HAP Emissions by NCASI 98.01 and 105 from the Drying of Ponderosa Pine and White Wood Lumber

Replaces Report from July 18, 2007

Report to
Hampton Affiliates

Report by

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I. Results Summary

Two charges, containing approximately 73.3 or 80.6 board feet of 2x4 lumber were dried in a small kiln at Oregon State University to less than 15% moisture content. The kiln dry- and wet-bulb temperatures were based on schedules provided by Hampton. The maximum temperature was 170°F (76.6°C) for pine and 190°F (87.7°C) for white wood. The maximum temperatures were reached after 25 and 36 hours, respectively, for the two charges and held for the duration of drying. The maximum wet-bulb temperature was 140°F (60.0°C) for pine and 150°F (65.5°C) for white wood.   These maximums were reached after 25 and 36 hours, respectively, and held for the duration of drying. The air velocity was 750 feet per minute (3.8 m/s). The kiln was indirectly heated with steam. There was no humidification. Regulating the amount of air entering the kiln controlled the humidity.

A JUM VE-7 total hydrocarbon analyzer was used to measure organic emissions following EPA Method 25A. A chilled impinger sampling trains were used to sample for methanol and formaldehyde following NCASI Method 105 and NCASI Method 98.01. The results are shown in Table 1.

TABLE 1. Summary of results.   Both methods for HAP measurement were run simultaneously.

Methods 25A & 98.01	Initial MC %	Time[a] hr:min	VOC[b] lb/mbf	Methanol lb/mbf	Formaldehyde lb/mbf
Ponderosa Pine	82.6	42:00	1.59	0.040	0.0048
White wood	119.2	45:25	1.39	0.090	0.0063

Method 105[c]	Methanol lb/mbf	Form-aldehyde lb/mbf	Acet-aldehyde lb/mbf	Propion-aldehyde lb/mbf	Acrolein lb/mbf
Ponderosa Pine	0.035	0.0027	0.042	0.0019	0.0017
White wood	0.074	0.0045	0.144	0.0044	0.0050

[a] time is to 15% moisture content
[b] as carbon from green to 15% moisture content
[c] phenol was not detected so it is not included in table

II.   Lumber Source and Handling

Ponderosa pine lumber was delivered to Oregon State on June 1 and white wood on June 25. The wood was delivered in a covered vehicle and wrapped in plastic. Upon arrival at OSU the wood was wrapped in plastic and stored at 5°C until used. The charges were dried on June 3-5 and June 27-29, 2007

III.   Kiln Description and Operation

A schematic of the kiln is shown in Figure 1. The kiln box is approximately 4' by 4' by 4'. It is indirectly heated by steam. Four dry-bulb thermocouples and two wet-bulb thermocouples are located on the entering-air side of the load. The dry-bulb thermocouples are spaced in a grid. The two wet-bulb thermocouples are under a single sock at the center of the entering-air side of the load.

Humidity control

A 200 L/min MKS mass flow meter controlled and measured the amount of air entering the kiln. It was factory calibrated and checked using a bubble meter. The amount of air entering the kiln is based on the wet-bulb temperature - if it is above setpoint, the airflow is increased and if it is below setpoint the airflow is decreased. This is analogous to venting for
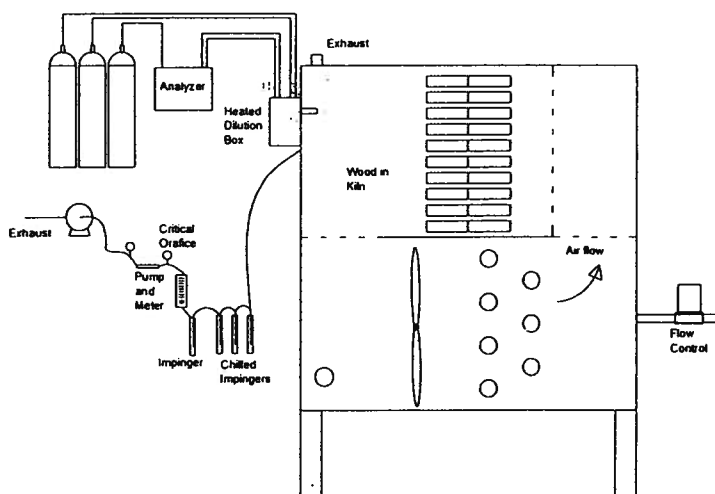
FIGURE 1. Schematic of kiln and sampling system.

a commercial kiln. A minimum of 8-12 L/min entered the kiln at all times, more than removed through the analyzer and impinger trains (< 3.2 L/min combined). Putting air into the kiln at a rate of 100 L/min causes the pressure in the kiln to be 60 to 130 Pa above ambient, depending on location in the kiln (high-pressure or low-pressure side). Thus, any fugitive leakage should be out of the kiln. Two additional flow meters can be manually set to provide additional airflow. One of these was used for small segments of the charges. The steam spray line is disabled, so no water vapor is added to the kiln atmosphere.

Temperature control

Temperature in the kiln is controlled by indirect steam heating. When the average of the four dry-bulb thermocouples is below setpoint, the steam pressure in the coil is increased. When it is above setpoint, steam flow to the coil is reduced.

Schedules

The drying schedules used were based on drying conditions supplied by the mill and are shown in Table 2. The values in Table 2 are based on the entering-air temperature. This represents the highest temperature the wood would experience in a commercial kiln. The actual temperatures in the lab kiln are presented in Figure 2. These compare well with what the mill uses.

Charge Sequence

After removing from the refrigerator and unwrapped, 2" were trimmed from each end of each board to give 44" samples. These were then weighed, placed in the kiln as shown in the photo to the right, and dried according to the one of the schedules in Table 2. Sampling for hydrocarbon and HAPs was done as described in section IV. At the end of drying the wood was weighed, oven dried, and reweighed so initial and final moisture contents could be determined by ASTM D4442 (oven-dry method).
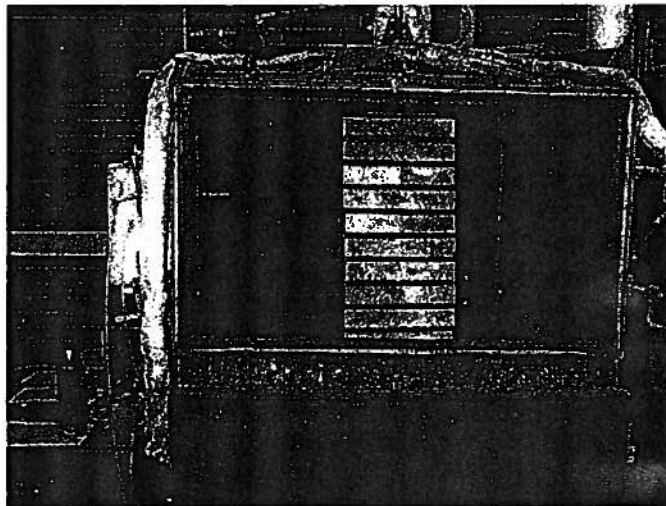
TABLE 2a. Drying schedule used for ponderosa pine. Actual final moisture content was 10.8%.

Step time, hr:min	Ramp time, hr:min	Run time, hr:min	Dry-bulb, °F	Wet-bulb, °F
0	-	-	120	110
1	0	1	120	110
24	24	25	170	140
17	0	42	170	140

TABLE 2b. Drying schedule used for white wood. Actual final moisture content was 9.8%.

