heated tube dryers. Of the 10 MDF dryers for which emission data were available, seven indicated that resin was applied prior to the tube dryer. For the remaining three dryers, information was not available in the data base to indicate when resin was applied. It is assumed for this report that all 10 dryers applied resin prior to the tube dryer. All dryer emission factors are presented in units of pounds per oven-dried ton (lb/ODT).

4.3.2.1 Particulate Matter. For emissions of PM, the data from dryers were grouped by firing type and by wood species. Emission factors were developed for emissions of filterable PM, filterable PM-10, and condensible PM. Although the organic and inorganic fractions of condensible PM were reported in some of the references, most of the condensible PM data are for total condensibles. Therefore, where applicable, the organic and inorganic fractions for individual data sets were combined and only the total condensible PM factors are presented. Appendix A, Table A-1, presents the emission factor calculations for filterable PM, filterable PM-10, and condensible PM emissions from MDF dryers.

4.3.2.2 Volatile Organic Compounds. Data were available for VOC emission factors based on tests performed using Method 25A. The candidate VOC emission factors also were grouped by wood species and generic classifications as was described previously for PM emissions. Appendix A, Table A-1 includes the candidate emission factor calculations for VOC emissions from MDF dryers. Note that for total VOC, the emission factor for formaldehyde (where available) should be added to the VOC emission factor presented. In addition, emission factors for acetone, methylene chloride, and other non-VOC compounds (where available) should be subtracted from the VOC emission factor presented.

4.3.2.3 Carbon Monoxide. All dryer CO emission data were for direct wood-fired tube dryers. All CO dryer emission data were based on tests performed using Method 10. The emission factor calculations for MDF dryer CO emissions are summarized in Appendix A, Table A-1.

TABLE 4-10. SUMMARY OF CANDIDATE EMISSION FACTORS FOR MDF DRYERS

Pollutant[a]	Emission control device[b]	No. of tests	No. of dryers	Wood species	Emission factor, lb/ODT[c] Minimum	Maximum	Average	Rating	Ref.
Direct wood-fired:									
Filterable PM	None	4	4	Unspecified pines[d]	3.1	16	10	D	3
Filterable PM-10	None	4	4	Unspecified pines[d]	0.40	2.7	1.6	D	3
Condensible PM	None	4	4	Unspecified pines[d]	0.34	0.86	0.59	D	3
CO	None	4	4	All species[e]	0.88	6.9	4.0	D	3
VOC[f]	None	1	1	Unspecified pines[d]			6.6	E	3
VOC[g]	None	3	3	Hardwood	6.4	6.7	6.5	D	3
Formaldehyde	None	4	4	Hardwood	0.42	1.3	0.86	E	3
Indirect heat:									
Filterable PM	None	1	1	Unspecified pines[d]			1.4	E	3
VOC[g]	None	2	2	Hardwood	3.6	5.8	4.7	D	3
Formaldehye	None	3	3	Hardwood	0.090	0.26	0.20	E	3
Acetaldehyde	None	2	2	Hardwood	0.0071	0.019	0.013	E	3
Filterable PM	None	1	1	Mixed species[h]			1.5	E	3
Filterable PM-10	None	1	1	Mixed species[h]			0.28	E	3
Condensible PM	None	1	1	Mixed species[h]			0.73	E	3
VOC[j]	None	1	1	Mixed species[h]			2.2	E	3
2,5-dimethyl benzaldehyde	None	1	1	Mixed species[h]			3.8E-04	E	3
Acetaldehyde	None	1	1	Mixed species[h]			0.013	E	3
Acetone	None	2	1	Mixed species[h]	0.0011	0.0040	0.0025	E	3
Acetophenone	None	1	1	Mixed species[h]			2.4E-04	E	3
Acrolein	None	1	1	Mixed species[h]			0.0022	E	3
Alpha pinene	None	2	1	Mixed species[h]	0.0059	0.0065	0.0062	E	3
Alpha terpeneol	None	1	1	Mixed species[h]			0.0022	E	3
Benzaldehyde	None	1	1	Mixed species[h]			0.0026	E	3
Bis-(2-ethylhexyl phthalate)	None	1	1	Mixed species[h]			2.7E-04	E	3
Butylbenzyl phthalate	None	1	1	Mixed species[h]			2.4E-04	E	3
Butylaldehyde	None	1	1	Mixed species[h]			0.0028	E	3
Beta pinene	None	2	1	Mixed species[h]	0.0061	0.0067	0.0064	E	3
Chloromethane	None	1	1	Mixed species[h]			0.0015	E	3
Crotonaldehyde	None	1	1	Mixed species[h]			0.0019	E	3
Di-n-butyl phthalate	None	1	1	Mixed species[h]			1.8E-04	E	3
Formaldehyde	None	1	1	Mixed species[h]			1.4	E	3

