Emission Factor Documentation for AP-42
Section 10.5

Plywood Manufacturing

Final Report

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

EPA Contract 68-D2-0159
Work Assignment No. IV-05

MRI Project No. 4604-05

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Research Triangle Park, NC 27711

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NOTICE

The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under Contract No. 68-D2-0159 to Midwest Research Institute. It has been reviewed by the Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, and has been approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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. Mr. Dallas Safriet was the requester of the work.

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September 1997

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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 10.5, Plywood Manufacturing, which replaces Section 10.3, Plywood Veneer and Layout Operations, in previous editions of AP-42.

This background report consists of five sections. Section 1 includes the introduction to the report. Section 2 gives a description of the plywood 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 revised AP-42 section was developed. It includes the review of specific data sets, a description of how candidate emission factors were developed, and a summary of changes to the AP-42 section. Section 5 presents the AP-42 Section 10.5, Plywood Manufacturing.

2. INDUSTRY DESCRIPTION

Plywood is a building material consisting of veneers (thin wood layers or plies) bonded with an adhesive. The outer layers (face and back) surround a core which is usually lumber, veneer, or particleboard. Plywood has many uses, including wall siding, sheathing, roof decking, concrete formboards, floors, and containers.

Plywood mills are classified under Standard Industrial Classification (SIC) code 2435, hardwood veneer plywood, and SIC code 2436, softwood veneer plywood. No other industries are classified under these SIC codes. Emission sources in plywood manufacture are included under the Source Classification Code (SCC) 3-07-007.

2.1 INDUSTRY CHARACTERIZATION[1,2]

According to the *1992 Census of Manufactures*, there were 201 softwood plywood and veneer plants operating in the United States in 1992. There were 168 softwood plywood and veneer plants listed in the *1995 Directory of the Wood Products Industry*. Annual capacity for the plants that reported their capacities in the *1995 Directory of the Wood Products Industry* ranged from 5.6×10^3 to 1.1×10^8 square meters (m^2) (6.0×10^4 to 1.2×10^9 square feet [ft^2]) of plywood or veneer on a 0.95-centimeter (cm) (3/8-inch [in.]) basis. The leading production states in 1992 were Oregon, Louisiana, Texas, and Arkansas. Their combined production was about 60 percent of the total.

According to the *1992 Census of Manufactures*, there were 318 hardwood plywood and veneer plants operating in the United States in 1992. There were 191 hardwood plywood and veneer plants listed in the *1995 Directory of the Wood Products Industry*. Annual capacity for the plants that reported their capacities in the *1995 Directory of the Wood Products Industry* ranged from 1.1×10^5 to 7.4×10^7 m^2 (1.2×10^6 to 8.0×10^8 ft^2) of plywood or veneer on an unspecified basis. The leading production states in 1992 were Oregon, North Carolina, California, and Indiana. Their combined production was about 48 percent of the total.

2.2 PROCESS DESCRIPTION[3-5,13]

The manufacture of plywood consists of seven main processes: log debarking and bucking, heating the logs, peeling the logs into veneers, drying the veneers, gluing the veneers together, pressing the veneers in a hot press, and finishing processes such as sanding and trimming. Figure 2-1 provides a generic process flow diagram for a plywood mill.

The initial step of debarking is accomplished by feeding logs through one of several types of debarking machines. The purpose of this operation is to remove the outer bark of the tree without substantially damaging the wood. Although the different types of machines function somewhat differently, emissions from the different machines are expected to be comparable. After the bark is removed, the logs are cut to appropriate lengths in a step known as bucking.

The logs (now referred to as blocks) then are heated to improve the cutting action of the veneer lathe or slicer, thereby generating a product from the lathe or slicer with better surface finish. Blocks are heated to around 93°C (200°F) using a variety of methods--hot water baths, steam heat, hot water spray, or a combination of the three.

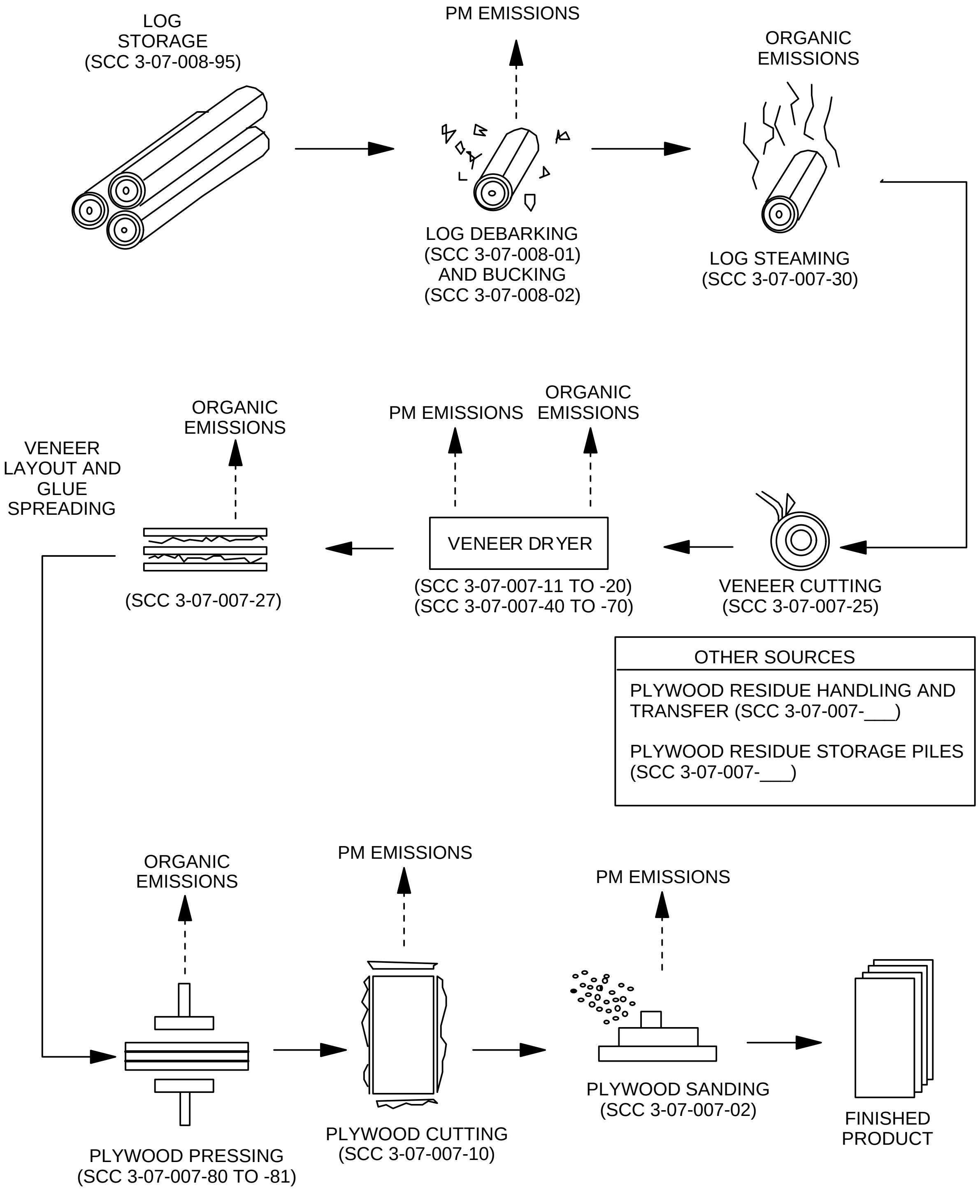

Figure 2-1. Generic process flow diagram for a plywood mill.
(SCC = Source Classification Code)

After heating, the logs are processed to generate veneer. For most applications, a veneer lathe is used, but some decorative, high quality veneer is generated with a veneer slicer. The slicer and veneer lathe both work on the same principle; the wood is compressed with a nosebar while the veneer knife cuts the blocks into veneers that are typically 3 mm (1/8 in.) thick. These pieces are then clipped to a useable width, typically 1.37 m (54 in.), to allow for shrinkage and trim.

Veneers are taken from the clipper to a veneer dryer where they are dried to moisture contents that range from less than 1 to 15 percent. Target moisture contents depend on the type of resin used in subsequent gluing steps. The typical drying temperature ranges from 150° to 200°C (300° to 400°F). The veneer dryer may be a longitudinal dryer, which circulates air parallel to the veneer, or a jet dryer. The jet dryers direct hot, high velocity air at the surface of the veneers in order to create a more turbulent flow of air. The increased turbulence provides more effective use of dryer energy, thereby reducing drying time. In direct-heated wood-fired dryers, the combustion gases are blended with recirculated exhaust from the dryer to reduce the combustion gas temperature. In such cases, the gases entering the dryer generally are maintained in the range of 316° to 427°C (600° to 800°F).

When the veneers have been dried to their specified moisture content, they are glued together with a thermosetting resin. The two main types of resins are phenol-formaldehyde, which is used for softwood and exterior grades of hardwood, and urea-formaldehyde, which is used to glue interior grades of hardwood. The resins are applied by glue spreaders, curtain coaters, or spray systems. Spreaders have a series of rubber-covered grooved application rolls that apply the resin to the sheet of veneer. Generally, resin is spread on two sides of one ply of veneer, which is then placed between two plies of unspread veneer.

Assembly of the plywood panels must be symmetrical on either side of a neutral center in order to avoid excessive warpage. For example, a five-ply panel would be laid up in the following manner. A back, with the grain direction parallel to the long axis of the panel, is placed on the assembly table. The next veneer has a grain direction perpendicular to that of the back, and is spread with resin on both sides. Then, the center is placed, with no resin, and with the grain perpendicular to the previous veneer (parallel with the back). The fourth veneer has a grain perpendicular to the previous veneer (parallel with the short axis of the panel) and is spread with resin on both sides. The final, face, veneer with no resin is placed like the back with the grain parallel to the long axis of the plywood panel.

The laid-up assembly of veneers then is sent to a hot press in which it is consolidated under heat and pressure. Hot pressing has two main objectives: (1) to press the glue into a thin layer over each sheet of veneer; and (2) to activate the thermosetting resins. Typical press temperatures range from 132° to 165°C (270° to 330°F) for softwood plywood, and 107° to 135°C (225° to 275°F) for hardwood plywood, while press times range from 2 to 7 minutes. The time and temperature vary depending on the wood species used, the resin used, and the press design.

The plywood then is taken to a finishing process where edges are trimmed; the face and back may or may not be sanded smooth. The type of finishing depends on the end product desired.

2.3 EMISSIONS[4-14]

The primary emissions from the manufacture of plywood include filterable particulate matter (PM) and PM less than 10 micrometers in aerodynamic diameter (PM-10) from log debarking and bucking, and plywood cutting and sanding; filterable and condensible PM/PM-10 from drying and pressing; organic compounds from steaming and drying operations; and organic compounds, including formaldehyde and other hazardous air pollutants (HAPs), from gluing and hot pressing. Emissions of HAPs from veneer drying that originate from the wood material are unlikely. However, trace amounts of combustion by-products, some of which are HAPs (e.g., aldehydes), may be present in direct-fired veneer dryer exhausts as a result of fossil fuel or wood combustion gases being passed through the dryer. Fuel combustion for material drying also can generate carbon monoxide (CO), carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxide (NO_x) emissions.

The main source of emissions is the veneer dryer, which emits significant quantities of organic compounds. The quantity and type of organic compounds emitted varies depending on the wood species, the dryer type, and its method of operation. The two discernible fractions released from the dryer are condensibles and volatiles. The condensible organic compounds consist largely of sesqui-terpenes, resin acids, fatty acids, and alcohols. As these condensible compounds cool after being emitted from the stack, they often combine with water vapor to form aerosols, which can cause a blue haze. The other fraction, volatile organic compounds (VOCs), comprises terpenes along with small quantities of volatile combustion by-products where direct-fired dryers are used.

The hot pressing operation is also a source of organic emissions. The quantity and composition of emissions from this operation are expected to vary with wood species and resin components. However, for hot presses few test data are available to characterize this variability.

Significant quantities of sawdust and other small wood particles are generated by plywood cutting and sanding operations. Sanders and trim saws typically have control devices to recover the material for use as a fuel in the dryer or boiler. However, small amounts of PM may be released from cutting and sanding. Log debarking, log sawing, and sawdust handling are additional sources of PM emissions. Emissions from such woodworking and waste collection operations are discussed in AP-42 Section 10.1. Finally, fugitive PM emissions are generated from open dust sources such as sawdust storage and vehicular traffic. Emissions from these operations are discussed in more detail in AP-42 Chapter 13.

2.4 EMISSION CONTROL TECHNOLOGY[4-17]

Particulate matter and PM-10 emissions from log debarking, sawing, sanding, and material handling 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.

Methods of controlling PM emissions from the veneer dryer include multiple spray chambers, a packed tower combined with a cyclonic collector, a sand filter scrubber, an ionizing wet scrubber (IWS), an electrified filter bed (EFB), and a wet electrostatic precipitator (WESP). The first three devices are older technologies that are being replaced with newer technologies that combine electrostatic processes with other scrubbing or filtration processes. Wet PM controls, such as IWS and WESP systems also may reduce VOC emissions from veneer dryers, but to a lesser extent than PM emissions are reduced by such systems.