Step time, hr:min	Ramp time, hr:min	Run time, hr:min	Dry-bulb, °F	Wet-bulb, °F
0	-	-	130	110
36	38	36	190	150
9:25	0	45:25	190	150
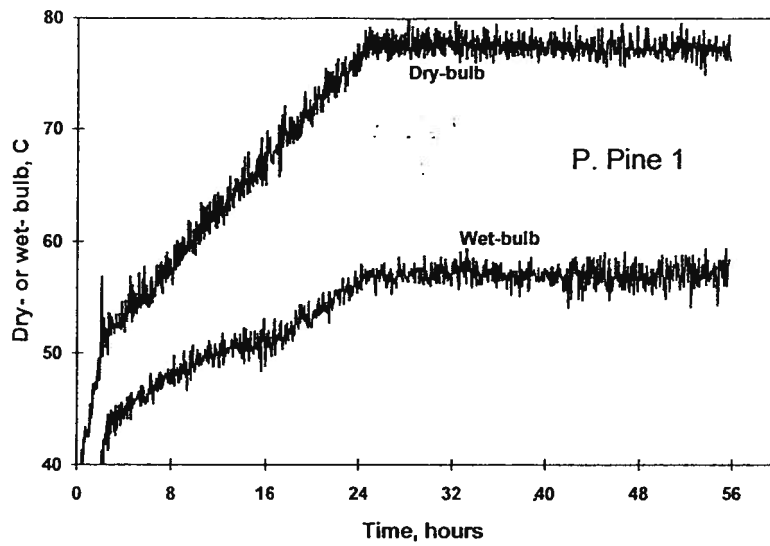
FIGURE 2a. Dry- and wet-bulb temperatures during ponderosa pine drying. 15% moisture content was reached at 42:00 hours .
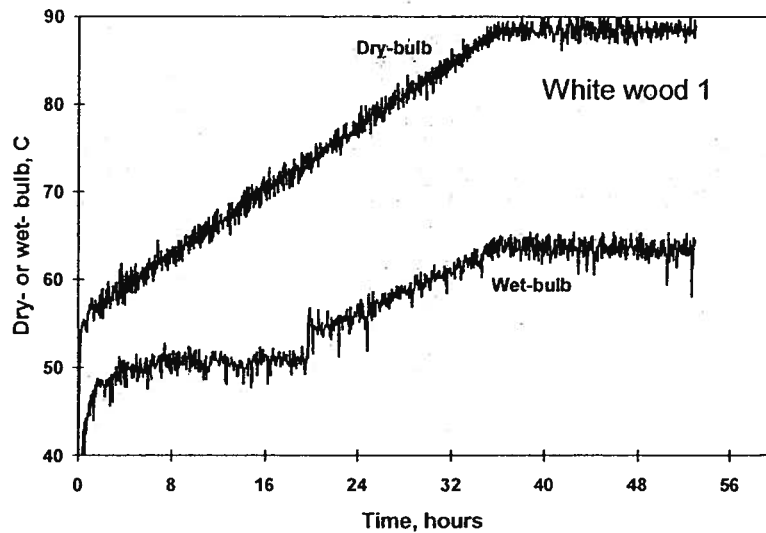
FIGURE 2b. Dry- and wet-bulb temperatures during white wood drying. 15% moisture content was reached at 45:25 hours.

IV.   Sampling Systems and Methodologies

Sampling for total hydrocarbon, methanol, and formaldehyde is done directly from the kiln as shown in Figure 1 (except there are three sets of impingers). The concentration obtained from the hydrocarbon analyzer and the amount of air entering the kiln allow the total hydrocarbon emissions to be calculated. The concentration obtained from the impingers, the amount of air flowing through the impingers, and the amount of air entering the kiln allow the HAP emissions to be calculated.

Total hydrocarbon

Figures 3a and 3b show the hydrocarbon sampling system. Unlike stack testing, all necessary equipment is permanently mounted on the kiln and flows are controlled with valves. The sample is withdrawn from the kiln under the assumption that the gas in the kiln is well-mixed and that the composition in the kiln near the exhaust is the same as the composition of the exhaust. The THC sample was drawn from the kiln directly into a heated dilution/filter box mounted on the side of the kiln. The box was heated to 125°C. Heated dilution gas can be added to the hydrocarbon sample gas to lower the gas moisture content to the detector. Dilution air was used when the gas moisture content in the kiln was greater than 15% so that the air moisture content to the detector remained less than 15%. The sample line from the box to the analyzer was heated to 135°C. The valve at the back of the analyzer was heated to 145°C.

The fuel gas was hydrogen. The span gas was EPA Protocol 611 ppm propane in air, the mid-gas was EPA Protocol 300 ppm propane. The zero gas was 0.1 ppm air. Detailed sampling procedures are in Appendix 1 and a summary is presented below.

Leak checks were conducted before and after the charge was dried. Valves are closed and all components from just behind the probe tip to the valve at the back of the analyzer are placed under a 18-20 inHg vacuum. Less than one inHg pressure change during two minutes is acceptable and this was met.

Total flow and sample flow to the analyzer were checked using an NIST-traceable flow meter. Total flow is measured with the dilution gas off. Sample flow is measured with it on. This was done at the beginning and end of each sampling interval. The meter was attached to the system near the probe tip within the heated box. The valves were repositioned so that the sample came from the flow meter rather than the kiln. Readings of flow were made with the dilution gas both off and on. The flow readings were verified by observing the change in the analyzer reading for span gas with the dilution gas off and on. The dilution ratio calculated based on the analyzer readings was within 2% of that determined by the flow meter.
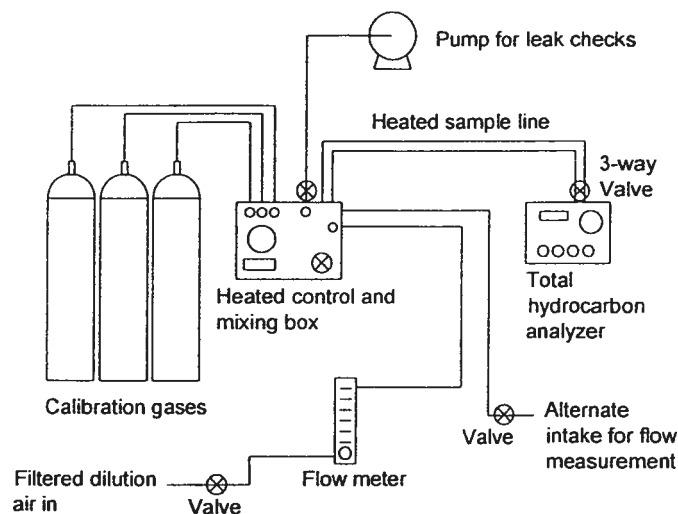
FIGURE 3A. Schematic of heated filter box with air dilution system, heated sample line, and analyzer. Sample enters heated box from back of drawing (box is attached to kiln).
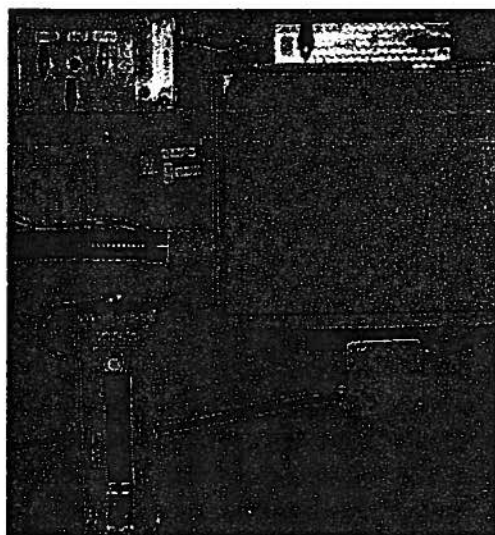
FIGURE 3B. Photo of VOC sampling system showing heated sample box (with white insulation), valves and flow meter for calibration gases (upper left), on/off valve for calibration gas (3 at upper center right), heated sample line to analyzer (green tube, center left), valve for sample (2 at center), toggle valve to vacuum pump (near calibration gas valves).

Calibration of the zero and span of the detector was done at the beginning of each measurement interval (about every three to six hours). The calibration gas was introduced by setting the valves so the calibration gas entered the system near the probe tip at ambient pressure. The calibration was checked at the end of each run with no adjustments made to the zero or span during the run. The span drift was always less than five percent of full scale for a run and generally less than one percent. The zero drift was minimal during entire drying cycles.