TABLE 4-10. (continued)

Pollutant[a]	Emission control device[b]	No. of tests	No. of dryers	Wood species	Emission factor, lb/ODT[c]			Rating	Ref.
					Minimum	Maximum	Average		
Hexaldehyde	None	1	1	Mixed species[h]			0.0026	E	3
Isooctane	None	1	1	Mixed species[h]			6.2E-04	E	3
Isovaleraldehyde	None	1	1	Mixed species[h]			0.0019	E	3
Methyl ethyl ketone	None	1	1	Mixed species[h]			0.0063	E	3
Methylene chloride	None	1	1	Mixed species[h]			0.0029	E	3
Naphthalene	None	1	1	Mixed species[h]			6.6E-04	E	3
n-Hexane	None	1	1	Mixed species[h]			0.0014	E	3
o-Tolualdehyde	None	1	1	Mixed species[h]			7.4E-04	E	3
Phenol	None	1	1	Mixed species[h]			2.0E-04	E	3
Propionaldehyde	None	1	1	Mixed species[h]			0.0011	E	3
p-Cymene	None	3	1	Mixed species[h]	1.4E-04	2.4E-04	1.9E-04	E	3
p-Tolualdehyde	None	1	1	Mixed species[h]			0.0036	E	3
Trichlorofluoro-methane	None	1	1	Mixed species[h]			0.0014	E	3
Valeraldehyde	None	1	1	Mixed species[h]			0.0021	E	3

[a]Factors for VOC on a propane basis.
[b]Cyclones are used as product recovery devices and are not considered to be emission control equipment.
[c]Emission factors in units of pounds per oven-dried ton of wood material out of dryer (lb/ODT).
[d]Unspecified pines = mixed pine species or specific pine species processed not provided.
[e]Average of all available data.
[f]Formaldehyde has not been added, but is suspected to be present, which would increase the VOC value given.
[g]Formaldehyde has been added.
[h]Mixed species = 50 percent hardwood and 50 percent softwood.
[j]Formaldehyde has been added; acetone and methylene chloride have been subtracted.

4.3.2.4 Speciated Organic Compounds. Data were available for speciated organic compound emission factors based on tests performed using Method 0011 and modified Method 5 (semi-VOST). Emission factors were developed for 30 speciated organic compounds. These candidate emission factors were grouped by wood species and dryer firing type. Appendix A, Table A-1 includes the candidate emission factor calculations for speciated organic compound emissions from MDF dryers.

4.3.3 MDF Presses

Table 4-11 includes a summary of the candidate emission factors for MDF presses. Emission factors were developed for emissions of criteria pollutants (except SO_2) and 15 speciated organic compounds. The emission factors are presented in units of pounds of pollutant per thousand square feet of 3/4-inch thick board (lb/MSF 3/4). The factors for MDF presses were developed using the same general methodology as was described in Section 4.3.2 for MDF dryers. The emission factor calculations for MDF presses are summarized in Table A-2 of Appendix A.