In multiple spray chamber systems, the dryer exhaust is routed through a series of chambers in which water is used to capture pollutants. The water is then separated from the exhaust stream in a demisting zone. Multiple spray chambers are the most common control technology used on veneer dryers today. However, because they provide only limited removal of PM, PM-10, and condensible organic emissions, they are being replaced with newer, more effective techniques. The packed tower/cyclonic collector comprises a spray chamber, a cyclonic collector, and a packed tower in series. Applications of this system are also limited as newer, more efficient controls are applied. The sand filter scrubber incorporates a wet scrubbing section followed by a wet-sand filter and mist eliminator. The larger PM is removed in the scrubber, while a portion of the remaining organic material is collected in the filter bed or the mist eliminator. This scrubbing system is also becoming obsolete as newer, more efficient controls are applied.

Three newer technologies for controlling veneer dryer emissions are the IWS, the EFB, and the WESP. Because applications of these systems are relatively recent, there are limited data on their performance for veneer dryer emission control. The IWS combines electrostatic forces with packed bed scrubbing techniques to remove pollutants from the exhaust stream. The EFB uses electrostatic forces to attract pollutants to an electrically charged gravel bed. The WESP uses electrostatic forces to attract pollutants to either a charged metal plate or a charged metal tube. The collecting surfaces are continually rinsed with water to wash away the pollutants.

Little information is available on control devices for plywood pressing operations, as these operations are generally uncontrolled. However, one test report indicates that hot press emissions at one facility are captured by a large hood placed over and around the hot press and cooling station. The captured emissions are ducted to a packed-bed caustic scrubber. Formaldehyde collected in the scrubber is converted to sodium formate and discharged to the sewer.

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.

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. Industry experience 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. oriented strandboard 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.

Other potential control technologies for plywood veneer dryers and presses include exhaust gas recycle, regenerative catalytic oxidation (RCO), absorption systems (scrubbers), and adsorption systems.

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.

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3. GENERAL DATA REVIEW AND ANALYSIS PROCEDURES

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 AP-42 background files located in the Emission Factor and Inventory Group (EFIG) were reviewed for information on the industry, processes, and emissions. 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 *1992 Census of Manufactures*, and 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 plywood manufacturing industry. The EPA library was searched for additional test reports. Publications lists from the Office of Research and Development (ORD) and Control Technology Center (CTC) were also searched for reports on emissions from the plywood manufacturing industry. In addition, the National Council of the Paper Industry for Air and Stream Improvement (NCASI) and representative trade associations, including the American Forest and Paper Association (AFPA), and the American Plywood Association (APA), 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., one-page reports were generally rejected).

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

3.2 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 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/or 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/or 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[2,3]

The primary air pollutants of concern from the manufacture of plywood 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. 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 plywood veneer 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 plywood industry are EPA Method 17 for total PM, EPA Methods 201 and 201A for PM-10, EPA Method 202 for condensible PM, Oregon Department of Environmental Quality Method 8 (ODEQ-8) for filterable PM, and the Oregon Department of Environmental Quality Method 7 (ODEQ-7) for both filterable PM and condensible 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 ± 14°C [250 ± 25°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.

The other two methods that have been used to collect total PM emissions from wood products industry operations, EPA Method 17 and ODEQ-7, encompass the same principles as EPA Method 5 but have specific modifications. The primary difference between EPA Methods 5 and 17 is in the collection temperature for the front half 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 Method 17 train employs an in-stack filter, so the collection temperature is equal to the actual temperature of the stack gas. If the stack gas temperature is less than 120°C (250°F), then any material that condenses at temperatures between the stack gas temperature and 120°C (250°F) will be measured as filterable PM with Method 17. 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 measures are reversed if the stack gas temperature is greater than 120°C (250°F).

The ODEQ-7 method modifies EPA Method 5 by adding a filter between the third and fourth impingers to collect any condensed material that escapes the impingers. This filter is maintained at approximately ambient temperature, and the material collected in the first three impingers and on the second filter are added to the front-half catch to obtain total PM. This procedure is intended to measure those constituents in the emissions responsible for the formation of PM once the emissions have cooled to ambient temperature.

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), then 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 volatile organic compound emission estimates from plywood veneer 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 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 often used to bond plywood products are formaldehyde-based, the exhaust gases from the presses and from drying operations 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 plywood 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. Although no data on PM-10 emissions from plywood veneer dryers and presses were included in this revision to AP-42, these issues are a general concern in the wood products industry and should be considered in the planning of emission test programs for the industry. The paragraphs below first discuss the characteristics of the organic material in wood products exhaust streams and then address the general issues outlined above.

3.5.1 Organic Emissions from Dryers and Presses

As green wood is subjected to heat in plywood veneer 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 exhaust streams from plywood veneer dryers complicate measurement of PM-10 emissions in these streams. This problem is most prevalent for facilities that have wet control devices such as wet ESP's 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 contains 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 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.

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

In summary, plywood source characteristics and differences in test methods used for collecting the historical test data make it difficult to combine the available data to obtain average emission factors. Consequently, engineering judgment was used to combine the data and develop average emission factors.

Several general conclusions can be made regarding the measurement of PM-10 and VOC emissions for these 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.

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. REVIEW OF SPECIFIC DATA SETS

4.1 INTRODUCTION

The AP-42 section is a revised section addressing plywood manufacture. This revision is based on information gathered from references cited and includes an industry description and emission factors for veneer dryers.

4.2 REVIEW OF SPECIFIC DATA SETS

A total of 15 references were reviewed in the process of revising the section on plywood manufacturing. References 1, 2, 3, 5, and 15 are emission test reports. Reference 4 is the National Council of the Paper Industry for Air and Stream Improvement (NCASI) Technical Bulletin No. 450. References 6 through 13 are various documents cited in support of text sections. Reference 14 is the NCASI Technical Bulletin No. 694 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 air emission tests performed January 12-15, 1981, and March 2-6, 1981, on the No. 1 veneer dryer stack at the Georgia-Pacific Corporation plywood mill located in Whiteville, North Carolina. The report contains no production data for the veneer dryer, therefore no emission factors could be developed from the emission rates reported. Because this report does not contain sufficient data to evaluate the source operating conditions during the test and no emission factors could be developed, these emission data are not incorporated into AP-42 Section 10.5, and are not addressed further in this background report.

4.2.2 Reference 2

Woodtech, Inc. conducted stack tests of wood-fired boilers No. 1 and No. 2, the veneer dryer, and the hot press to determine the representative emissions for these sources in accordance with its operating permit. Emissions from both the veneer dryer and the hot press were measured for TOC and formaldehyde. Emissions from the steam-heated tunnel dryer were sampled at the stack. No control device was indicated. The wood species being dried was poplar. The hot press is hooded and the emissions are controlled by a packed-bed caustic scrubber. Both the inlet and outlet of the scrubber were tested for TOC and formaldehyde.

Method 25A was used to measure TOC concentration. The data from the FID were reduced based on the response as propane. A modified Method 18 sampling system was used to determine formaldehyde concentrations. Formaldehyde measurements made with Method 18 are questionable, especially when the method has not been subject to a Method 301 validation.

Hot press emissions are captured by a large hood placed over and around the press and cooling station. The capture efficiency of the hood is not specified. The hood is exhausted to the packed-bed caustic scrubber. In the scrubber, any collected formaldehyde is converted to sodium formate and discharged to the sewer. The scrubber has a diameter of 1.5 m (5 ft) and contains 3.7 m (12 ft) of Tellerette packing followed by a chevron blade demister.

A rating of B was assigned to the TOC data due to the limited process description and lack of sampling location detail. A rating of D was assigned to the formaldehyde data due to the questionable test method and the same shortcomings cited above for the TOC data.

4.2.3 Reference 3

In 1981, the Georgia-Pacific (G-P) plywood plant in Springfield, Oregon, was selected by EPA as a site for an emission test program because it is considered to use process and emission technology representative of the industry. The test program was designed to determine the emission rate of PM and condensible and noncondensible organic material emitted from the veneer drying operation. A second objective was to measure the collection efficiency of the G-P scrubber system for condensible and noncondensible organic emissions.

Method 5X tests were performed at the scrubber inlet and outlet for PM and condensible organic emissions. Method 25 was performed simultaneously at the scrubber inlet and outlet for TNMOC.

The Method 5X sampling train is essentially the same as a Method 5 sampling train except that the Greenburg-Smith system is used to determine stack gas moisture content and condensible organic matter and an unheated 6.4 centimeter (cm) (2.5-in) glass fiber filter is inserted between the third and fourth impingers. In addition, before initial use, the impingers and filter assemblies are washed with a chromic acid cleaning solution followed by a thorough tap water rinse and six deionized distilled water and acetone rinses.

Particulate and condensible organic matter was withdrawn isokinetically from the source, in accordance with Method 5. Particulate matter was collected on a glass fiber filter maintained at temperatures of 177°C ± 14°C (350° ± 25°F). Condensed organics were collected in the water-filled Greenburg-Smith impingers at temperatures less than 21°C (70°F). Any condensible inorganic material present in the stack gas should have been collected in these impingers. However, the nature of these emissions suggested that most of the condensible material were organic, and this report treats all back half catch as condensible organic material.

The G-P Springfield plant has four veneer dryers. Each is a steam-heated, multideck unit, with the number of drying zones varying between dryers. Dryers 1, 2, and 3 are longitudinal dryers, with 22, 18, and 18 zones, respectively. Dryer 4 is a 22-zone jet dryer. Each dryer has two exhausts from the heated zones, except dryer 4 which has three exhausts. The nine exhausts are ducted to a common manifold that carries the exhaust to the G-P scrubber system. The G-P scrubber system includes a wet spray zone, six wet cyclones, a packed tower, and a mesh pad entrainment separator.

The scrubber outlet data were considered unratable because outlet emission measurements for filterable PM and TNMOC were greater than inlet measurements, suggesting some difficulty. A rating of C was assigned to the inlet PM data reported. Because this source is known to generate condensible organic emissions, the filterable PM results from a sampling train with a 177°C (350°F) filter temperature may be biased low in comparison with an EPA Method 5 train, which has a filter temperature of 120°C (250°F). The inlet Method 25 TNMOC data are assigned a rating of D because a possibility exists that components and reagents used in the Method 5X sampling train may have caused interferences with the Method 25 samples drawn from the Method 5X train.

4.2.4 Reference 4

This NCASI technical bulletin provides background material on the characteristics of veneer dryer emissions and the objectives of emission control technology currently applied at these sources. It also goes into some depth in describing the principal source test methods (ODEQ-7, Washington State University method, and EPA Method 25) used to characterize VOC emissions from these sources, as well as the capabilities and limitations of each.

Hourly average emission factors for uncontrolled veneer dryer emissions were developed from results of studies conducted during the development of the technical bulletin and from historical data. Emission factor data for total organic emissions and noncondensible organic emissions were derived from NCASI-conducted studies using variations of EPA Method 25. Emission factors for PM and condensible PM were derived from NCASI-conducted studies and historical data produced from measurements with ODEQ-7.

Tables 9, 10, and 11 of the bulletin are summary tables presenting uncontrolled TOC, noncondensible organic compound, and PM and condensible organic compound emission factors developed from the individual mill data presented in Appendix C of the bulletin. These emission factors are segregated by dryer type and by wood species being dried. In many instances, however, the primary source of the data is unclear. In addition, there are several discrepancies between the information in the summary tables presented in the body of the bulletin and the information contained in Appendix C of the bulletin. Because of the uncertainty associated with the summary tables, emission data presented in this background report were taken directly from the mill data given in Appendix C of the bulletin, and rated independently. However, Appendix C of the bulletin does not include the individual mill data on gas-fired veneer dryers. Because the emission factors for gas-fired veneer dryers from Table 11 of the bulletin are for combined PM and condensible PM, and no data are presented with which to separate the filterable and condensible fractions, these data are not presented in this report. The following paragraphs describe the emission results presented in Appendix C of the bulletin.

Mill A: This study compared the results of ODEQ-7 with EPA Method 25 when sampling veneer dryer emissions controlled by a wet scrubber. The source tested was a steam-heated 4-deck, 18-section, 2-zone Coe veneer dryer equipped with a Burley 5-section wet scrubber. Species dried included Douglas fir heartwood, Douglas fir sapwood, white fir, lodgepole pine, and redry, which is wood that is cycled through a dryer a second time for additional drying. The wood species of the redry material was not identified in the report.

The organic emissions following the scrubber were substantially greater than the organic emissions entering the scrubber when redry was being processed. This increase suggests that some dissolved organics were stripped from the scrubber solution and entrained in the exhaust stream when the scrubber inlet stream was lightly loaded.

Data from this mill were assigned a rating of B with the exception of the lodgepole pine data and the uncontrolled redry data. Test methodologies appear to be sound, but this is not an original test report, and raw data sheets and detailed process information are lacking. The lodgepole pine and uncontrolled redry data are rated D because only one test run was conducted.

Mill B: This study was conducted to determine the need for isokinetic sampling and the proportion of organic material caught on an in-stack filter when sampling with EPA Method 25. A veneer dryer was sampled both before and after a sand filter control device with EPA Method 25.

Data from this mill were not incorporated into the revision of AP-42 Section 10.5. No process data were given that would facilitate the conversion of concentration levels into mass emission rates.

Mill C: This test is the same test as was documented in Reference 3.