HAPs sampling

The sampling train for NCASI Method 105 (modified to have an extra impinger) is shown in Figure 4. The impingers were in a glycol solution maintained at -1 C. Prior to each sampling interval, the impingers were laboratory-washed and 10 to 15 mL of BHA solution were added to each impinger. The fourth impinger was not used. The system was then assembled and a vacuum check was performed with the valves at each end closed. Less than 1" Hg of pressure change over 2 minutes was acceptable. This was met. The flow rate through the system was then measured by taking four flow readings by attaching the probe tip to a Gilibrator flow meter. This was approximately 500 mL/min. The probe tip was then inserted into the kiln and the sampling interval begun. The collection interval time varied from 2 to about 3 hours, depending on the condensation rate of water.
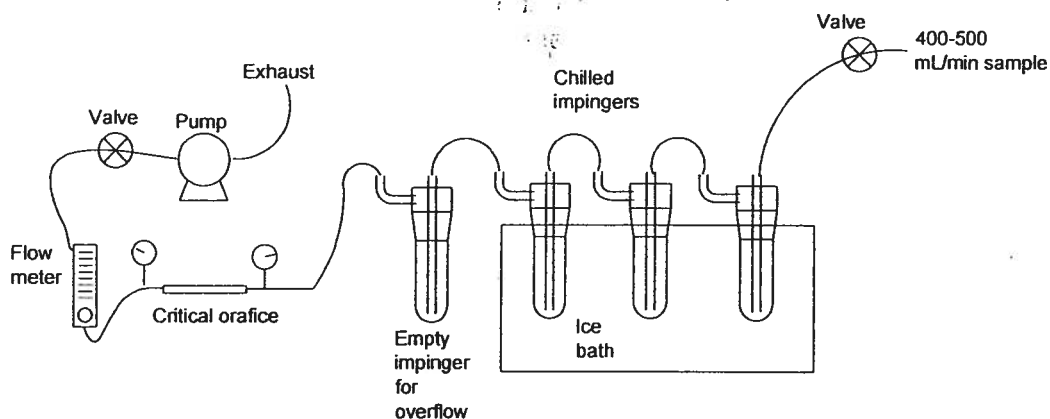
FIGURE 4. Sampling train for the methanol and formaldehyde.

At the end of each interval, the flow rate was again measured. The sampling line(s) was rinsed. The fluid in the three impingers was weighed, placed in a vial. The impingers were than rinsed with 10 mL of water followed by 3 to 5 mL of hexane. The rinses were also placed in the vial and it was sealed. Samples were kept refrigerated and in the dark until lab analysis was done. Lab analysis was done within two weeks after sample collection. The local airport altimeter setting and the lab temperature were recorded at the beginning and end of each interval so the flow rates could be adjusted to standard conditions.

Sampling by the NCASI Method 98.01 was the same as described above for NCASI 105 with the following exceptions. The first impingers were filled with 15 and 10 mL of water, respectively, instead of BHA solution. No water was put in the third impinger. There is no water rinse or hexane rinse after sample collection.

Lab analysis for aldehydes (105)

The aldehyde standard was prepared by the volumetric dilution of neat aldehydes into a solution of ortho-benzylhydroxylamine hydrochloride (BHA) and water (30g BHA per liter of water). The BHA solution was vigorously agitated and allowed to sit for 15 minutes to allow for derivatization of the aldehydes into aldoximes. The derivatized aldehyde solution was extracted with three aliquots of hexane and brought to volume to make 1000 mg/L. A standard curve was prepared by volumetric dilution in hexane at a range from 1 to 100 mg/L as aldehydes into autosampler vials with 100 mg/L of nitrobenzene as an internal standard.

The samples were prepared by extraction in a separatory funnel with three aliquots of hexane for a total hexane volume of approximately 25 mL. The volumes of the two phases were calculated from their weights. A 1 mL aliquot of the hexane fraction was transferred to an autosampler vial and spiked with internal standard.

The analytical instrument was a Shimadzu GC model 2010 with a flame thermionic detector (FTD), the Shimadzu equivalent of a nitrogen phosphorous detector (NPD). The column was a 105-meter Restek RTX-5 capillary with a 0.25 mm outside diameter and a stationary phase thickness of .25 µm. The oven schedule was: 2 minutes at 120°C, 2°C/min ramp to 160°C, 40°C/min ramp to 220°C and 6.5 minutes at 220°C. The column flow was 25 cm/sec, with 3 mL/min septum purge, and a 1:10 split ratio with a glass wool packed split injection liner. The detector make up He was set to 20 mL/min and the H_2 was set to 3 mL/min. The air was set to 140 mL/min, and the source current was set to 2 pA. The He and H_2 gases were grade 5 and the air was grade 0.1. The injector temperature was 200°C and the detector temperature 280°C. An AOC-20i autosampler was used to perform 1 µL injections using a 10 µL syringe with a steel plunger.

Lab analysis for alcohols (105)

The methanol standard was prepared by the volumetric dilution of neat methanol into water. The phenol standard was prepared by the gravimetric addition of solid phenol to a known volume of water. The alcohol mixed standard was prepared by volumetric addition of methanol to a gravimetrically prepared phenol standard. The mixed standard was prepared at a concentration of 1000 milligrams per liter (mg/L). A standard curve was prepared by the volumetric dilution of the mixed standard at a range from 5 mg/L to 1000 mg/L into autosampler vials.

Samples were prepared by transferring aliquots of the previously hexane extracted aqueous fractions into autosampler vials.

The analytical instrument was a Shimadzu GC model 2010 with a FID detector. The column was a 60-meter Restek Stabilwax capillary with a 0.53 mm outside diameter and a stationary phase thickness of 1.5 μm. The oven schedule was: 3 minutes at 80°C, 10°C/min ramp to 240°C, and 10 minutes at 240°C. The column flow was 30 cm/sec, with 3 mL/min septum purge, and a 1:10 split ratio with a glass wool packed split injection liner. The detector make up He was set to 25 mL/min and the H_2 was set to 50 mL/min. The air was set to 500 mL/min. The He and H_2 gases were grade 5 and the air was grade 0.1. The injector temperature was 175°C and the detector temperature 250°C. An AOC-20i autosampler was used to perform 1 μL injections using a 10 μL syringe with a PTFE plunger.

Lab analysis for methanol (98.01)

Methanol solutions in varying concentrations were prepared by dilution, 1 gram of HPLC grade methanol to 1000 grams with distilled water (at 20°C). This stock solution was further diluted to provide methanol solutions in the 1 ppm to 150 ppm range for use as standards.

Autosample vials for GC analysis were prepared by adding 2mL of the impinger sample or standard to a 2mL vial. These were crimp sealed and refrigerated until tested.

The GC was an Shimadzu 2010 with a 60-meter Restek Rtx-624 fused capillary column. A FID was the detection device. The column had a internal diameter of 0.53 mm and a stationary phase thickness of 3 μm. The oven schedule was: 7 minutes at 10°C, 20°C/min ramp to 200°C, and 5.5 minutes at 200°C. The column flow was 6 mL/min of He (48.1 Pa head pressure), 3 mL/min septum purge, and a 1:4 split ratio (24 mL/min through the split vent purge). The detector make up He was set to 25 mL/min and the H_2 was set to 50 mL/min. The air was set to 500 mL/min. The He and H_2 gases were grade 5 and the air was grade 0.1. The injector temperature was 150°C and the detector temperature 250°C. An AOC-20i autosampler was used to perform 1 μL injections.

Lab analysis for formaldehyde (98.01)

Formaldehyde solutions in varying concentrations were prepared by diluting 2.703 grams of formalin to 1000 grams with distilled water at 20°C. This stock solution was further diluted to provide methanol solutions in the 0.25 ppm to 7.5 ppm range for use as standards.

An acetylacetone reagent was prepared by dissolving 15.4 g of ammonium acetate in 50 mL of water. To this, 0.2 mL of acetylacetone and 0.3 mL of glacial acetic acid were added. This was then diluted to 100 mL and stored in the dark in a refrigerator.

A 2.0 mL aliquot of the impinger catch or standard was placed in a test tube and 2 mL of the acetylacetone reagent was added. Once mixed, the test tube was placed in a 60°C water bath for 10 minutes. The vials were allowed to cool to room temperature, then the solution was transferred to a cuvette and absorbance measured at 412 nm. For each impinger catch, two replications of this procedure were done.