Data were available for one test of PM-10 emissions from a batch-type MDF press (Reference 3) processing pines with UF resin, and the emission factor developed from that PM-10 data was 0.23 lb/MSF 3/4. It would be expected that PM-10 emissions would be less than PM emissions from the same source. However, as shown in Table A-2, the PM-10 factor is greater than the PM factor for the same press at the same operating conditions. Therefore, it was concluded that these PM-10 data were not representative, and they were not incorporated in the AP-42 section.

4.3.4 Other MDF Emission Sources

Emission factors also were developed for emissions of filterable PM, filterable PM-10, VOCs, and 14 speciated organic compounds from MDF board coolers. These candidate emission factors are summarized in Table 4-12. The emission factors are presented in units of lb/MSF 3/4. The emission factor calculations for these sources are summarized in Table A-3 of Appendix A.

4.3.5 Cross-Reference of Emission Data References

Table 4-13 presents a cross-referenced list giving reference numbers for sources reviewed in Chapter 4 of this report, and the corresponding reference numbers for those documents subsequently used in the AP-42 section.

TABLE 4-11. SUMMARY OF CANDIDATE EMISSION FACTORS FOR MDF PRESSES

Pollutant[a]	Emission control device[b]	No. of tests	No. of presses	Resin type[c]	Emission factor, lb/MSF 3/4[d]			Rating	Ref.
					Minimum	Maximum	Average		
Batch press:									
Filterable PM	None	2	2	UF	0.16	0.20	0.18	D	3
Filterable PM-10	None	1	1	UF			0.075	E	3
Condensible PM	None	1	1	UF			0.26	E	3
CO	None	1	1	UF			0.034	E	3
NO_x	None	1	1	UF			0.030	E	3
VOC[e]	None	2	2	UF	0.66	0.72	0.69	D	3
2,5-Dimethyl benzaldehyde	None	1	1	UF			0.0025	E	3
Acetaldehyde	None	1	1	UF			0.0051	E	3
Acetone	None	1	1	UF			0.0031	E	3
Acrolein	None	1	1	UF			0.0012	E	3
Benzaldehyde	None	1	1	UF			0.00055	E	3
Butylaldehyde	None	1	1	UF			0.0024	E	3
Crotonaldehyde	None	1	1	UF			0.0011	E	3
Formaldehyde	None	3	3	UF	0.027	0.56	0.30	D	3
Hexaldehyde	None	1	1	UF			0.0029	E	3
Isovaleraldehyde	None	1	1	UF			0.0014	E	3
Methyl ethyl ketone	None	1	1	UF			0.00059	E	3
o-Tolualdehyde	None	1	1	UF			0.00070	E	3
Propionaldehyde	None	1	1	UF			0.00054	E	3
p-Tolualdehyde	None	1	1	UF			0.0010	E	3
Valeraldehyde	None	1	1	UF			0.0024	E	3
Continuous press:									
Filterable PM	None	1	1	UF			0.17	E	4
Filterable PM	RTO	1	1	UF			0.040	E	4
Condensible PM	None	1	1	UF			0.14	E	4
Condensible PM	RTO	1	1	UF			0.016	E	4
CO	RTO	1	1	UF			0.085	E	4
NO_x	RTO	1	1	UF			0.51	E	4
VOC[e]	None	1	1	UF			1.4	E	4
VOC[e]	RTO	1	1	UF			0.032	E	4
Formaldehyde	None	1	1	UF			1.1	E	4
Formaldehyde	RTO	1	1	UF			0.0091	E	4

[a]Factors for VOC on a propane basis.
[b]Emission control device: RTO = regenerative thermal oxidizer.
[c]UF = urea-formaldehyde.
[d]Emission factors in units of pounds per thousand square feet of 3/4-inch thick panel.
[e]Formaldehyde has been added.