Mill D: This study was undertaken to investigate the organic compound destruction efficiency of a wood residue-fired Dutch oven boiler using veneer dryer emissions as combustion air. Emission factor data for uncontrolled veneer dryer emissions were also collected. Emissions from two steam-heated 4-deck, single zone dryers were ducted to wood-residue fired Dutch oven boilers to be used as combustion air. Wood species dried included Douglas fir, and a combination of hemlock, Douglas fir, and redry. The boiler combustion air (veneer dryer emissions) and boiler exit gas were sampled with EPA Method 25 preceded by an in-stack filter.

Data from this mill for TNMOC emissions from Douglas fir were assigned a rating of B. Test methodologies appear to be sound, but this is not an original test report and raw data sheets and detailed process information are lacking. The data for TNMOC emissions from a combination of hemlock, Douglas fir, and redry are rated D because only one test run was conducted.

Mill E: This test is the same test as was documented in Reference 5, which is described below.

Mill F: This study was undertaken to determine quantities of PM and condensible organic compounds, and TNMOC in uncontrolled veneer dryer emissions when lodgepole pine was being dried. The dryer sampled was a 2-zone, 6-deck, 16-section, steam-heated dryer with two stacks; one at the green end and one at the dry end. An ODEQ-7 train modified to operate with an 88°C (190°F) front filter temperature was used to gather information on particulate and condensible organics. The wet end stack was sampled first and the dry end stack was sampled an hour later. Only one test run was conducted. The wet end result plus the dry end result gives the total PM and condensible organic emission rates for the dryer. To determine TNMOC concentrations, a pair of EPA Method 25 trains were connected to the ODEQ-7 train following the 88°C (190°F) filter. Two test runs for TNMOC were conducted at each stack. Again, the green end result plus the dry end result yields the total emission rate for the dryer.

The TNMOC data from this mill were assigned a rating of B with the exception of uncontrolled TNMOC from drying hemlock. Test methodologies appear to be sound, but this appendix is not an original test report, and raw data sheets and detailed process information are lacking. The ODEQ-7 PM and condensible organics data are rated D because only one run was conducted.

Mill G: The primary goal of this study was to determine a TNMOC emission factor using EPA Method 25. In conjunction with this work, PM samples were taken using an ODEQ-7 train that allowed Method 25 samples to be drawn after the front filter via a slipstream. The front filter temperature was varied in order to determine the effect this parameter had on the amount of organics measured as "particulate material" (front half Method 5 catch) and the amount measured as TNMOC. The mill tested contained three 4-deck, steam-heated Coe jet dryers. Dryer No. 1 was a 24-section, 3-zone unit; No. 2 was a 20-section, 3-zone unit; and No. 3 was a 12-section, 2-zone unit. The mill's feedstock was loblolly pine and shortleaf pine.

The first ODEQ-7 test had an average front filter temperature of 89°C (193°F). The second ODEQ-7 test had an average front filter temperature of 125°C (257°F). The front half catch with the 88°C (190°F) filter was 39.4 percent of the total, while the front half catch at 121°C (250°F) was only 11.2 percent of the total. Only the green end stack (stack No. 1) on dryer No. 1 was sampled using ODEQ-7. This dryer has three additional stacks at the dry end that were not sampled with ODEQ-7 and for which volumetric flow rates are not available. Thus, the ODEQ-7 data are not usable for developing emission factors.

Two Method 25 test runs were conducted on all four dryer stacks for dryer No. 1. During the first test run, veneer that had been peeled up to 24 hours before being dried was used. Freshly peeled veneer was dried during the second test run. Total organic compound emission rates expressed as lb/MSF were somewhat higher when freshly peeled veneer was being dried.

The TNMOC data from this mill were assigned a rating of B. Test methodologies appear to be sound, but this appendix is not an original test report, and raw data sheets and detailed process information are lacking.

Mill H: The objective of this study was to determine typical TNMOC emissions from the drying of southern wood species using EPA Method 25. This mill operated three 4-deck, steam-heated Coe jet dryers. Dryer No. 1 was a 26-section, 3-zone unit; No. 2 was a 20-section, 3-zone unit; and No. 3 was a 14-section, 2-zone unit. The mill's feedstock was loblolly pine and shortleaf pine. Results from two successful tests were reported. Results from a third test were discarded because analytical difficulties were indicated.

Data from this mill were assigned a rating of B. Test methodologies appear to be sound, but this appendix is not an original test report, and raw data sheets and detailed process information are lacking.

Mill I: The objective of this study was to determine the amount of organic compounds and PM in emissions from a wood-residue fired, direct-heated veneer dryer while drying white fir and hemlock. The dryer sampled was a 6-deck, 17-zone, 2-section longitudinal dryer with two cooling sections. The fuel cell is direct-heated with wood residue. Hemlock, or a mixture of hemlock and white fir were dried during these tests.

Total nonmethane organic compound emissions were measured with EPA Method 25 preceded by an in-stack filter. Condensible organic compounds were measured with an ODEQ-7 sampling train. Emissions of TNMOC also were measured with EPA Method 25 preceded by an 88°C (190°F) filter.

Data from this mill were assigned a rating of B with the exception of uncontrolled TNMOC from drying hemlock. Test methodologies appear to be sound, but this appendix is not an original test report, and raw data sheets and detailed process information are lacking. The uncontrolled data for TNMOC from drying hemlock are rated D because only one test run was conducted.

Mill J: A wood-residue fired, direct-heated veneer dryer with emissions controlled by an IWS was sampled to determine its efficiency of organic compound and PM removal. Additional information on TOC, condensible organic, and total PM and condensible organic emission factors from uncontrolled wood-residue fired, direct-heated dryers was also collected. This mill operated three dryers. Dryer 1 was a 6-deck, 11-section, single zone Prentice dryer. Dryer 2 was a 6-deck, 14-section, single zone Moor dryer. Dryer 3 was a 6-deck, 12-section, single-zone Moor dryer with a sealing section on the feed end. Heat to the three dryers was supplied by a central fuel cell. The exhausts from the dryers were returned to a central blend box, and the excess was vented to the scrubber. The effect of this exhaust gas recirculation on the characteristics of VOC, PM, and CO in the dryer exhaust is uncertain. Dryers 1 and 2 processed Douglas fir during all the tests. Dryer 3 processed white fir during the first three tests and Douglas fir during the fourth test.

Samples were taken at the inlet and outlet of the Ceilcote IWS using ODEQ-7. Samples were taken with EPA Method 25 preceded by a filter maintained at 88°C (190°F) at the inlet and outlet of the scrubber.

The samples were drawn anisokinetically. Carbon monoxide data were also reported, although the method used to make the CO determination was not indicated.

The organic data for this mill were assigned a rating of B with the exception of the one-run data, which were rated D. Test methodologies appear to be sound, but this appendix is not an original test report, and raw data sheets and detailed process information are lacking. The CO data for this mill were assigned a rating of D because the test method is not specified, and because this appendix is not an original test report, and raw data sheets and detailed process information are lacking.

Mill K: A wood-residue, direct-fired veneer dryer was sampled with EPA Method 25 for TNMOC to determine emission factors for drying Douglas fir veneer in this type of dryer, and the fate of organic compounds in the dryer emissions when passed through the blend box where hot combustion gases are cooled. The dryer tested was an 18-section, 2-zone, 6-deck longitudinal unit. A wood-residue fired fuel cell supplied heat directly to the dryer. Hot combustion gases from the fuel cell were blended with return air from the dryer exhaust in a blend box to reduce the burner exhaust temperature to approximately 388°C (730°F). Approximately 45 percent of the dryer exhaust was recycled to the blend box. This study indicates that higher molecular weight, condensible organic compounds may be partially broken down to lower molecular weight noncondensible organic compounds when wood-residue direct-fired veneer dryer exhaust is passed through a blend box.

Total organic compound concentrations in the veneer dryer emissions were determined at the dryer exit and in the duct following the blend box. Total gaseous nonmethane organic concentrations were determined with an EPA Method 25 train with its heated filter operated at stack temperatures. Total gaseous nonmethane organics also were determined with an EPA Method 25 train with a filter held at 88°C (190°F). Duplicate simultaneous samples were collected for TNMOC using an Method 25 train with an in-stack filter, and a single sample was collected for TNMOC with the Method 25 train with an 88°C (190°F) filter. Carbon monoxide data were also reported, although the method used to make the CO determination was not indicated.

The organic data for this mill were assigned a rating of D. Test methodologies appear to be sound, but only one run was conducted for each wood type, this appendix is not an original test report, and raw data sheets and detailed process information are lacking. The CO data for this mill were assigned a rating of D because the test method is not specified, this appendix is not an original test report, and raw data sheets and detailed process information are lacking.

4.2.5 Reference 5

In 1981, the Champion plywood plant in Lebanon, Oregon, was selected by EPA as a site for an emission test program because it is considered to use process and emission control technology representative of the industry. The test program was designed to determine the emission rate of PM, condensible, and noncondensible organic material emitted from the veneer drying operation. A second objective was to measure the destruction efficiency of wastewood-fired boilers as incinerators for condensible and noncondensible organic emissions.

Tests were performed at the veneer dryer exhaust duct (boiler inlet) and at the outlet of boiler No. 2, which used veneer dryer exhaust for combustion air. Method 5X tests were performed at the inlet and outlet for PM and condensible organic emissions. Method 25 was performed simultaneously at the boiler inlet and outlet for TNMOC. The Method 5X sampling train is described in detail in Section 4.2.1.2.

The Champion International Lebanon plant has seven veneer dryers, six of which are steam-heated and whose emissions are incinerated in the plant boilers. Dryer No. 7 is heated by hot gases from a fuel cell and is not ducted to the boiler system. All steam-heated dryers except No. 6 are crossflow conventional dryers of 15-section length, except Dryer No. 4, which has 14 sections. Dryer Nos. 1, 2, 3, and 5 are 3-zone, 5-deck models. Dryer No. 4 is 2-zone, 5-deck, while Dryer No. 6 is a single-zone, 6-deck, longitudinal dryer. Dryer No. 7 dries white fir exclusively and the remaining six dryers dry Douglas fir primarily. Douglas fir was the only species dried during the six-dryer testing program.

A rating of C was assigned to the PM data reported. Because this source is known to generate condensible organic emissions, the PM results from a sampling train with a 177°C (350°F) filter temperature may be biased low in comparison with an EPA Method 5 train that has a filter temperature of 120°C (250°F). The Method 25 data are assigned a rating of B due to the lack of good information for conversion into mass emission rates.

4.2.6 References 6, 7, and 8

The existing AP-42 Chapter 10 includes a Section 10.3, Plywood Veneer and Layout Operations, which is the basis for the revised Section 10.5, Plywood Manufacturing.

Two references (References 6 and 7) are cited in support of a table of emission factors for fugitive PM emissions from plywood veneer and layout operations. The first of these two references (Reference 6), which is cited for emission factors for log debarking, log sawing, and sawdust handling, is a secondary reference. The primary reference for the data is an earlier PEDCo report (PEDCo Environmental, Inc., *Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions*, EPA-450/3-77-010, U. S. Environmental Protection Agency, 1977). This document presents industrial process fugitive PM emission data for 24 industrial categories. Emission factors for log debarking and log sawing are estimates based on a material balance of the wood residue produced by the operations and engineering judgement of the amount that becomes airborne. An emission factor for sawdust pile loading, unloading and storage is based on engineering judgement, which is based on observations from plant visits. Because these processes are applicable to practically all wood product manufacturing processes, these emission factors were moved from the existing plywood section to AP-42 Chapter 10, Section 10.1, Lumber and Wood Products Manufacturing and Woodworking Operations.

The second of these two references (Reference 7) is cited as the source for an emission factor for plywood cutting and sanding. This reference, too, is a secondary reference. There is no indication as to the primary source of the data. Only the emission factor is presented; no process data or test methodologies are included. Because this is not an original test report or primary reference, and the value is unrealistically high (99 pounds per thousand square feet), the emission factor was not rated and was not incorporated in the revised AP-42 section.

A single reference (Reference 8) is cited for a table of emission factors for organic emissions from plywood veneer dryers. This report presents the findings of a study undertaken by Washington State University (WSU) that was sponsored by the American Plywood Association and EPA. The objectives of the study included the determination of the physical and chemical nature of the emissions from these dryers during the drying of various veneer species under normal conditions and the evaluation of process differences that might account for the observed differences in visible emissions. Determinations were made of the volatile and condensible hydrocarbon emissions.

Condensible hydrocarbons were sampled by drawing veneer dryer stack gases through an in-stack fritted glass filter followed by an ice-cooled glass condenser with a vacuum pump. A rotameter between the condenser and vacuum pump measured gas flow. The samples collected were dried in a rotary evaporator at 40°C (104°F) under pressure equalling 27 inches of mercury (in. Hg). These dried samples were weighed and prepared for further analysis by gas chromatography and thin layer liquid chromatography.

A later study by the same investigators (F. L. Monroe, *et al*., *An Investigation of Operating Parameters and Emission Rates of Plywood Veneer Dryers, Final Report*, prepared for the Plywood Research Foundation, by Washington State University, Pullman, WA, July 1972) showed that this procedure gave a result that was 54 percent of the result from a simultaneously drawn ODEQ-7 sample. An investigation of the WSU procedure showed sample losses resulted from aerosol escaping the cold trap and from losses during evaporation of the water and solvents during analysis.

Because the emission data developed from the WSU report were severely biased, they were not rated and were not included in the AP-42 section.