V. Data Reduction and Treatment

The "FlowCalc" worksheet in the Excel file "Kiln, RunName.XLS" in Appendix 2 shows the calculations for each 3-minute interval during the charges (RunName="Hampton, DF4" or "Hampton HF4"). Column A is a reading number. Columns B and C are the clock and charge times, respectively. Columns D and E are the average dry- and wet-bulb temperatures. Column F is the vapor pressure of water at the wet-bulb temperature. The absolute humidity is shown in column G and the molal humidity in column H. These are calculated based on the dry-bulb temperature, wet-bulb temperature, vapor pressure.

Flow calculations

The volumetric dry gas flow rate in column I is the flowmeter reading adjusted for the meter calibrations and the molar humidity of the entering gas. This is in standard (at 0°C) liters per minute. In column J this has been converted to a mass flow rate in kg/min and in column K is the same information is expressed as a molal flow rate. These values are for the dry gas vented from the kiln.

Moisture calculations

The water removal rate in g/min (column L) is calculated from the humidity (column G) and the gas flow (column J). The total water (column M) is an integration of column L over time.

The moisture content of the wood at each time interval in the event (column N) was determined by reducing the MC of the wood from the previous time interval by accounting for the amount of water leaving the kiln during the interval. This amount has been adjusted by adjusting the wet-bulb temperature to make the ending moisture content match.

Total hydrocarbon calculations

The original total hydrocarbon analyzer reading is shown in column O. In column P this has been corrected to compensate for the range setting switch on the analyzer and scaling between the analyzer reading and the computer reading. Also in column P, the THA data between sampling runs has been adjusted to the average of the data during the 12-minute period before the analyzer testing and calibration time. The dilution THA (column Q) is the corrected THA reading divided by the dilution ratio (from column Y). In column R we have the opportunity to compensate for the effect of moisture on the JUM detector. This was not done so column R equals column Q. Finally in column S, the hydrocarbon concentration is converted to a dry gas basis concentration using the molar humidity (column H).

In column T, the hydrocarbon flow rate in g_{carbon}/min is calculated in a manner analogous to the water flow rate using the dry gas flow rate from column K and the hydrocarbon concentration from column S. Column U is the integral of column T over time, the cumulative hydrocarbon release up to that point in the schedule. Column V is the cumulative unit emissions, that is, column U divided by the oven-dry weight of the wood in the kiln.

Column X indicates the hydrocarbon sampling run and column Y is the dilution ratio during that run. The next two columns, Z and AA, are the cumulative dry gas and water during the kiln cycle. These are used obtain the average gas moisture contents. The uncorrected wood moisture content is shown in column AC. This is the MC in column N before adjustment of the wet-bulb to make the beginning and ending MCs match the oven-dry test. The kiln air and analyzer air moisture contents (based on volume) are shown in columns AD and AE.

At the end of the FlowCalc spreadsheet (below the data) are summaries by run of the flow data for the total hydrocarbon run intervals. Further down are summaries by impinger interval. These are the tables that appear in the body of the report. The other pages in the files "Kiln, RunName.XLS" are graphs of the data in the FlowCalc page.

Moisture content and board weight data are in the files named "Weights, RunName.XLS."

HAP calculations (105)

Data from the lab analysis for HAPs is shown in Appendix 3. The laboratory data reduction for the HAPs (from the field data sheets and lab analysis) is shown in electronic form in the file named "HAPs, RunName.XLS" in Appendix 2. Within this file the summary page presents the data by run interval. The "Field Data" page is the data from the field data sheets (samples of actual sheets included in Appendix 3 and PDF versions are included in Appendix 2) and includes the ambient pressure, lab temperature, flow rate through the impingers, and run start and stop times. The "Laboratory Data" page includes the results of the lab analyses on the impinger catch or hexane fraction. The lab data sheets are included in Appendix 2. On the "Impinger Calculations" page, the field data is manipulated to give a dry gas flow rate through the impingers (columns J and K) and the mass HAPs in the impingers (columns L to Q).

The "Kiln Calculations" page uses a ratio of the dry gas flow through the kiln (calculated in the spreadsheets named "Kiln, RunName.XLS") to the dry gas flow rate through the impinger to scale up the quantities and obtain the mass of each compound leaving the kiln (columns I to N).

On the "Emission" page, the amount of a HAP leaving the kiln is divided by the mass (in kg) or volume of wood (in mbf) to express the emissions on a per kg (columns B-G) or per mbf basis (columns H-M). Concentrations leaving the kiln are given in columns N to Y.

The "Quality Assurance" page presents information on the spikes, duplicates and blanks. For each spike a % recovery is calculated based on the mass of a HAP recovered divided by the amount added. The difference for each duplicate is calculated as a percentage from the difference between the impingers divided by the average mass collected.

The remaining pages in "HAPs, RunName.XLS" are for graphing purposes.

HAP calculations (98.01)

The laboratory data reduction for the HAPs (from the field data sheets and lab analysis) is shown in electronic form in the file named "Methanol and Formaldehyde, RunName.XLS" in Appendix 2. Within this file the summary page presents the data by run interval. The "Field Data" page is the data from the field data and includes the ambient pressure, lab temperature, flow rate through the impingers, and run start and stop times. The field data sheets are presented electronically in Appendix 2. The "Concentrations" page includes the results of the lab analyses on the impinger catch. The lab data sheets are included in Appendix 2. On the "Impinger Calculations" page, the field data is manipulated to give a dry gas flow rate through the impingers (columns J and K) and the mass of methanol and formaldehyde in the impingers.

The "Kiln Calculations" page uses a ratio of the dry gas flow through the kiln (calculated in the spreadsheets named "Kiln.XLS") to the dry gas flow rate through the impinger to scale up the quantities and obtain the mass of each compound leaving the kiln (column I-M). The unit emissions in columns K-N are obtained by dividing the total emissions by either the volume or mass of wood in the kiln.

VI.   Sampling Results

Hydrocarbon

The hydrocarbon emissions are summarized graphically here. All emission data is presented in detail in electronic form in Appendix 2. The time to 15% moisture content was estimated by interpolation and the emissions are reported from green to 15% moisture content.

Figure 5 shows total hydrocarbon concentration (left scale) and dry gas vent rate (right scale) versus time. Profiles are similar in replicate charges.

The total hydrocarbon concentration is very dependent on the venting early in the schedule with a high vent rate resulting in a low hydrocarbon concentration and vice versa. Once the venting increases, the total hydrocarbon concentration decreases. The ponderosa pine and the white wood both have a very high vent rate early in the schedule because of the low initial wet-bulb temperatures and the very gradual increase in temperature.

Note that total hydrocarbon concentration is not indicative of the amount of hydrocarbon emissions unless one also considers the vent rate. These two factors combined determine the emissions.

Figure 6 shows the cumulative hydrocarbon emissions and the rate of emissions versus time. The cumulative emissions is the emissions up to any point in time in the schedule. The rate of emissions is how much is coming out per unit time. The maximum emission rates occur early in the schedules.

Figure 7 shows the wood moisture content versus time. The estimated moisture content should most accurately represent the MC-time relationship because the initial and final moisture contents match the oven-dry test. The initial moisture contents and final moisture contents based on the oven-dry method are shown on each plot.