TABLE 4-12. SUMMARY OF CANDIDATE EMISSION FACTORS FOR MDF BOARD COOLERS[a]

Pollutant	No. of tests	No. of units	Resin type[c]	Emission factor, lb/MSF 3/4[b]			Rating	Ref.
				Minimum	Maximum	Average		
Coolers:								
Filterable PM	2	1	UF	0.036	0.071	0.054	E	3
Filterable PM-10	1	1	UF			0.0038	E	3
VOC[d]	1	1	UF			0.20	E	3
2,5-Dimethyl benzaldehyde	1	1	UF			0.00019	E	3
Acetaldehyde	1	1	UF			0.0010	E	3
Acetone	1	1	UF			0.0021	E	3
Acrolein	1	1	UF			0.00022	E	3
Benzaldehyde	1	1	UF			0.000099	E	3
Butylaldehyde	1	1	UF			0.0014	E	3
Crotonaldehyde	1	1	UF			0.00026	E	3
Formaldehyde	1	1	UF			0.11	E	3
Hexaldehyde	1	1	UF			0.00065	E	3
Isovaleraldehyde	1	1	UF			0.00025	E	3
Methyl ethyl ketone	1	1	UF			0.00011	E	3
o-Tolualdehyde	1	1	UF			0.000065	E	3
p-Tolualdehyde	1	1	UF			0.00017	E	3
Valeraldehyde	1	1	UF			0.00048	E	3

[a]Uncontrolled emissions. Factors for VOC on a propane basis.
[b]Emission factors in units of pounds per thousand square feet of 3/4-inch thick panel.
[c]UF = urea-formaldehyde.
[d]Formaldehyde has been added.

TABLE 4-13. CROSS REFERENCED LIST OF REFERENCES

Background Report	AP-42
1[a]	Not used[b]
2[a]	Not used[b]
3	5
4	9
5	Not used
6	Not used
7	Not used

[a]Data included in Background Report Reference 3.
[b]Data included in AP-42 Reference 5.

REFERENCES FOR SECTION 4

1. *Emission Test Results: Particulate, PM-10, Formaldehyde, VOC, CO--Dryer Stacks, Press Vents, Former Stack, and Boiler Stacks--Louisiana-Pacific Corporation, Clayton, Alabama Plant*, prepared for Louisiana-Pacific Corporation, by Industrial and Environmental Analysts, Report No. 192-92-49, May 1992.

2. *Emission Test Report: HAP Emission Testing at Facility B*, EMB Report 92-PAR-02, prepared for U. S. Environmental Protection Agency, Research Triangle Park, NC, May 1993.

3. *Particleboard and Medium Density Fiberboard Air Emission Databases, Technical Bulletin No. 693*, the National Council of the Paper Industry for Air and Stream Improvement, New York, New York, April 1995.

4. *Report of Air Emissions and Inlet Loading Tests for Louisiana-Pacific Corporation Urania MDF Plant*, Urania, Louisiana, January 18 through 21, 1994, prepared by Environmental Monitoring Laboratories, Ridgeland, Mississippi, February 1994.

5. *Certification Report for Continuous Emission Monitoring System Louisiana-Pacific Corporation Oroville Boilers #4 and #5*, prepared for Louisiana-Pacific Corporation, by Carnot, Concord, California, May 1994.

6. *Medium Density Fiberboard Production Line #2 Emission Measurement Evaluation for the Louisiana-Pacific Oroville, California Facility*, prepared for Louisiana-Pacific Corporation, by Science & Engineering Analysis Corporation (SEACOR), Fort Collins, Colorado, August 1994.

7. *Report of Air Emissions Tests for Louisiana-Pacific Corporation Clayton MDF Plant*, Clayton, Alabama, June 6 and 7, 1995, prepared by Environmental Monitoring Laboratories, Ridgeland, Mississippi, July 1994.

5. PROPOSED AP-42 SECTION

The proposed AP-42 Section 10.6.3, Medium Density Fiberboard Manufacturing, is presented on the following pages as it would appear in the document.