4.2.7 References 9 through 13

Five additional references (References 9 through 13) are cited in support of the text subsections presenting general background information and general emission and control information. This information was generally retained with some degree of editorial revision.

4.2.8 Reference 14

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 118 emission tests conducted at nine plywood 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 and other pollutants from plywood veneer dryers. Table 4-1 presents data on dryer design and operating parameters, including dryer type, type of firing, dryer capacity, emission control device, and the hot air source. Table 4-2 summarizes the emission data for plywood veneer 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 4-4 defines the pollutant codes used in Tables 4-1 to Table 4-3 and Table 4-5 to Table 4-7. These pollutant codes match those used in the NCASI data base and throughout this section.

TABLE 4-1. SUMMARY OF PLYWOOD VENEER 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]	Hot air source[f]			
							Primary		Secondary	
							Source	%	Source	%
149-021292A	1D149	PM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-021391A	1D149	PM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-021391B	2D149	PM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-021392A	2D149	PM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-042193A	1D149	PM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-042293A	2D149	PM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
176-052293A	1D176	PM	JET	IHEAT	18.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
176-052293B	XD176	PM	PLAT	IHEAT	5.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
176-052293C	2D176	PM	RFREQ	NA	7.0 MSF 3/8/hr	NONE	RFREQ	100	NS	NA
176-070192D	1D176	PM	JET	IHEAT	18.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
176-070192E	XD176	PM	PLAT	IHEAT	5.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
179-050193B	1D179	PM	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA
179-070192B	1D179	PM	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA
203-041393A	XD203	PM	LFLOW	IHEAT	25.92 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-041593A	YD203	PM	LFLOW	IHEAT	22.7 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-051591A	XD203	PM	LFLOW	IHEAT	25.92 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-051691A	YD203	PM	LFLOW	IHEAT	22.7 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-100592A	YD203	PM	LFLOW	IHEAT	22.7 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-100692A	XD203	PM	LFLOW	IHEAT	25.92 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
149-021292A	1D149	CPM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-021391A	1D149	CPM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-021391B	2D149	CPM	LFLOW	DFIRE	1501 lb/hr	WESP	SUSP BU	100	NS	NA
149-021392A	2D149	CPM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-042193A	1D149	CPM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-042293A	2D149	CPM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
176-052293A	1D176	CPM	JET	IHEAT	18.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
176-052293B	XD176	CPM	PLAT	IHEAT	5.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA

TABLE 4-1. (continued)

Test code	Unit code	Pollutant[b]	Dryer type[c]	Firing type[d]	Dryer capacity	Emission control device[e]	Hot air source[f]			
							Primary		Secondary	
							Source	%	Source	%
176-052293C	2D176	CPM	RFREQ	NA	7.0 MSF 3/8/hr	NONE	RFREQ	100	NS	NA
176-070192D	1D176	CPM	JET	IHEAT	18.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
176-070192E	XD176	CPM	PLAT	IHEAT	5.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
179-050193B	1D179	CPM	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA
179-070192B	1D179	CPM	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA
203-041393A	XD203	CPM	LFLOW	IHEAT	25.92 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-041593A	YD203	CPM	LFLOW	IHEAT	22.7 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-051591A	XD203	CPM	LFLOW	IHEAT	25.92 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-051691A	YD203	CPM	LFLOW	IHEAT	22.7 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-100592A	YD203	CPM	LFLOW	IHEAT	22.7 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-100692A	XD203	CPM	LFLOW	IHEAT	25.92 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
149-021292A	1D149	PM&CPM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-021391A	1D149	PM&CPM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-021391B	2D149	PM&CPM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-021392A	2D149	PM&CPM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-042193A	1D149	PM&CPM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-042293A	2D149	PM&CPM	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
176-052293A	1D176	PM&CPM	JET	IHEAT	18.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
176-052293B	XD176	PM&CPM	PLAT	IHEAT	5.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
176-052293C	2D176	PM&CPM	RFREQ	NA	7.0 MSF 3/8/hr	NONE	RFREQ	100	NS	NA
176-070192D	1D176	PM&CPM	JET	IHEAT	18.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
176-070192E	XD176	PM&CPM	PLAT	IHEAT	5.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
178-081392A	1D178	PM&CPM	JET	IHEAT	NS	WESP	NS	NA	NS	NA
178-101492A	1D178	PM&CPM	JET	IHEAT	NS	WESP	NS	NA	NS	NA
178-120292A	1D178	PM&CPM	JET	IHEAT	NS	WESP	NS	NA	NS	NA
179-050193B	1D179	PM&CPM	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA

TABLE 4-1. (continued)

Test code	Unit code	Pollutant[b]	Dryer type[c]	Firing type[d]	Dryer capacity	Emission control device[e]	Hot air source[f]			
							Primary		Secondary	
							Source	%	Source	%
179-070192B	1D179	PM&CPM	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA
203-041393A	XD203	PM&CPM	LFLOW	IHEAT	25.92 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-041593A	YD203	PM&CPM	LFLOW	IHEAT	22.7 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-051591A	XD203	PM&CPM	LFLOW	IHEAT	25.92 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-051691A	YD203	PM&CPM	LFLOW	IHEAT	22.7 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-100592A	YD203	PM&CPM	LFLOW	IHEAT	22.7 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
203-100692A	XD203	PM&CPM	LFLOW	IHEAT	25.92 MSF 3/8/hr	WESP	IHEAT	100	NS	NA
222-082990A	XD222	PM&CPM	JET	DFIRE	20,000 lb/hr	NONE	DFIRE	100	NS	NA
149-042193B	1D149	CO	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-042293B	2D149	CO	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
176-070192C	1D176	CO	JET	IHEAT	18.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
179-050193C	1D179	CO	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA
179-050193D	2D179	CO	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA
179-070192C	1D179	CO	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA
149-042193B	1D149	NOX	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-042293B	2D149	NOX	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
179-050193C	1D179	NOX	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA
179-050193D	2D179	NOX	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA
179-070192C	1D179	NOX	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA
149-042193B	1D149	VOC	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-042293B	2D149	VOC	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
176-052293A	1D176	VOC	JET	IHEAT	18.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
176-052293B	XD176	VOC	PLAT	IHEAT	5.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
176-052293C	2D176	VOC	RFREQ	NA	7.0 MSF 3/8/hr	NONE	RFREQ	100	NS	NA
176-070192C	1D176	VOC	JET	IHEAT	18.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA
176-070192E	XD176	VOC	PLAT	IHEAT	5.7 MSF 3/8/hr	NONE	IHEAT	100	NS	NA

TABLE 4-1. (continued)

							Hot air source[f]			
							Primary		Secondary	
Test code	Unit code	Pollutant[b]	Dryer type[c]	Firing type[d]	Dryer capacity	Emission control device[e]	Source	%	Source	%
176-070192F	2D176	VOC	RFREQ	NA	7.0 MSF 3/8/hr	NONE	RFREQ	100	NS	NA
179-050193C	1D179	VOC	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA
179-050193D	2D179	VOC	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA
179-070192B	1D179	VOC	LFLOW	DFIRE	NS	NONE	DFIRE	100	NS	NA
149-042193B	1D149	SO2	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA
149-042293B	2D149	SO2	LFLOW	DFIRE	1500 lb/hr	WESP	SUSP BU	100	NS	NA

[a] NS = not specified. NA = not applicable.

[b] Pollutant codes are identified in Table 4-4.

[c] Dryer types: LFLOW = longitudinal flow; JET = jet; PLAT = platen; RFREQ = radio frequency.

[d] Firing types: DFIRE = direct firing; IHEAT = indirect heat.

[e] Emission control devices: WESP = wet electrostatic precipitator.

[f] Hot air sources: SUSP BU = suspension burner; DFIRE = unspecified type of direct firing; IHEAT = unspecified type of indirect heat; RFREQ = radio frequency.

TABLE 4-2. SUMMARY OF EMISSION DATA FOR PLYWOOD VENEER DRYERS 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	Moisture, %	ppm	gr/dscf	Emission rate, lb/hr	Production rate, MSF 3/8/hr	Emission factor, lb/MSF 3/8
149-021292A	1D149	PM	3	OD7	12,996	133	17		0.022	2.45	9.28	0.27
149-021391A	1D149	PM	3	M5	NS	126	14	NS	NS	2.40	15.2	0.16
149-021391B	2D149	PM	3	M5	NS	131	16	NS	NS	2.63	8.6	0.32
149-021392A	2D149	PM	3	OD7	15,208	123	13	NS	0.023	2.95	8.69	0.34
149-042193A	1D149	PM	3	OD7	13,330	136	19	NS	0.020	2.29	8.74	0.26
149-042293A	2D149	PM	3	OD7	15,686	127	15	NS	0.013	1.79	8.78	0.20
176-052293A	1D176	PM	3	M5	NS	NS	NS	NS	NS	3.09	15.6	0.19
176-052293B	XD176	PM	3	M5	NS	NS	NS	NS	0.006	1.40	4.8	0.42
176-052293C	2D176	PM	3	M5	NS	NS	NS	NS	NS	0.03	6.3	0.0050
176-070192D	1D176	PM	3	M5	NS	NS	NS	NS	NS	3.26	12.5	0.28
176-070192E	XD176	PM	2	M5	NS	NS	NS	NS	0.011	3.00	5.9	0.50
179-050193B	1D179	PM	3	M5	7,760	336	34	NS	NS	1.29	15.8	0.082
179-070192B	1D179	PM	3	M5	5,666	329	32	NS	NS	0.99	13.5	0.075
203-041393A	XD203	PM	3	OD7	19,167	156	26	NS	NS	1.80	30.3	0.059
203-041593A	YD203	PM	3	OD7	21,367	151	23	NS	NS	1.31	28.2	0.047
203-051591A	XD203	PM	3	OD7	23,433	147	25	NS	NS	0.87	25.7	0.034
203-051691A	YD203	PM	3	OD7	21,133	144	23	NS	NS	1.07	20.4	0.053
203-100592A	YD203	PM	3	OD7	17,233	150	27	NS	NS	0.50	23.48	0.021
203-100692A	XD203	PM	3	OD7	21,900	150	26	NS	NS	0.50	36.84	0.013
149-021292A	1D149	CPM	3	OD7	12,996	133	17	NS	0.003	0.30	9.28	0.032
149-021391A	1D149	CPM	3	OD7	NS	126	14	NS	NS	0.75	15.2	0.049
149-021391B	2D149	CPM	3	OD7	NS	NS	NS	NS	NS	0.60	8.6	0.069
149-021392A	2D149	CPM	3	OD7	15,208	123	13	NS	0.002	0.32	8.69	0.036
149-042193A	1D149	CPM	3	OD7	13,330	136	19	NS	0.003	0.30	8.74	0.032
149-042293A	2D149	CPM	3	OD7	15,686	127	15	NS	0.003	0.45	8.78	0.051
176-052293A	1D176	CPM	3	M202	NS	NS	NS	NS	NS	2.68	15.6	0.18

TABLE 4-2. (continued)

					Stack gas parameters			Pollutant concentration				
Test code	Unit code	Pollutant[b]	No. of runs	Test method[c]	Flow, dscfm	Temp., °F	Moisture, %	ppm	gr/dscf	Emission rate, lb/hr	Production rate, MSF 3/8/hr	Emission factor, lb/MSF 3/8
176-052293B	XD176	CPM	3	M202	NS	NS	NS	NS	0.006	1.87	4.8	0.39
176-052293C	2D176	CPM	3	M202	NS	NS	NS	NS	NS	0.03	6.3	0.0060
176-070192D	1D176	CPM	3	M202	NS	NS	NS	NS	NS	10.70	12.5	0.88
176-070192E	XD176	CPM	2	M202	NS	NS	14	NS	0.053	15.50	5.866	2.6
179-050193B	1D179	CPM	3	M202	7,760	336	34	NS	NS	4.63	15.8	0.29
179-070192B	1D179	CPM	3	M202	5,666	329	32	NS	NS	7.30	13.5	0.54
203-041393A	XD203	CPM	3	OD7	19,167	156	26	NS	NS	1.20	30.3	0.039
203-041593A	YD203	CPM	3	OD7	21,367	151	23	NS	NS	2.89	28.2	0.10
203-051591A	XD203	CPM	3	OD7	23,433	147	25	NS	NS	1.67	25.7	0.065
203-051691A	YD203	CPM	3	OD7	21,133	144	23	NS	NS	2.37	20.4	0.12
203-100592A	YD203	CPM	3	OD7	17,233	150	27	NS	NS	2.70	23.48	0.11
203-100692A	XD203	CPM	3	OD7	21,900	150	26	NS	NS	1.63	36.84	0.045
149-021292A	1D149	PM&CPM	3	OD7	12,996	133	17	NS	NS	2.77	9.28	0.30
149-021391A	1D149	PM&CPM	3	M5	NS	126	14	NS	NS	3.17	15.2	0.21
149-021391B	2D149	PM&CPM	3	M5	NS	131	16	NS	NS	3.23	8.6	0.39
149-021392A	2D149	PM&CPM	3	OD7	15,208	123	13	NS	NS	3.27	8.69	0.38
149-042193A	1D149	PM&CPM	3	OD7	13,330	136	19	NS	NS	3.08	8.74	0.35
149-042293A	2D149	PM&CPM	3	OD7	15,686	127	15	NS	NS	2.24	8.78	0.26
176-052293A	1D176	PM&CPM	3	M5/202	NS	NS	NS	NS	NS	5.80	15.6	0.37
176-052293B	XD176	PM&CPM	3	M5/202	NS	NS	NS	NS	0.012	3.87	4.8	0.81
176-052293C	2D176	PM&CPM	3	M5/202	NS	NS	NS	NS	NS	0.05	6.3	0.010
176-070192D	1D176	PM&CPM	3	M5/202	NS	NS	NS	NS	NS	13.93	12.5	1.2
176-070192E	XD176	PM&CPM	2	M5/202	NS	NS	NS	NS	NS	18.40	5.9	3.1
178-081392A	1D178	PM&CPM	3	OD7	26,600	152	18	NS	0.010	2.20	14.92	0.15
178-101492A	1D178	PM&CPM	3	OD7	23,900	151	24	NS	0.011	2.23	17.577	0.13
178-120292A	1D178	PM&CPM	3	OD7	25,767	143	21	NS	0.013	2.83	18.016	0.16
179-050193B	1D179	PM&CPM	3	M5/202	7,760	336	34	NS	NS	5.93	15.8	0.38