Figure 8 shows the cumulative hydrocarbon emissions versus moisture content. The hydrocarbon emissions for drying to any moisture content can be read from this graph. In agreement with past studies, there is a fairly linear relationship between the emissions and the decrease in moisture content for the white wood. The relationship is less linear for the pine.
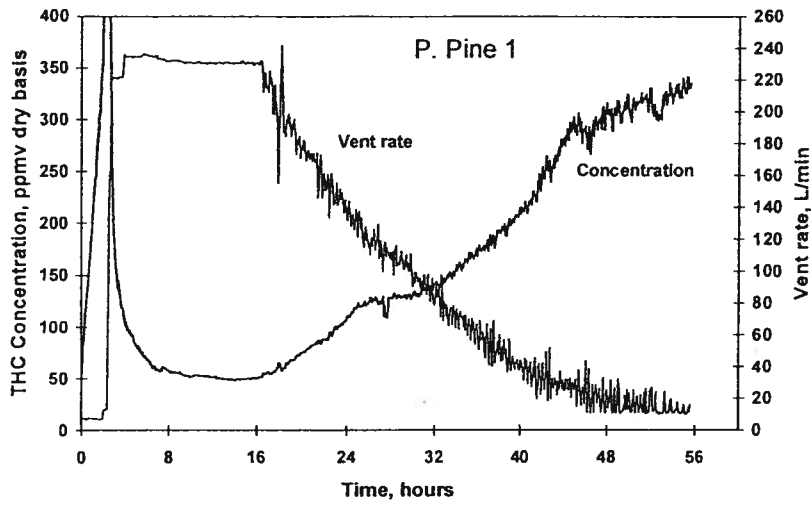
FIGURE 5a. Hydrocarbon concentration and vent rate versus time for the ponderosa pine charge.
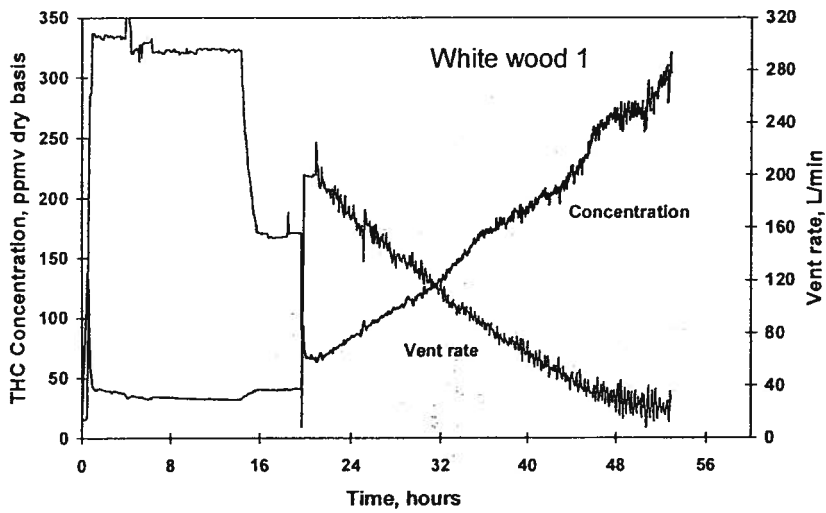
FIGURE 5b. Hydrocarbon concentration and vent rate versus time for the white wood charge.
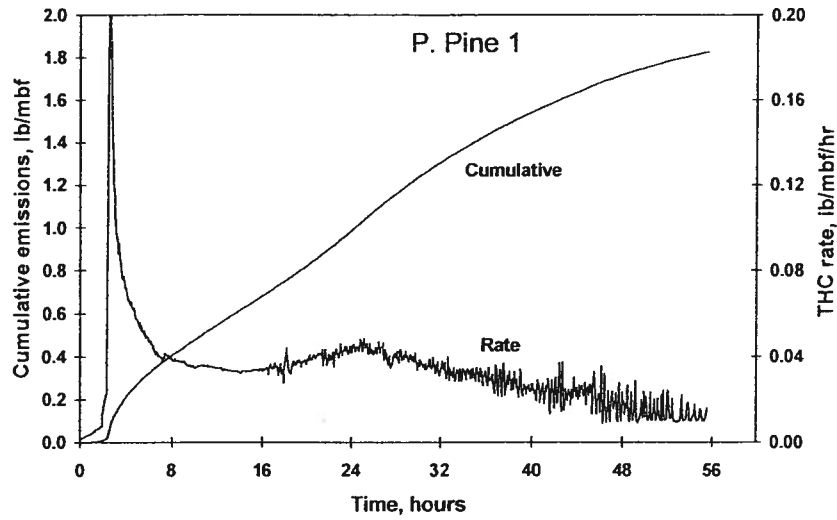
FIGURE 6a. Cumulative and rate of emissions versus time (as carbon) for the ponderosa pine charge.
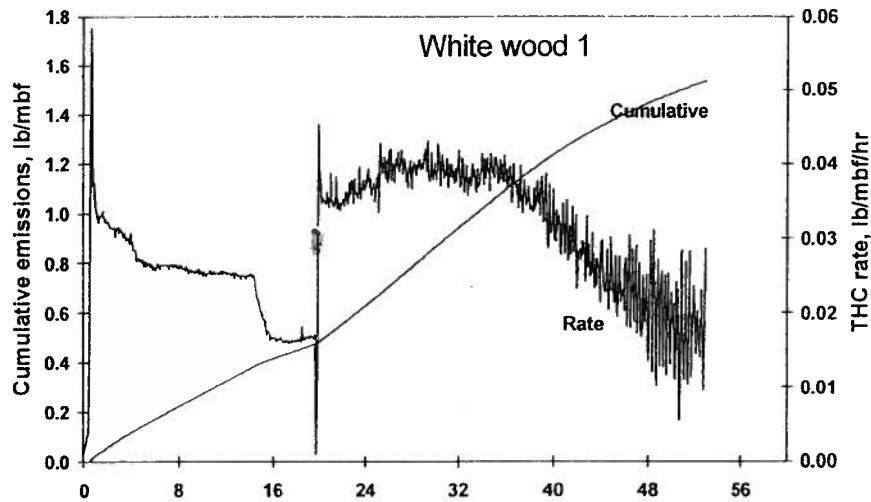
FIGURE 6b. Cumulative and rate of emissions versus time (as carbon) for the white wood charge.
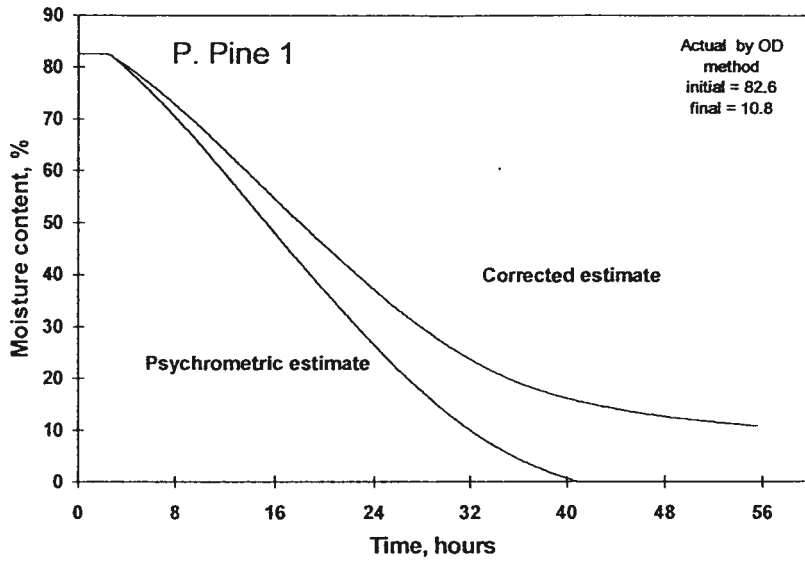
FIGURE 7a. Moisture content versus time for the ponderosa pine charge.
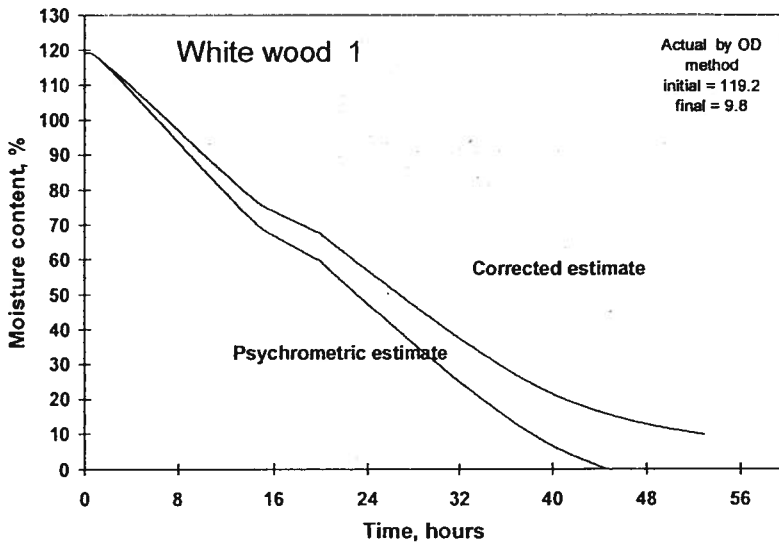
FIGURE 7b. Moisture content versus time for the white wood charge.
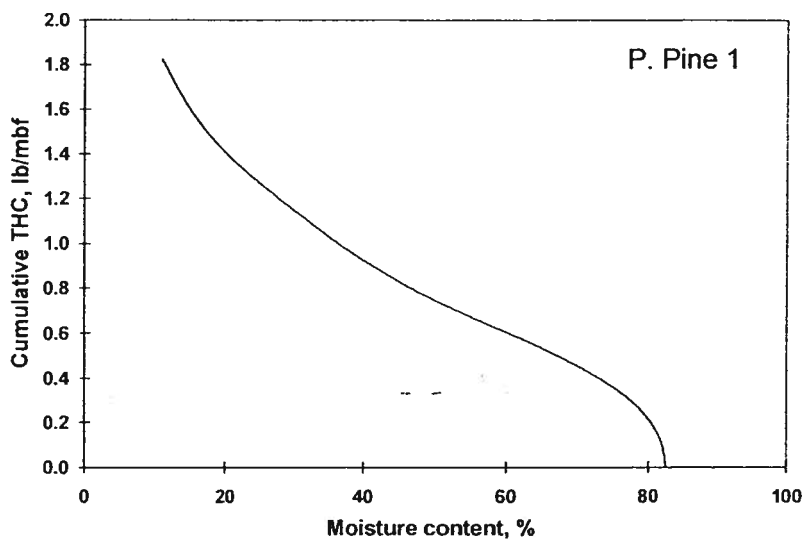
FIGURE 8a. Cumulative emissions versus moisture content (as carbon) for the ponderosa pine charge.
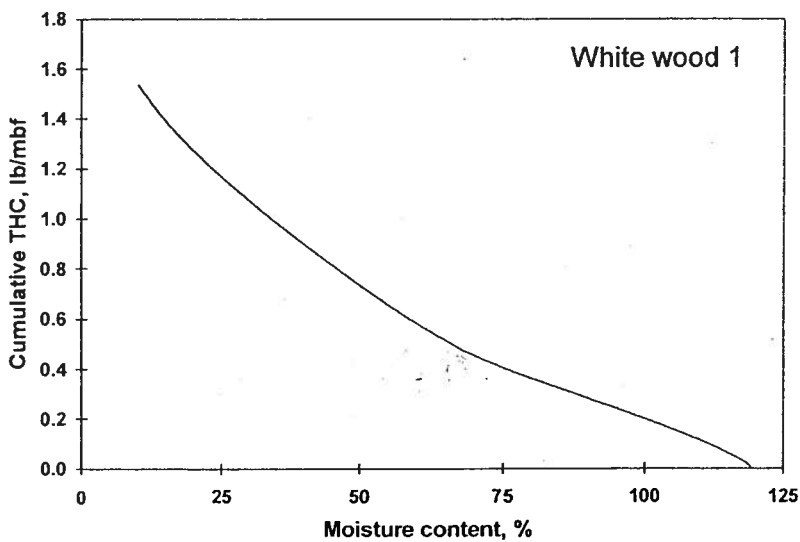
FIGURE 8b. Cumulative emissions versus moisture content (as carbon) for the white wood charge.

Table 3 shows the VOC results by run for the charges. A run is an interval between analyzer calibrations, about three to four hours of data. The interval time periods shown in the table include the times between sampling and mass calculations are adjusted to account for these. Sampling occurred for approximately 95% of the drying time. Sample copies of field sampling sheets, including dilution system and heated component data are given in Appendix 3 with full PDF format versions in Appendix 2.

TABLE 3a. Summary of sample runs for analysis of total hydrocarbon for the ponderosa pine charge.

Sample Run	Time hrs	Average Humidity kg/kg	Dry Flow Rate @68 L/min	THC mass as C g	THC dry conc ppmv	THC mass as C lbs/mbf	THC rate as C lb/hr/mbf	Average Wood MC %	Average Air MC %	Average Anal. MC %
1	3.45	0.047	70.8	5.43	259.8	0.163	0.0473	82.4	7.0	7.0
2	3.90	0.058	250.5	7.14	82.4	0.215	0.0550	77.7	8.6	8.6
3	2.85	0.067	248.5	3.55	55.8	0.107	0.0374	71.1	9.8	9.8
4	2.65	0.073	247.5	3.08	52.3	0.093	0.0349	65.0	10.5	10.5
5	5.75	0.078	238.1	6.46	52.7	0.194	0.0337	55.2	11.2	11.2
6	2.95	0.091	191.0	3.79	74.9	0.114	0.0386	45.3	12.8	12.8
7	6.25	0.108	143.2	8.75	110.1	0.263	0.0420	35.8	14.8	14.8
8	3.30	0.113	109.3	4.22	130.2	0.127	0.0384	27.3	15.4	10.8
9	2.55	0.115	88.0	2.86	142.3	0.086	0.0337	23.1	15.7	10.8
10	3.20	0.114	69.2	3.29	165.8	0.099	0.0309	19.9	15.5	10.7
11	4.45	0.112	48.7	3.88	201.0	0.117	0.0262	16.8	15.3	10.6
12	0.70	0.108	35.3	0.52	235.0	0.016	0.0224	15.2	14.9	10.3
Sum	42.00			53.0		1.591				
Average		0.090	145.0		130.2		0.0367			

TABLE 3b. Summary of sample runs for analysis of total hydrocarbon for the white wood charge.

Sample Run	Time hrs	Average Humidity kg/kg	Dry Flow Rate @68 l/min	THC mass as C g	THC dry conc ppmv	THC mass as C lbs/mbf	THC rate as C lb/hr/mbf	Average Wood MC %	Average Air MC %	Average Anal. MC %
1	2.85	0.062	258.8	2.99	53.3	0.082	0.0287	116.9	9.1	9.1
2	3.25	0.073	325.2	3.35	35.4	0.092	0.0282	108.2	10.5	10.5
3	2.85	0.077	316.2	2.73	33.7	0.075	0.0262	98.6	11.1	11.1
4	3.75	0.076	316.7	3.48	32.6	0.095	0.0253	88.1	11.0	11.0
5	5.70	0.074	222.3	4.10	37.0	0.112	0.0196	75.2	10.6	10.6
6	3.20	0.089	187.9	3.18	57.3	0.087	0.0272	66.9	12.6	12.6
7	3.40	0.103	189.3	4.53	78.6	0.124	0.0364	58.6	14.2	14.2
8	2.95	0.118	162.3	4.27	99.3	0.117	0.0395	50.6	15.9	15.9
9	4.55	0.136	134.0	6.55	120.0	0.179	0.0393	41.5	17.9	10.6
10	4.50	0.163	99.7	6.35	158.1	0.174	0.0386	31.3	20.8	12.3
11	5.05	0.172	71.5	6.11	189.3	0.167	0.0331	22.3	21.7	12.8
12	3.20	0.170	49.4	3.05	216.0	0.083	0.0261	16.7	21.5	12.7
Sum	45.25			50.7		1.385				
Average		0.109	194.4		92.5		0.0307			

HAP results (105)

Results of the lab analyses for HAPs by NCASI Method 105 are summarized in Table 4 and complete results are in Appendix 2. Table 5 shows a summary of the HAP analyses by run during the charge.

The HAPs released are plotted as a function of time in Figure 9. In Figure 9, acetaldehyde and methanol are plotted with bold lines and correspond to the axis with larger values. The other HAPs are plotted on the smaller-scale axis. The total HAPs released is a nonlinear function of moisture content (Figure 10), with the rate increasing with decreasing moisture content.