TABLE 4-2. (continued)

					Stack gas parameters			Pollutant concentration				
Test code	Unit code	Pollutant[b]	No. of runs	Test method[c]	Flow, dscfm	Temp., °F	Moisture, %	ppm	gr/dscf	Emission rate, lb/hr	Production rate, MSF 3/8/hr	Emission factor, lb/MSF 3/8
179-070192B	1D179	PM&CPM	3	M5/202	5,666	329	32	NS	NS	8.30	13.5	0.61
203-041393A	XD203	PM&CPM	3	OD7	19,167	156	26	NS	0.018	3.00	30.3	0.098
203-041593A	YD203	PM&CPM	3	OD7	21,367	151	23	NS	0.023	4.20	28.2	0.15
203-051591A	XD203	PM&CPM	3	OD7	23,433	147	25	NS	0.013	2.53	25.7	0.099
203-051691A	YD203	PM&CPM	3	OD7	21,133	144	23	NS	0.019	3.43	20.4	0.17
203-100592A	YD203	PM&CPM	3	OD7	17,233	150	27	NS	0.022	3.20	23.48	0.14
203-100692A	XD203	PM&CPM	3	OD7	21,900	150	26	NS	0.011	2.13	36.84	0.058
222-082990A	XD222	PM&CPM	1	OD7	29,200	275	16	NS	NS	31.90	16	2.0
149-042193B	1D149	CO	3	M10	13,330	NS	NS	470	NS	27.33	8.16	3.3
149-042293B	2D149	CO	3	M10	15,686	NS	NS	559	NS	38.00	8.78	4.3
176-070192C	1D176	CO	1	M10	NS	NS	NS	NS	NS	0.25	15.5	0.017
179-050193C	1D179	CO	3	M10	7,760	336	34	NS	NS	11.00	15.1	0.73
179-050193D	2D179	CO	3	M10	7,494	NS	NS	NS	NS	47.67	6	7.7
179-070192C	1D179	CO	3	M10	5,666	329	32	NS	NS	5.83	13.9	0.42
149-042193B	1D149	NOX	3	M7E	13,330	NS	NS	18	NS	1.77	8.16	0.22
149-042293B	2D149	NOX	3	M7E	15,686	NS	NS	19	NS	2.16	8.78	0.25
179-050193C	1D179	NOX	3	M7E	7,760	336	34	NS	NS	0.31	15.1	0.020
179-050193D	2D179	NOX	3	M7E	7,494	NS	NS	NS	NS	1.47	6	0.25
179-070192C	1D179	NOX	3	M7E	5,666	329	32	NS	NS	0.06	13.9	0.0041
149-042193B	1D149	VOC	2	M25A	13,330	NS	NS	173	NS	4.31	8.16	0.50
149-042293B	2D149	VOC	2	M25A	15,686	NS	NS	99	NS	2.79	8.78	0.32
176-052293A	1D176	VOC	3	M25A	NS	NS	NS	NS	NS	37.93	15.6	2.4
176-052293B	XD176	VOC	3	M25A	NS	NS	NS	76	NS	5.07	4.8	1.1
176-052293C	2D176	VOC	3	M25A	NS	NS	NS	459	NS	1.03	6.3	0.17
176-070192C	1D176	VOC	3	M25A	NS	NS	NS	NS	NS	38.53	15.5	2.5
176-070192E	XD176	VOC	3	M25A	NS	NS	14	NS	NS	18.73	5.866	3.2
176-070192F	2D176	VOC	2	M25A	NS	NS	NS	611	NS	1.55	8.05	0.20

TABLE 4-2. (continued)

Test code	Unit code	Pollutant[b]	No. of runs	Test method[c]	Stack gas parameters			Pollutant concentration		Emission rate, lb/hr	Production rate, MSF 3/8/hr	Emission factor, lb/MSF 3/8
					Flow, dscfm	Temp., °F	Moisture, %	ppm	gr/dscf			
179-050193C	1D179	VOC	3	M25A	7,760	336	34	NS	NS	27.33	15.1	1.8
179-050193D	2D179	VOC	3	M25A	7,494	NS	NS	NS	NS	16.00	6	2.7
179-070192B	1D179	VOC	3	M25A	5,666	329	32	NS	NS	21.67	13.5	1.6
149-042193B	1D149	SO2	3	MGC	13,330	NS	NS	4	NS	0.57	8.16	0.069
149-042293B	2D149	SO2	3	MGC	15,686	NS	NS	3	NS	0.42	8.78	0.048

[a] NS = not specified.

[b] Pollutant codes are identified in Table 4-4. Factors for VOC on a carbon basis.

[c] Test methods: M5 = EPA Method 5; OD7 = Oregon Department of Environmental Quality (ODEQ) Method 7;M202 = EPA Method 202; M10 = EPA Method 10; M7E = EPA Method 7E; M25A = EPA Method 25A; MGC = Unspecified Gas Chromatographic Method.

TABLE 4-3. SUMMARY OF EMISSION FACTORS FOR PLYWOOD VENEER 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/MSF 3/8	Data rating
					Primary	%	Second.	%	Inlet	Outlet	Inlet	Outlet				
149-021292A	1D149	PM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	850	132	WESP	3	0.27	A
149-021391A	1D149	PM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	880	124	WESP	3	0.16	A
149-021391B	2D149	PM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	880	131	WESP	3	0.32	A
149-021392A	2D149	PM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	850	123	WESP	3	0.34	A
149-042193A	1D149	PM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	880	136	WESP	3	0.26	A
149-042293A	2D149	PM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	825	127	WESP	3	0.20	A
176-052293A	1D176	PM	IHEAT	WREF	PINE SP	100	NONE	NA	NS	12	NS	NS	NONE	3	0.19	A
176-052293B	XD176	PM	IHEAT	WREF	PINE SP	100	NONE	NA	NS	14	NS	NS	NONE	3	0.42	A
176-052293C	2D176	PM	RFREQ	WREF	PINE SP	100	NONE	NA	NS	12	NS	NS	NONE	3	0.0050	A
176-070192D	1D176	PM	IHEAT	WREF	PINE SP	100	NONE	NA	NS	12	NS	NS	NONE	3	0.28	A
176-070192E	XD176	PM	IHEAT	WREF	PINE SP	100	NONE	NA	NS	14	NS	NS	NONE	2	0.50	B
179-050193B	1D179	PM	DFIRE	NGAS	PINE SP	100	NONE	NA	95	5.3	NS	NS	NONE	3	0.082	A
179-070192B	1D179	PM	DFIRE	NGAS	PINE SP	100	NONE	NA	82	5.3	NS	NS	NONE	3	0.075	A
203-041393A	XD203	PM	IHEAT	STEAM	SPRUCE	66	DFIR	33	NS	NS	NS	NS	WESP	3	0.059	A
203-041593A	YD203	PM	IHEAT	STEAM	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.047	A
203-051591A	XD203	PM	IHEAT	STEAM	WFIR	66	DFIR	33	NS	NS	NS	NS	WESP	3	0.034	A
203-051691A	YD203	PM	IHEAT	STEAM	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.053	A
203-100592A	YD203	PM	IHEAT	STEAM	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.021	A
203-100692A	XD203	PM	IHEAT	STEAM	DFIR	33	WFIR	44	NS	NS	NS	NS	WESP	3	0.013	A
149-021292A	1D149	CPM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	850	132	WESP	3	0.032	A
149-021391A	1D149	CPM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	880	124	WESP	3	0.049	A
149-021391B	2D149	CPM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	880	131	WESP	3	0.069	A
149-021392A	2D149	CPM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	850	123	WESP	3	0.036	A
149-042193A	1D149	CPM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	880	136	WESP	3	0.032	A
149-042293A	2D149	CPM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	825	127	WESP	3	0.051	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/MSF 3/8	Data rating
					Primary	%	Second.	%	Inlet	Outlet	Inlet	Outlet				
176-052293A	1D176	CPM	IHEAT	WREF	PINE SP	100	NONE	NA	NS	12	NS	NS	NONE	3	0.18	A
176-052293B	XD176	CPM	IHEAT	WREF	PINE SP	100	NONE	NA	NS	14	NS	NS	NONE	3	0.39	A
176-052293C	2D176	CPM	RFREQ	WREF	PINE SP	100	NONE	NA	NS	12	NS	NS	NONE	3	0.0060	A
176-070192D	1D176	CPM	IHEAT	WREF	PINE SP	100	NONE	NA	NS	12	NS	NS	NONE	3	0.88	A
176-070192E	XD176	CPM	IHEAT	WREF	PINE SP	100	NONE	NA	NS	14	NS	NS	NONE	2	2.6	B
179-050193B	1D179	CPM	DFIRE	NGAS	PINE SP	100	NONE	NA	95	5.3	NS	NS	NONE	3	0.29	A
179-070192B	1D179	CPM	DFIRE	NGAS	PINE SP	100	NONE	NA	82	5.3	NS	NS	NONE	3	0.54	A
203-041393A	XD203	CPM	IHEAT	STEAM	SPRUCE	66	DFIR	33	NS	NS	NS	NS	WESP	3	0.039	A
203-041593A	YD203	CPM	IHEAT	STEAM	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.10	A
203-051591A	XD203	CPM	IHEAT	STEAM	WFIR	66	DFIR	33	NS	NS	NS	NS	WESP	3	0.065	A
203-051691A	YD203	CPM	IHEAT	STEAM	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.12	A
203-100592A	YD203	CPM	IHEAT	STEAM	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.11	A
203-100692A	XD203	CPM	IHEAT	STEAM	DFIR	33	WFIR	44	NS	NS	NS	NS	WESP	3	0.045	A
149-021292A	1D149	PM&CPM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	850	132	WESP	3	0.30	A
149-021391A	1D149	PM&CPM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	880	124	WESP	3	0.21	A
149-021391B	2D149	PM&CPM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	880	131	WESP	3	0.39	A
149-021392A	2D149	PM&CPM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	850	123	WESP	3	0.38	A
149-042193A	1D149	PM&CPM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	880	136	WESP	3	0.35	A
149-042293A	2D149	PM&CPM	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	825	127	WESP	3	0.26	A
176-052293A	1D176	PM&CPM	IHEAT	WREF	PINE SP	100	NONE	NA	NS	12	NS	NS	NONE	3	0.37	A
176-052293B	XD176	PM&CPM	IHEAT	WREF	PINE SP	100	NONE	NA	NS	14	NS	NS	NONE	3	0.81	A
176-052293C	2D176	PM&CPM	RFREQ	WREF	PINE SP	100	NONE	NA	NS	12	NS	NS	NONE	3	0.010	A
176-070192D	1D176	PM&CPM	IHEAT	WREF	PINE SP	100	NONE	NA	NS	12	NS	NS	NONE	3	1.2	A
176-070192E	XD176	PM&CPM	IHEAT	WREF	PINE SP	100	NONE	NA	NS	14	NS	NS	NONE	2	3.1	B
178-081392A	1D178	PM&CPM	IHEAT	STEAM	LODGE P	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.15	A
178-101492A	1D178	PM&CPM	IHEAT	STEAM	POND P	100	NONE	NA	NS	NS	NS	132	WESP	3	0.13	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/MSF 3/8	Data rating
					Primary	%	Second.	%	Inlet	Outlet	Inlet	Outlet				
178-120292A	1D178	PM&CPM	IHEAT	STEAM	LODGE P	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.16	A
179-050193B	1D179	PM&CPM	DFIRE	NGAS	PINE SP	100	NONE	NA	95	5.33	NS	NS	NONE	3	0.38	A
179-070192B	1D179	PM&CPM	DFIRE	NGAS	PINE SP	100	NONE	NA	82	5.3	NS	NS	NONE	3	0.61	A
203-041393A	XD203	PM&CPM	IHEAT	STEAM	SPRUCE	66	DFIR	33	NS	NS	NS	NS	WESP	3	0.098	A
203-041593A	YD203	PM&CPM	IHEAT	STEAM	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.15	A
203-051591A	XD203	PM&CPM	IHEAT	STEAM	WFIR	66	DFIR	33	NS	NS	NS	NS	WESP	3	0.099	A
203-051691A	YD203	PM&CPM	IHEAT	STEAM	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.17	A
203-100592A	YD203	PM&CPM	IHEAT	STEAM	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.14	A
203-100692A	XD203	PM&CPM	IHEAT	STEAM	DFIR	33	WFIR	44	NS	NS	NS	NS	WESP	3	0.058	A
222-082990A	XD222	PM&CPM	DFIRE	WREF	UFIR	100	NONE	NA	NS	NS	410	390	NONE	1	2.0	D
149-042193B	1D149	CO	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	3.3	A
149-042293B	2D149	CO	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	4.3	A
176-070192C	1D176	CO	IHEAT	WREF	PINE SP	100	NONE	NA	NS	12	NS	NS	NONE	1	0.017	D
179-050193C	1D179	CO	DFIRE	NGAS	PINE SP	100	NONE	NA	91	4.57	NS	NS	NONE	3	0.73	A
179-050193D	2D179	CO	DFIRE	WREF	PINE SP	100	NONE	NA	99.33	3.33	NS	NS	NONE	3	7.7	A
179-070192C	1D179	CO	DFIRE	NGAS	PINE SP	100	NONE	NA	82	5.3	NS	NS	NONE	3	0.42	A
149-042193B	1D149	NOX	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.22	A
149-042293B	2D149	NOX	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.25	A
179-050193C	1D179	NOX	DFIRE	NGAS	PINE SP	100	NONE	NA	91	4.57	NS	NS	NONE	3	0.020	A
179-050193D	2D179	NOX	DFIRE	WREF	PINE SP	100	NONE	NA	99.33	3.33	NS	NS	NONE	3	0.25	A
179-070192C	1D179	NOX	DFIRE	NGAS	PINE SP	100	NONE	NA	82	5.3	NS	NS	NONE	3	0.0041	A
149-042193B	1D149	VOC	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	2	0.50	B
149-042293B	2D149	VOC	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	2	0.32	B
176-052293A	1D176	VOC	IHEAT	WREF	PINE SP	100	NONE	NA	NS	12	NS	NS	NONE	3	2.4	A
176-052293B	XD176	VOC	IHEAT	WREF	PINE SP	100	NONE	NA	NS	14	NS	NS	NONE	3	1.1	A
176-052293C	2D176	VOC	RFREQ	WREF	PINE SP	100	NONE	NA	NS	12	NS	NS	NONE	3	0.17	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/MSF 3/8	Data rating
					Primary	%	Second.	%	Inlet	Outlet	Inlet	Outlet				
176-070192C	1D176	VOC	IHEAT	WREF	PINE SP	100	NONE	NA	NS	12	NS	NS	NONE	3	2.5	A
176-070192E	XD176	VOC	IHEAT	WREF	PINE SP	100	NONE	NA	NS	14	NS	NS	NONE	3	3.2	A
176-070192F	2D176	VOC	RFREQ	WREF	PINE SP	100	NONE	NA	NS	NS	NS	NS	NONE	2	0.20	B
179-050193C	1D179	VOC	DFIRE	NGAS	PINE SP	100	NONE	NA	91	4.57	NS	NS	NONE	3	1.8	A
179-050193D	2D179	VOC	DFIRE	WREF	PINE SP	100	NONE	NA	99.33	3.33	NS	NS	NONE	3	2.7	A
179-070192B	1D179	VOC	DFIRE	NGAS	PINE SP	100	NONE	NA	82	5.3	NS	NS	NONE	3	1.6	A
149-042193B	1D149	SO2	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.069	A
149-042293B	2D149	SO2	DFIRE	SDUST	DFIR	100	NONE	NA	NS	NS	NS	NS	WESP	3	0.048	A