TABLE 4a. Results of NCASI 105 laboratory analyses for the ponderosa pine charge.

| Aqueous concentrations | | | Hexane concentrations | | | | | |
Sample Run	Methanol µg/mL	Phenol µg/mL	Sample Run	Formaldehyde µg/mL	Acetaldehyde µg/mL	Propionaldehyde µg/mL	Acrolein µg/mL	Mass g
1	4.0	0.00	1	0.2	27.3	0.1	0.0	15.48
2	2.3	0.00	2	0.3	11.0	0.0	0.0	12.67
3	1.3	0.00	3	0.2	7.9	0.0	0.0	15.09
4	0.9	0.00	4	0.4	10.8	0.1	0.2	13.24
5	2.1	0.00	5	0.6	11.0	0.2	0.2	16.57
6	4.0	0.00	6	1.1	14.4	0.5	0.5	15.94
7	5.6	0.00	7	2.0	19.2	0.9	1.0	13.34
8	4.9	0.00	8	1.1	10.1	0.7	0.7	11.94
9	6.8	0.00	9	1.5	12.4	1.2	1.2	14.17
10	15.2	0.00	10	2.3	20.5	2.9	2.8	14.51
11	19.8	0.00	11	2.8	26.4	5.0	4.1	15.22
12	27.1	0.00	12	3.3	37.8	8.0	5.8	14.33
13	34.5	0.00	13	3.2	39.4	6.4	4.1	13.44
14	36.4	0.00	14	3.5	46.1	8.0	5.1	12.29
15	34.3	0.00	15	3.6	56.1	14.2	9.4	14.75

TABLE 4b. Results of NCASI 105 laboratory analyses for the white wood charge.

| Aqueous concentrations | | | Hexane concentrations | | | | | |
Sample Run	Methanol µg/mL	Phenol µg/mL	Sample Run	Formaldehyde µg/mL	Acetaldehyde µg/mL	Propionaldehyde µg/mL	Acrolein µg/mL	Mass g
1	3.0	0.00	1	0.2	10.0	0.1	0.2	11.62
2	3.7	0.00	2	0.3	28.2	0.1	0.2	13.95
3	2.8	0.00	3	0.4	43.2	0.3	0.6	12.91
4	2.1	0.00	4	0.5	49.0	0.3	0.3	11.87
5	2.4	0.00	5	0.6	46.5	0.6	0.7	13.81
6	3.4	0.00	6	0.9	43.4	0.8	1.0	14.37
7	4.4	0.00	7	0.8	33.0	0.9	1.0	14.72
8	6.7	0.00	8	1.7	37.7	1.4	1.5	13.88
9	13.7	0.00	9	3.0	50.3	3.5	4.0	12.92
10	21.2	0.00	10	3.8	39.5	4.2	4.7	14.72
11	32.9	0.00	11	6.0	42.3	6.2	6.2	11.31
12	33.7	0.00	12	4.9	35.0	5.5	5.3	12.72
13	21.4	0.00	13	2.4	17.3	2.5	2.3	12.31
14	57.1	0.00	14	6.1	43.3	5.8	5.2	12.52
15	41.9	0.00	15	4.1	31.4	4.7	4.3	12.60

TABLE 5a. Summary of NCASI 105 sample runs for HAPs for the ponderosa pine charge (Method 105).

Sample Run ID	Mass					
	Methanol	Phenol	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
	lb/mbf	lb/mbf	lb/mbf	lb/mbf	lb/mbf	lb/mbf
1	0.0007	0.0000	0.0000	0.0023	0.0000	0.00000
2	0.0025	0.0000	0.0001	0.0043	0.0000	0.00000
3	0.0016	0.0000	0.0001	0.0039	0.0000	0.00000
4	0.0013	0.0000	0.0002	0.0050	0.0001	0.00008
5	0.0029	0.0000	0.0003	0.0065	0.0001	0.00010
6	0.0043	0.0000	0.0005	0.0060	0.0002	0.00019
7	0.0039	0.0000	0.0004	0.0043	0.0002	0.00022
8	0.0026	0.0000	0.0002	0.0019	0.0001	0.00013
9	0.0037	0.0000	0.0003	0.0022	0.0002	0.00022
10	0.0056	0.0000	0.0003	0.0027	0.0004	0.00037
11	0.0056	0.0000	0.0003	0.0028	0.0005	0.00044
SUM	0.035	0.0000	0.0027	0.042	0.0019	0.0017

Sample Run ID	Concentration in dry gas						Concentration in wet gas					
	Methanol	Phenol	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein	Methanol	Phenol	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
1	1.75	0.00	0.04	4.41	0.01	0.00	1.63	0.00	0.04	4.11	0.01	0.00
2	1.26	0.00	0.05	1.55	0.00	0.00	1.16	0.00	0.05	1.42	0.00	0.00
3	0.84	0.00	0.06	1.46	0.01	0.00	0.76	0.00	0.05	1.33	0.01	0.00
4	0.58	0.00	0.08	1.65	0.01	0.02	0.52	0.00	0.08	1.48	0.01	0.02
5	1.12	0.00	0.14	1.81	0.03	0.02	0.99	0.00	0.12	1.61	0.02	0.02
6	2.24	0.00	0.26	2.31	0.06	0.06	1.96	0.00	0.23	2.02	0.05	0.05
7	3.12	0.00	0.39	2.52	0.09	0.10	2.67	0.00	0.33	2.15	0.08	0.09
8	1.78	0.00	0.16	0.97	0.05	0.05	1.51	0.00	0.14	0.82	0.04	0.04
9	6.19	0.00	0.50	2.72	0.20	0.21	5.22	0.00	0.42	2.30	0.17	0.17
10	8.16	0.00	0.49	2.89	0.31	0.31	6.89	0.00	0.41	2.45	0.27	0.26
11	11.11	0.00	0.62	4.02	0.58	0.49	9.42	0.00	0.52	3.40	0.49	0.42
SUM												

TABLE 5b. Summary of NCASI 105 sample runs for HAPs for the white wood charge (Method 105).

Sample Run ID	Mass					
	Methanol	Phenol	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
	lb/mbf	lb/mbf	lb/mbf	lb/mbf	lb/mbf	lb/mbf
1	0.0027	0.0000	0.0001	0.0030	0.0000	0.00006
2	0.0043	0.0000	0.0001	0.0138	0.0001	0.00008
3	0.0038	0.0000	0.0002	0.0203	0.0001	0.00030
4	0.0033	0.0000	0.0002	0.0239	0.0002	0.00015
5	0.0025	0.0000	0.0002	0.0172	0.0002	0.00026
6	0.0029	0.0000	0.0003	0.0147	0.0003	0.00034
7	0.0040	0.0000	0.0003	0.0125	0.0003	0.00039
8	0.0059	0.0000	0.0005	0.0118	0.0004	0.00048
9	0.0103	0.0000	0.0007	0.0119	0.0008	0.00094
10	0.0117	0.0000	0.0007	0.0076	0.0008	0.00090
11	0.0134	0.0000	0.0006	0.0045	0.0007	0.00065
12	0.0094	0.0000	0.0004	0.0028	0.0004	0.00043
SUM	0.074	0.0000	0.0045	0.144	0.0044	0.0050