[a] NS = not specified. NA = not applicable.

[b] Pollutant codes are identified in Table 4-4. Factors for VOC on a carbon basis.

[c] Firing types: DFIRE = direct firing; IHEAT = indirect heating; RFREQ = radio frequency.

[d] Fuel types: SDUST = sanderdust; WREF = wood refuse; NGAS = natural gas; STEAM = steam.

[e] Wood species: DFIR = douglas fir; PINE SP = unknown pine species; SPRUCE = spruce; WFIR = white fir; POND P = ponderosa pine; LODGE P = lodgepole pine; UFIR = unspecified fir.

[f] Emission control device: WESP = wet electrostatic precipitator.

TABLE 4-4. POLLUTANT CODES

Code	Pollutant
CO	Carbon monoxide
CPM	Condensible PM
FOR	Formaldehyde
NOX	Nitrogen oxides
PM	Filterable PM
SO2	Sulfur dioxide
VOC	Volatile organic compounds

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

Test code	Unit code	Pollutant[b]	Press size		No. of vents	Test method[c]	No. of runs	Stack parameters			Pollutant concentration		Emission rate, lb/hr	Process rate, MSF 3/8/hr	Emission factor, lb/MSF 3/8
			Dim., ft	No. of openings				Flow, dscfm	Temp., °F	Moist., %	ppm	gr/dscf			
176-052293D	1P176	PM	4x8	40	1	M5	3	14,760	NS	NS	NS	0.004	0.51	20.5	0.025
179-050193F	1P179	PM	NS	31	1	M5	3	33	NS	NS	NS	NS	2.97	14.3	0.21
176-052293D	1P176	CPM	4x8	40	1	M202	3	14,760	NS	NS	NS	0.004	0.54	20.5	0.027
179-050193F	1P179	CPM	NS	31	1	M202	3	47,009	NS	NS	NS	NS	1.97	14.3	0.14
176-052293D	1P176	PM&CPM	4x8	40	1	M5/202	3	14,760	NS	NS	NS	0.008	1.03	20.5	0.051
179-050193F	1P179	PM&CPM	NS	31	1	M5/202	3	47,009	NS	NS	NS	NS	4.93	14.3	0.35
176-052293D	1P176	VOC	4x8	40	1	M25A	3	14,760	NS	NS	103.3	NS	2.87	20.5	0.14
176-070192G	1P176	VOC	4x8	40	1	M25A	2	11,835	NS	NS	49.5	49.5	1.06	20	0.054
179-050193E	1P179	VOC	NS	31	1	M25A	3	45,880	NS	2.13	71.3	NS	6.57	16.5	0.40
179-070192D	1P179	VOC	NS	31	1	M25A	3	43,103	NS	NS	102	NS	8.23	16.966	0.49
213-042291A	1P213	FOR	4x8	NS	3	N3500	3	164,468	91	NS	0.370	NS	0.28	21.55	0.013
213-042291B	2P213	FOR	4x8	NS	1	N3500	3	55,250	95	NS	0.427	NS	0.11	15.79	0.0070

[a] NS = not specified; NA = not applicable.

[b] Pollutant codes are identified in Table 4-4. Factors for VOC on a carbon basis.

[c] Test methods: M202 = EPA Method 202; M5 = EPA Method 5; M25A = EPA Method 25A; N3500 = NIOSH Method 3500.

TABLE 4-6. PLYWOOD PRESS EMISSION FACTOR SUMMARY FROM NCASI DATA BASE[a]

Test code	Unit code	Pollutant[b]	Press cycle, min	Board thick., in.	Wood species		Adhesive/ resin type	Emission factor, lb/MSF 3/8	Data rating
					Primary[c]	%			
176-052293D	1P176	PM	4.25	3/8	PINE SP	100	PF	0.025	A
179-050193F	1P179	PM	NS	23/32	PINE SP	100	PF	0.21	A
176-052293D	1P176	CPM	4.25	3/8	PINE SP	100	PF	0.027	A
179-050193F	1P179	CPM	NS	23/32	PINE SP	100	PF	0.14	A
176-052293D	1P176	PM&CPM	4.25	3/8	PINE SP	100	PF	0.051	A
179-050193F	1P179	PM&CPM	NS	23/32	PINE SP	100	PF	0.35	A
176-052293D	1P176	VOC	4.25	3/8	PINE SP	100	PF	0.14	A
176-070192G	1P176	VOC	4.25	3/8	PINE SP	100	PF	0.054	B
179-050193E	1P179	VOC	NS	23/32	PINE SP	100	PF	0.40	A
179-070192D	1P179	VOC	NS	15/32	PINE SP	100	PF	0.49	A
213-042291A	1P213	FOR	4.49	15/32	SY PINE	100	PF	0.013	NR
213-042291B	2P213	FOR	4.67	15/32	SY PINE	100	PF	0.0070	NR

[a] NS = not specified; NA = not applicable.

[b] Pollutant codes are identified in Table 4-4. Factors for VOC on a carbon basis.

[c] Wood species: PINE SP = unknown pine species; SY PINE = southern yellow pine.

TABLE 4-7. SUMMARY OF EMISSION FACTORS FOR PLYWOOD MISCELLANEOUS EQUIPMENT FROM NCASI DATA BASE[a]

Test code	Unit code	Pollutant[b]	Description	Wood species[c]	No. of runs	Test method[d]	Stack flow, dscfm	Pollutant concentration, gr/dscf	Emission rate, lb/hr	Production rate	Emission factor, lb/ODT	Data rating
214-080189A	1A214	PM	Planer cyclone	SY PINE	3	OD8	28,300	0.0243	6.157	2.13 ODTH	2.9	NR
214-080189B	2A214	PM	Planer cyclone	SY PINE	3	OD8	22,900	0.0120	2.437	3.72 ODTH	0.66	NR
214-080289A	9Z214	PM	Sawdust cyclone	SY PINE	2	OD8	8,800	0.0010	0.085	2.6 wet tons/hr	0.10	NR
214-080389A	3I214	PM	Chip bin cyclone	SY PINE	3	OD8	3,300	0.0097	0.277	8.85 ODTH	0.030	NR
214-080389B	4I214	PM	Chip bin cyclone	SY PINE	3	OD8	3,100	0.0013	0.05	1.9 ODTH	0.027	NR
214-080489A	5I214	PM	Shavings bin cyclone	SY PINE	3	OD8	1,000	0.0003	0.003	1.02 ODTH	0.0029	NR
214-080589A	2Z214	PM	Chip cyclone	SY PINE	3	OD8	4,800	0.0010	0.01	7.81 wet ton/hr	0.0030	NR
214-080789A	3Z214	PM	Trim cyclone	SY PINE	3	OD8	4,400	0.0063	0.2	3.08 ODTH	0.067	NR
214-080889A	1S214	PM	Sander cyclone	SY PINE	3	OD8	28,933	0.0750	19.27	0.174 ODTH	111	NR
214-080889B	2S214	PM	Sander/saw cyclone	SY PINE	3	OD8	26,300	0.0153	3.607	2.7 ODTH	1.3	NR
214-080889C	2W214	PM	Sawdust cyclone	SY PINE	3	OD8	10,200	0.0057	0.507	0.22 ODTH	2.3	NR
214-080989A	4Z214	PM	Trim cyclone	SY PINE	3	OD8	26,100	0.0020	0.403	1.02 ODTH	0.40	NR
214-080989B	1I214	PM	Hog fuel bin cyclone	SY PINE	3	OD8	26,300	0.0117	2.707	1.34 wet tons/hr	NS	NR
214-080989C	2I214	PM	Hog fuel bin cyclone	SY PINE	3	OD8	12,600	0.0010	0.08	14.07 wet tons/hr	0.011	NR
214-081089A	5Z214	PM	Chip cyclone	SY PINE	3	OD8	9,100	0.0080	0.524	67.9 wet tons/hr	NS	NR
214-081089B	6Z214	PM	Chip cyclone	SY PINE	3	OD8	9,000	0.0006	0.03	71.9 wet tons/hr	NS	NR
214-081089C	7Z214	PM	Chip cyclone	SY PINE	2	OD8	6,100	0.0003	0.01	62.3 wet tons/hr	NS	NR
214-081189A	8Z214	PM	Chip cyclone	SY PINE	3	OD8	9,700	0.0023	0.021	71.9 wet tons/hr	NS	NR

[a] NS = not specified. NR = not rated. Because emission factors are in units of lb/ton of material collected by cyclones and cannot be related to the process rate for the operation served by the cyclones, these factors are not incorporated in the AP-42 section.

[b] Pollutant codes are identified in Table 4-4.

[c] Wood species: SY PINE = Southern yellow pine.

[d] Test method: OD8 = Oregon Department of Environmental Quality (ODEQ) Method 8.

Table 4-5 and Table 4-6 present a summary of the data on plywood presses. Table 4-5 includes press design and operating data and emission test parameters including press size, number of vents, tests 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, wood species, type of resin, pollutant, emission factor, and data rating.

Table 4-7 summarizes the emission data for miscellaneous plywood sources. The table presents for each emission test, the pollutant, number of runs, test method, stack parameters, pollutant concentration, emission rate, production rate, emission factor, and data rating. The emission factors that appear in Table 4-7 are based on tests performed on product recovery cyclones that serve planing, sawing, sanding, and storage operations. The factors are presented in units of pounds of PM emitted from a specific cyclone per ton of material collected by that cyclone. However, because there are no data on the processing rates of the operations that these cyclones served, the reported emission rates cannot be related to the amount of plywood processed during the emission tests. Furthermore, considering the variations in cyclone design and capture efficiency and processing equipment design and operation, any generic emission factors based on these data would be highly suspect. For this reason, the data presented in Table 4-7 were not incorporated into the AP-42 section and are not discussed further in this report.

The quality ratings for the emission data presented in Tables 4-1 to 4-3 and 4-5 to 4-7 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 three or more test runs were assigned a rating of A, two-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.

4.2.9 Reference 15

This report presents the results of air emissions tests performed February 6-8, 1995, on the No. 1 veneer dryer, No. 4 veneer dryer, and press at the Louisiana Pacific Corporation plywood plant located in Urania, Louisiana. The report contains no production data for the veneer dryers or for the press; therefore, no emission factors could be developed from the emission rates reported. Because this report does not contain sufficient data to evaluate the source operating conditions during the test, and no emission factors could be developed, these emission data are not incorporated into AP-42 Section 10.5, and are not addressed further in this background report.

4.2.10 Review of XATEF and SPECIATE Data Base Emission Factors

A search of the XATEF data base revealed no emission factors for plywood manufacturing operations.

The SPECIATE data base includes nine emission profiles for speciated VOC's from plywood veneer dryers. Eight of the nine VOC profiles are based on a 1983 journal article (D. R. Cronn, *et al*., Chemical Characterization of Plywood Veneer Dryer Emissions, *Atmospheric Environment*, 17(2), pp. 201-211, 1983). No process data are included in the article and the sampling and analysis procedures do not appear to be comparable with EPA reference methods. For these reasons, these emission factors have not been incorporated into the draft of AP-42 Section 10.5.

The remaining VOC profile is a surrogate based on an average of all profiles. For that reason, these emission factors have not been incorporated into the draft of AP-42 Section 10.5.

The SPECIATE data base includes nine emission profiles for speciated PM from plywood manufacturing operations. One of these profiles is based on a report written for the Oregon Department of Environmental Quality (R. T. DeCesar, and J. A. Cooper, *Medford Aerosol Characterization Study, Final Report*, prepared for the State of Oregon, Department of Environmental Quality, Portland, OR, February 1981). This report states that veneer dryers contribute to the Medford area TSP and respirable particulate levels, but does not specifically mention any sampling program for these sources. Neither are the results of any testing presented, nor are any specifics regarding the tests (if any), such as test method(s) used, process rate, emission control device, etc. No test reports of veneer dryers are referenced. The report gives only an estimated percent contribution of veneer dryer emissions to total ambient levels of total solid PM and respirable PM in the Medford air quality maintenance area. For this reason, these emission factors have not been incorporated in the draft of AP-42 Section 10.5.

One of the speciated PM profiles is based on a 1979 report that characterizes fine PM emissions from stationary and miscellaneous sources in the California South Coast Air Basin (H. J. Taback, *et al*., *Fine Particle Emissions from Stationary and Miscellaneous Sources in the South Coast Air Basin, Final Report*, prepared for the California Air Resources Board, Sacramento, CA, by KVB, Inc., February 1979). This report states that wood processing contributes to South Coast Air Basin ambient particulate levels, but does not specifically mention any sampling program for these sources. The results of any testing are not presented, nor are any specifics regarding the tests, such as test method(s) used, process rate, emission control device, etc. No test reports of veneer dryers are referenced. The report gives only an estimated percent contribution of wood processing emissions to total ambient levels of particulate matter in the South Coast Air Basin. For this reason, these emission factors have not been incorporated in the draft of AP-42 Section 10.5.

Two of the speciated PM profiles are based on two reports (J. E. Core, *et al*., *Receptor Modeling Source Profile Development for the Pacific Northwest States; The Pacific Northwest Source Profile Library, Volume 2 - Project Final Report*, prepared for the State of Oregon, Department of Environmental Quality, Portland, OR, September 1989; and J. E. Core, *et al*., *Receptor Modeling Source Profile Development for the Pacific Northwest States; The Pacific Northwest Source Profile Library, Volume 3 - Project Final Report*, prepared for the State of Oregon, Department of Environmental Quality, Portland, OR, September 1989). These reports could not be obtained. For that reason, these emission factors have not been incorporated into the draft of AP-42 Section 10.5.

The remaining five speciated PM profiles are surrogates based on averages of all original profiles representing wood products industries. For that reason, these emission factors have not been incorporated into the revised AP-42 Section 10.5.

4.3 DEVELOPMENT OF CANDIDATE EMISSION FACTORS

As explained previously, Tables 4-1 to 4-7 summarize the data taken from the NCASI data base on emissions from plywood manufacturing. Table 4-8 summarizes the plywood veneer dryer data from the other references (References 2 to 5) that also were reviewed in the preparation of this report. Table 4-9 presents a summary of plywood press emission data from emission test reports that were not included in the NCASI data base.

TABLE 4-8. SUMMARY OF EMISSION FACTORS FOR PLYWOOD VENEER DRYERS FROM OTHER REFERENCES[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/MSF 3/8	Data rating
					Primary	%	Second.	%	Inlet	Outlet	Inlet	Outlet				
2	2-1	VOC	IHEAT	NS	POPLAR	100	NA	NA	NS	8	118	148	NONE	3	0.025	B
2	2-1	FOR	IHEAT	NS	POPLAR	100	NA	NA	NS	8	118	148	NONE	3	0.0023	D
3	3-1	PM	IHEAT	NS	DFIR	100	NA	NA	NS	NS	326	348	NONE	3	0.049	C
3	3-1	CPM	IHEAT	NS	DFIR	100	NA	NA	NS	NS	326	348	NONE	3	0.53	C
3	3-1	PM	IHEAT	NS	DFIR	100	NA	NA	NS	NS	326	348	WSCR	3	0.092	NR
3	3-1	CPM	IHEAT	NS	DFIR	100	NA	NA	NS	NS	326	348	WSCR	3	0.43	NR
3	3-1	VOC	IHEAT	NS	DFIR	100	NA	NA	NS	NS	326	348	NONE	3	0.87	D
3	3-1	VOC	IHEAT	NS	DFIR	100	NA	NA	NS	NS	326	348	WSCR	3	1.1	NR
4	4-A	VOC	IHEAT	NS	DFIR	100	NA	NA	NS	NS	NS	NS	NONE	2	1.2	B
4	4-A	VOC	IHEAT	NS	REDRY	100	NA	NA	NS	NS	NS	NS	NONE	1	0.023	D
4	4-A	VOC	IHEAT	NS	LODGE P	100	NA	NA	NS	NS	NS	NS	NONE	1	1.6	D
4	4-D	VOC	IHEAT	NS	HEM	NS	DFIR	NS	NS	NS	NS	NS	NONE	1	0.68	D
4	4-D	VOC	IHEAT	NS	DFIR	100	NA	NA	NS	NS	NS	NS	NONE	2	0.86	B
4	4-F	VOC	IHEAT	NS	LODGE P	100	NA	NA	NS	NS	345	375	NONE	2	1.6	B
4	4-F	PM	IHEAT	NS	LODGE P	100	NA	NA	NS	NS	345	375	NONE	1	0.48	D
4	4-F	CPM	IHEAT	NS	LODGE P	100	NA	NA	NS	NS	345	375	NONE	1	0.32	D
4	4-G	VOC	IHEAT	NS	LOB P	NS	SLEAF P	NS	NS	7	380	380	NONE	2	2.7	B
4	4-H	VOC	IHEAT	NS	LOB P	NS	SLEAF P	NS	NS	7	359	389	NONE	2	2.2	B
4	4-I	VOC	DFIRE	WREF	HEM	100	NA	NA	NS	NS	328	NS	NONE	4	0.58	B
4	4-I	VOC	DFIRE	WREF	HEM	100	NA	NA	NS	NS	328	NS	NONE	1	0.80	D
4	4-I	VOC	DFIRE	WREF	HEM	43	WFIR	57	NS	NS	328	NS	NONE	3	0.41	B
4	4-I	PM	DFIRE	WREF	HEM	54	WFIR	46	NS	NS	328	NS	NONE	2	1.4	B
4	4-I	CPM	DFIRE	WREF	HEM	54	WFIR	46	NS	NS	328	NS	NONE	2	0.39	B
4	4-J	VOC	DFIRE	WREF	DFIR	NS	WFIR	NS	NS	NS	NS	NS	IWS	2	0.50	B
4	4-J	VOC	DFIRE	WREF	DFIR	NS	WFIR	NS	NS	NS	NS	NS	NONE	1	0.51	D
4	4-J	VOC	DFIRE	WREF	DFIR	100	NA	NA	NS	NS	NS	NS	IWS	1	0.98	D
4	4-J	VOC	DFIRE	WREF	DFIR	100	NA	NA	NS	NS	NS	NS	NONE	1	0.90	D
4	4-J	CO	DFIRE	WREF	DFIR	NS	WFIR	NS	NS	NS	NS	NS	NONE	5	9.5	D
4	4-K	VOC	DFIRE	WREF	DFIR-H	100	NA	NA	NS	NS	NS	325	NONE	1	2.4	D

TABLE 4-8. (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/MSF 3/8	Data rating
					Primary	%	Second.	%	Inlet	Outlet	Inlet	Outlet				
4	4-K	VOC	DFIRE	WREF	DFIR-S	100	NA	NA	NS	NS	NS	325	NONE	1	3.9	D
4	4-K	CO	DFIRE	WREF	DFIR-H	100	NA	NA	NS	NS	NS	325	NONE	1	28	D
4	4-K	CO	DFIRE	WREF	DFIR-S	100	NA	NA	NS	NS	NS	325	NONE	1	57	D
5	5-1	PM	IHEAT	NS	DFIR	100	NA	NA	NS	NS	NS	NS	NONE	3	0.090	C
5	5-1	CPM	IHEAT	NS	DFIR	100	NA	NA	NS	NS	NS	NS	NONE	3	1.1	C
5	5-1	VOC	IHEAT	NS	DFIR	100	NA	NA	NS	NS	NS	NS	NONE	3	1.1	B

[a] NS = not specified. NA = not applicable.

[b] Pollutant codes are identified in Table 4-4. Factors for VOC on a carbon basis.

[c] Firing types: DFIRE = direct firing; IHEAT = indirect heating.

[d] Fuel types: WREF = wood refuse.

[e] Wood species: DFIR = Douglas fir; WFIR = white fir; POPLAR = poplar; HEM = hemlock; LODGE P = lodgepole pine; SLEAF P = shortleaf pine; LOB P = loblolly pine; REDRY = redry; DFIR-H = Douglas fir, heartwood; DFIR-S = Douglas fir, sapwood.

[f] Emission control device: IWS = ionizing wet scrubber; WSCR = wet scrubber.

TABLE 4-9. SUMMARY OF PLYWOOD PRESS DESIGN AND EMISSION DATA FROM OTHER REFERENCES[a]

Test code	Unit code	Pollutant[b]	Press		Board		Moist. cont., %	Wood species (c)				Adhesive/ resin		Cat/ Scav.?[d]	Wax applic. rate	Emission factor, lb/MSF 3/8	Data rating
			Temp., °F	Cycle, min	Thick., in.	Density, lb/ft3		Primary	%	Second.	%	Type	Applic. rate				
2	2-1	VOC	237	17.9	1.2	NS	NS	POPLAR	100	NA	NA	UF	NS	Y	NS	0.014	B
2	2-1	FOR	237	17.9	1.2	NS	NS	POPLAR	100	NA	NA	UF	NS	Y	NS	0.0042	D
2	2-1	VOC (e)	237	17.9	1.2	NS	NS	POPLAR	100	NA	NA	UF	NS	Y	NS	0.013	B
2	2-1	FOR (e)	237	17.9	1.2	NS	NS	POPLAR	100	NA	NA	UF	NS	Y	NS	0.0025	D

[a] NS = not specified; NA = not applicable.

[b] Pollutant codes are identified in Table 4-4. Factors for VOC on a carbon basis.

[c] Wood species: POPLAR = poplar.

[d] Cat/Scav.? = Y indicates either a catalyst or formaldehyde scavenger was used; Cat/Scav.? = S indicates a formaldehyde scavenger was used.

[e] Emissions controlled by a packed bed caustic scrubber.

The candidate emission factors for air pollutant emissions from plywood veneer dryers are presented in Table 4-10. Table 4-11 presents the candidate emission factors for plywood presses. Tables 4-10 and 4-11 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. For those emission factors based on five or more emission tests, the factor standard deviations also are presented. 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 and 4-11. The following paragraphs describe the general approach used to develop the emission factors presented in those tables. 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 plywood veneer dryers are control device, 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. For plywood presses, emission factors were differentiated only by resin type and control device.

Emission data for mixed wood species were discarded. Emission factors for specific mixes of wood species may be calculated by combining emission factors for individual wood species as appropriate. For example, an uncontrolled VOC emission factor for a blend of 50 percent pines and 50 percent hemlock for a direct wood-fired veneer dryer can be calculated by combining the uncontrolled VOC emission factor for pines (3.3 lb/MSF 3/8) and hemlock (0.71 lb/MSF 3/8), to get an emission factor of 2.0 lb/MSF 3/8.

For criteria pollutants (i.e., PM, VOC, NO_x, SO_2, and CO), the data were grouped by specific parameters as the data allowed. However, for speciated organic pollutants, the data for a specific pollutant generally were grouped by wood species; the values of the other parameters were not considered. The reason for taking this approach is that the data are so few and show such a wide variability that it is unlikely that the data would demonstrate the effects of specific parameters on emission levels.

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 from 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. 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, and 4-6 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. Factors based on a single data set were rated E. Factors based on 2 to 10 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 seven emission tests. Factors for formaldehyde were assigned a rating of E due to the inconsistency and sparsity of the data.

TABLE 4-10. SUMMARY OF CANDIDATE EMISSION FACTORS FOR PLYWOOD VENEER DRYERS[a]

Pollutant[b]	Emission control device[c]	No. of tests	No. of dryers	Wood species	Fuel type[d]	Type of firing[e]	Emission factor, lb/MSF 3/8[f]			Stan. dev.	Rating	Ref.
							Minimum	Maximum	Average			
Direct wood-fired dryers												
Filterable PM	WESP	6	2	Douglas fir	SDUST	DFIRE	0.16	0.34	0.26		D	14
Condensible PM	WESP	6	2	Douglas fir	SDUST	DFIRE	0.032	0.069	0.045	0.013	D	14
VOC[g]	NONE	1	1	Unspecified pines	WREF	DFIRE			3.3		E	14
VOC[g]	NONE	1	1	Hemlock	WREF	DFIRE			0.70		E	4I
VOC[g]	WESP	2	2	Douglas fir	SDUST	DFIRE	0.39	0.61	0.50		D	14
VOC[g]	IWS	1	1	Unspecified firs	WREF	DFIRE			0.61		E	4J
Sulfur dioxide	NONE	2	2	NA[h]	SDUST	DFIRE	0.048	0.069	0.058		D	14
Nitrogen oxides	NONE	3	3	NA[h]	WREF	DFIRE	0.22	0.25	0.24		D	14
Carbon monoxide	NONE	3	3	NA[h]	WREF	DFIRE	3.3	7.7	5.1		D	14
Direct natural gas-fired dryers												
Filterable PM	NONE	2	1	Unspecified pines	NGAS	DFIRE	0.075	0.082	0.079		E	14
Condensible PM	NONE	2	1	Unspecified pines	NGAS	DFIRE	0.29	0.54	0.42		E	14
VOC[g]	NONE	2	1	Unspecified pines	NGAS	DFIRE	1.9	2.2	2.1		E	14
Nitrogen oxides	NONE	2	1	NA[h]	NGAS	DFIRE	0.0041	0.020	0.012		E	14
Carbon monoxide	NONE	2	1	NA[h]	NGAS	DFIRE	0.42	0.73	0.57		E	14

TABLE 4-10. (continued)

Pollutant[b]	Emission control device[c]	No. of tests	No. of dryers	Wood species	Fuel type[d]	Type of firing[e]	Emission factor, lb/MSF 3/8[f]			Stan. dev.	Rating	Ref.
							Minimum	Maximum	Average			
Indirect heated dryers												
Filterable PM	NONE	4	2	Unspecified pines	WREF	IHEAT	0.19	0.50	0.35		D	14
Filterable PM	NONE	2	2	Douglas fir	NS	IHEAT	0.049	0.090	0.070		D	3,5
Filterable PM	WESP	3	1	Douglas fir	STEAM	IHEAT	0.021	0.053	0.040		E	14
Filterable PM	WESP	1	1	Unspecified firs	STEAM	IHEAT			0.034		E	14
Condensible PM	NONE	4	2	Unspecified pines	WREF	IHEAT	0.18	2.6	1.0		D	14
Condensible PM	NONE	2	2	Douglas fir	NS	IHEAT	0.53	1.1	0.82		D	3,5
Condensible PM	WESP	3	1	Douglas fir	STEAM	IHEAT	0.10	0.12	0.11		E	14
Condensible PM	WESP	1	1	Unspecified firs	STEAM	IHEAT			0.065		E	14
VOC[g]	NONE	7	5	Unspecified pines	NS	IHEAT	1.3	3.9	2.7	0.81	D	4FGH, 14
VOC[g]	NONE	3	3	Douglas fir	NS	IHEAT	1.0	1.5	1.3		D	4AD,5
VOC[j]	NONE	1	1	Poplar	NS	IHEAT			0.033		E	2
Formaldehyde	NONE	1	1	Poplar	NS	IHEAT			0.0023		E	2

TABLE 4-10. (continued)

Pollutant[b]	Emission control device[c]	No. of tests	No. of dryers	Wood species	Fuel type[d]	Type of firing[e]	Emission factor, lb/MSF 3/8[f]			Stan. dev.	Rating	Ref.
							Minimum	Maximum	Average			
Radio frequency heated dryers												
Filterable PM	NONE	1	1	Unspecified pines	WREF	RFREQ			0.0050		E	14
Condensible PM	NONE	1	1	Unspecified pines	WREF	RFREQ			0.0060		E	14
VOC[g]	NONE	2	1	Unspecified pines	WREF	RFREQ	0.20	0.24	0.22		E	14

[a] NS = not specified; NA = not applicable.

[b] Pollutant codes are identified in Table 4-4. Factors for VOC on a propane basis.

[c] Emission control device: WESP = wet electrostatic precipitator; WSCR = wet scrubber; IWS = ionizing wet scrubber.

[d] Fuel types: SDUST = sanderdust; WREF = wood refuse; NGAS = natural gas; STEAM = steam.

[e] Firing types: DFIRE = direct firing; IHEAT = indirect heating; RFREQ = radio frequency.

[f] Emission factors in units of pounds of pollutant per thousand square feet of 3/8-inch thick veneer (lb/MSF 3/8).

[g] Emission factor may not account for formaldehyde, which is suspected to be present; VOC factor indicated is likely to be biased low.

[h] Emissions of this pollutant are not dependent on wood species.

[j] Emission factor calculated as the sum of the factor for VOC and the factor for formaldehyde, based on a separate measurement.

4.3.2 Plywood Veneer Dryers

The candidate emission factors for plywood veneer dryers are presented in Table 4-10. Generally, dryer emission data were available for the criteria pollutants and formaldehyde. Data were available for uncontrolled emissions, as well as emissions controlled with WESPs. One data set was available for VOC controlled with an ionizing wet scrubber (IWS). Dryer emissions data were available for several wood species, including Douglas fir, lodgepole pine, hemlock, and poplar. However, for much of the data the wood species is reported as pines.

4.3.2.1 Particulate Matter. For emissions of PM, the data from dryers were grouped by firing type, by wood species and by control device. Emission factors were developed for emissions of filterable PM 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 and condensible PM emissions from plywood veneer dryers.

4.3.2.2 Volatile Organic Compounds. For emissions of VOC, the data from dryers were grouped by firing type, by wood species, and by control device as described above for PM emissions. Appendix A, Table A-1 summarizes the candidate emission factor calculations for VOC emissions from plywood veneer dryers. Data were available for VOC emission factors based on tests performed using Method 25 and Method 25A. The ranges of the Method 25 and Method 25A VOC data and the available formaldehyde data are summarized in Appendix A, Table A-3. Note that only one uncontrolled VOC emission factor (indirect heated dryers drying pines) uses combined Method 25 and Method 25A data. As can be seen from Table A-3, the Method 25 data fall completely within the range of the Method 25A data. Note that for total VOC, the emission factor for formaldehyde (where available) has been added to the VOC emission factor presented.

4.3.2.3 Carbon Monoxide. The data on emissions of CO were categorized only by dryer firing type. Wood species and control device were not considered to have a significant effect on CO emissions. All veneer dryer CO emission data were based on tests performed using Method 10. The emission factor calculations for plywood veneer dryer CO emissions are summarized in Appendix A, Table A-1.

4.3.2.4 Sulfur Dioxide. The data on emissions of SO_2 were categorized only by dryer firing type. Wood species and control device were not considered to have a significant effect on SO_2 emissions. All veneer dryer SO_2 emission data were for direct wood-fired longitudinal flow dryers drying Douglas fir. All veneer dryer SO_2 emission data were based on tests performed using an unspecified gas chromatographic method. The emission factor calculations for plywood veneer dryer SO_2 emissions are summarized in Appendix A, Table A-1.

4.3.2.5 Nitrogen Oxides. The data on emissions of NO_x were categorized only by dryer firing type. Wood species and control device were not considered to have a significant effect on NO_x emissions. All veneer dryer NO_x emission data were based on tests performed using Method 7E. The emission factor calculations for plywood veneer dryer NO_x emissions are summarized in Appendix A, Table A-1.

4.3.3 Plywood Presses

Table 4-11 includes a summary of the candidate emission factors for plywood presses. Emission factors were developed for emissions of filterable PM, condensible PM, VOC, and formaldehyde. The emission factors are presented in units of pounds of pollutant per thousand square feet of 3/8-inch thick plywood (lb/MSF 3/8). The factors for plywood presses were developed using the same general methodology as was described in Section 4.3.2 for plywood veneer dryers. The emission factor calculations for plywood presses are summarized in Table A-2 of Appendix A.

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

Pollutant[a]	Emission control device[b]	No. of tests	No. of presses	Wood species	Resin type	Emission factor, lb/MSF 3/8[c]			Standard deviation	Rating	Ref.
						Minimum	Maximum	Average			
Filterable PM	NONE	2	2	Pines	PF	0.025	0.21	0.12		D	14
Condensible PM	NONE	2	2	Pines	PF	0.027	0.14	0.083		D	14
VOC[d]	NONE	4	2	Pines	PF	0.066	0.60	0.33		D	14
VOC[e]	NONE	1	1	Poplar	UF			0.021		E	2
VOC[e]	WSCR	1	1	Poplar	UF			0.018		E	2
Formaldehyde	NONE	1	1	Poplar	UF			0.0042		E	2
Formaldehyde	WSCR	1	1	Poplar	UF			0.0025		E	2

[a] Pollutant codes are identified in Table 4-4. Factors for VOC on a propane basis.
[b] Emission control device: WSCR = wet scrubber.
[c] Emission factors in units of pounds of pollutant per thousand square feet of 3/8-inch thick panel (lb/MSF 3/8).
[d] Emission factor may not account for formaldehyde, which is suspected to be present; VOC factor indicated is likely to be biased low.
[e] Emission factor calculated as the sum of the factor for VOC and the factor for formaldehyde, based on a separate measurement.

4.3.4 Cross-Reference of Emission Data References

Table 4-12 presents a cross-referenced list giving reference numbers for sources reviewed in Chapter 4 of the Background Report, and corresponding reference number for those references subsequently used in the AP-42 section.

TABLE 4-12. CROSS-REFERENCED LIST OF EMISSION DATA REFERENCES

Reference No.	
Background Report, Chapter 4	AP-42, Section 10.5
1	Not used
2	12
3	11
4	10
5	14
6	7
7	5
8	2
9	1
10	3
11	4
12	6
13	8
14	19
15	Not Used

REFERENCES FOR SECTION 4

1. P. W. Kalika, *et al*., *Evaluation of Sampling and Analysis Procedures for the Plywood Industry*, prepared for EMB/U. S. Environmental Protection Agency, by TRC Environmental Consultants, Inc., EMB Report 81-PLY-1, February 1982.

2. *Source Test Report--Woodtech, Inc., Bluefield, Virginia*, prepared for Woodtech, Inc., by Environmental Quality Management, Inc., and Pacific Environmental Services, January 1992.

3. *Emission Test Report--Georgia-Pacific Springfield Plant, Springfield, Oregon*, prepared for EMB/U. S. Environmental Protection Agency, by TRC Environmental Consultants, Inc., EMB Report 81-PLY-4, June 1981.

4. *A Study of Organic Compound Emissions from Veneer Dryers and Means for Their Control*, Technical Bulletin No. 405, National Council of the Paper Industry for Air and Stream Improvement, New York, August 1983.

5. *Emission Test Report--Champion International Lebanon Plant, Lebanon, Oregon*, prepared for EMB/U. S. Environmental Protection Agency, by TRC Environmental Consultants, Inc., EMB Report 81-PLY-2, May 1982.

6. *Assessment of Fugitive Particulate Emission Factors for Industrial Processes*, EPA-450/3-78-107, U. S. Environmental Protection Agency, Research Triangle Park, NC, September 1978.

7. *Controlled and Uncontrolled Emission Rates and Applicable Limitations for Eighty Processes*, Second Printing, EPA-340/1-78-004, U. S. Environmental Protection Agency, Research Triangle Park, NC, April 1978.

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9. C. B. Hemming, Plywood, *Kirk-Othmer Encyclopedia of Chemical Technology*, Second Edition, Volume 15, John Wiley & Sons, Inc., New York, 1968, pp. 896-907.

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11. A. Mick, and D. McCargar, *Air Pollution Problems in Plywood, Particleboard, and Hardboard Mills in the Mid-Willamette Valley*, Mid-Willamette Valley Air Pollution Authority, Salem, OR, March 1969.

12. J. A. Danielson, ed., *Air Pollution Engineering Manual*, AP-40, Second Edition, U. S. Environmental Protection Agency, Research Triangle Park, NC, May 1973, pp. 372-374.

13. C. T. Van Decar, Plywood Veneer Dryer Control Device, *Journal of the Air Pollution Control Association*, *22*:968, December 1972.

14. *Oriented Strandboard and Plywood Air Emission Databases, Technical Bulletin No. 694*, The National Council of the Paper Industry for Air and Stream Improvement, New York, NY, April 1995.

15. Report of Air Emissions Tests for Louisiana Pacific Corporation Plywood Plant, Urania, Louisiana, February 6, 7, and 8, 1995, prepared by Environmental Monitoring Laboratories, April 1995.

5. PROPOSED AP-42 SECTION 10.5

The proposed AP-42 Section 10.5, Plywood Manufacturing, is presented in the following pages as it would appear in the document.