Sample Run ID	Concentration in dry gas						Concentration in wet gas					
	Methanol	Phenol	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein	Methanol	Phenol	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
1	2.07	0.00	0.05	1.71	0.02	0.03	1.89	0.00	0.04	1.56	0.02	0.02
2	1.82	0.00	0.07	4.29	0.01	0.02	1.63	0.00	0.06	3.84	0.01	0.02
3	1.54	0.00	0.08	6.02	0.03	0.07	1.37	0.00	0.07	5.35	0.02	0.06
4	1.12	0.00	0.09	5.85	0.03	0.03	1.00	0.00	0.08	5.21	0.03	0.03
5	1.26	0.00	0.13	6.38	0.06	0.08	1.13	0.00	0.12	5.70	0.06	0.07
6	1.93	0.00	0.22	7.00	0.10	0.13	1.69	0.00	0.19	6.14	0.09	0.11
7	3.16	0.00	0.24	7.27	0.15	0.18	2.71	0.00	0.21	6.24	0.13	0.15
8	4.54	0.00	0.44	6.65	0.18	0.21	3.82	0.00	0.37	5.60	0.15	0.18
9	7.57	0.00	0.56	6.36	0.33	0.39	6.20	0.00	0.46	5.21	0.27	0.32
10	12.40	0.00	0.82	5.82	0.47	0.54	9.79	0.00	0.65	4.59	0.37	0.43
11	20.39	0.00	1.03	4.95	0.55	0.57	15.96	0.00	0.80	3.88	0.43	0.44
12	24.96	0.00	1.13	5.48	0.66	0.66	19.59	0.00	0.89	4.30	0.52	0.52
SUM												
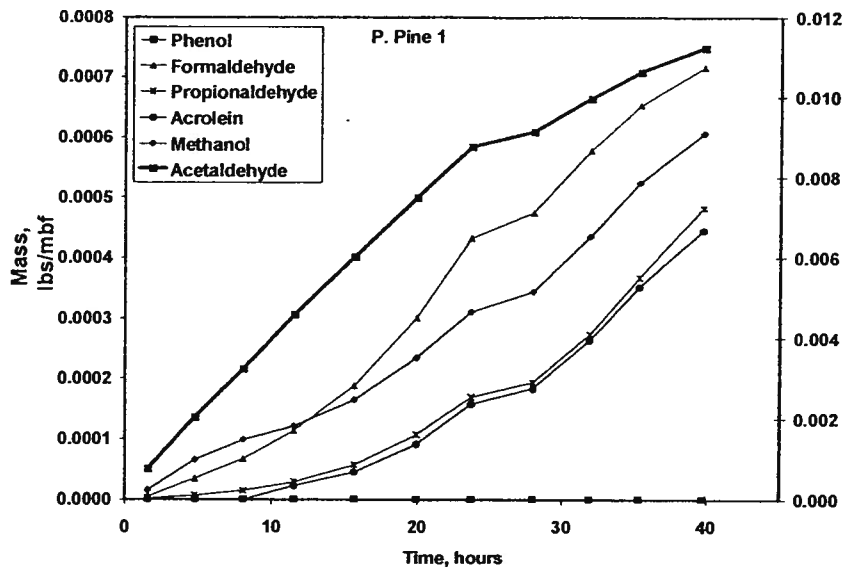
FIGURE 9a. Cumulative HAP emissions versus time for the ponderosa pine charge (Method 105). Read methanol and acetaldehyde from right axis.
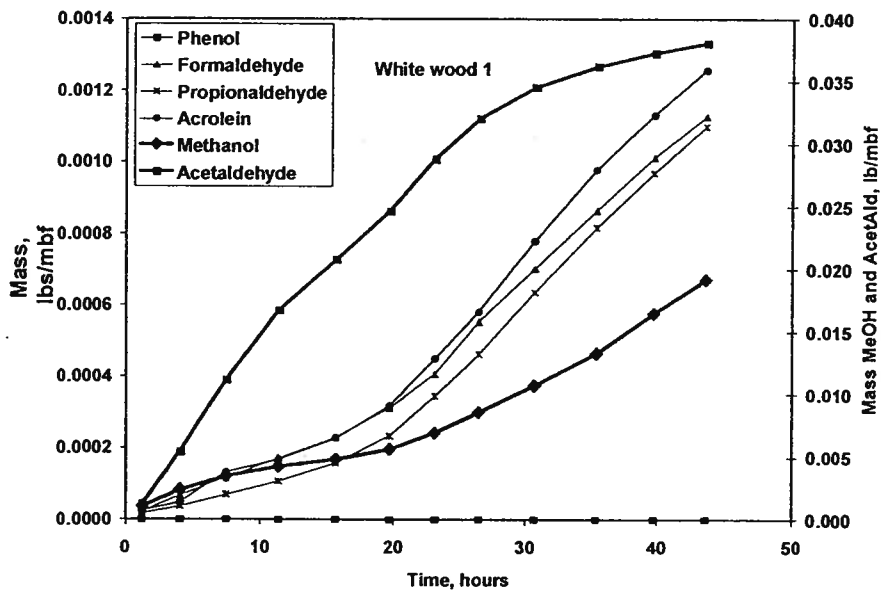
FIGURE 9b. Cumulative HAP emissions versus time for the white wood charge (Method105). Read methanol and acetaldehyde from right axis.
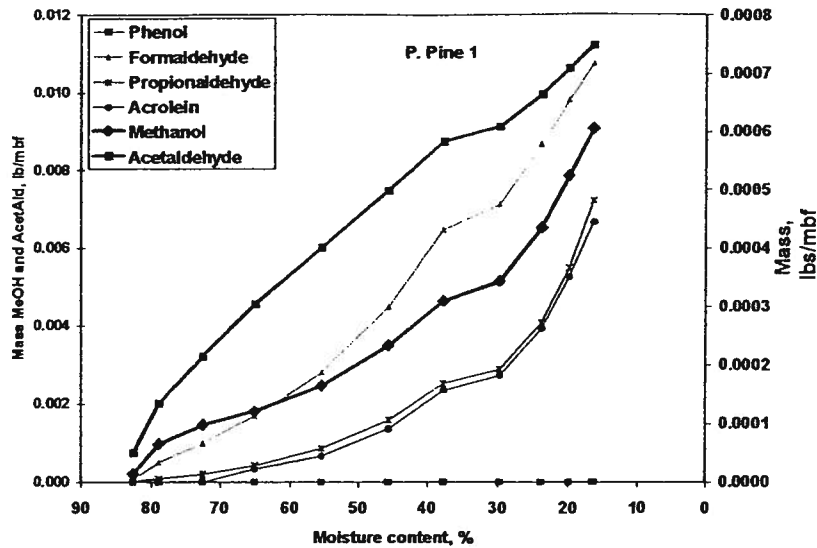
FIGURE 10a. Cumulative HAP emissions versus wood moisture content for the ponderosa pine charge (Method 105). Read methanol and acetaldehyde from left axis.
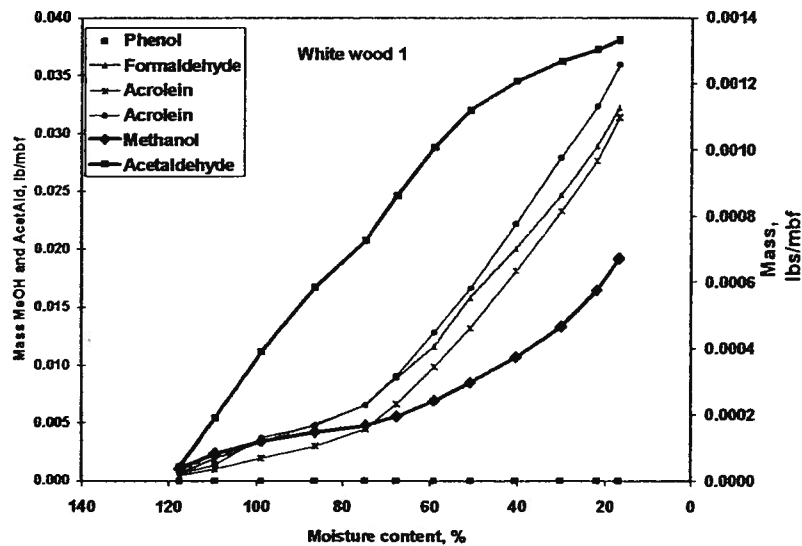
FIGURE 10b. Cumulative HAP emissions versus wood moisture content for the white wood charge (Method 105). Read methanol and acetaldehyde from left axis.

Methanol and formaldehyde (98.01)

Results of the lab analyses for methanol and formaldehyde by Method 98.01 are summarized in Table 6 and complete results are in Appendix 2. Table 7 shows a summary of the methanol and formaldehyde analyses by run during the charge.

The total emissions released as a function of time are shown in Figure 11. Figure 12 shown total emissions as a function of moisture content.

TABLE 6. Results of laboratory analyses for ponderosa pine (left) and white wood impinger samples (Method 98.01).

Impinger liquid concentrations			Impinger liquid concentrations		
Sample Run	Methanol mg/L	Formaldehyde mg/L	Sample Run	Methanol mg/L	Formaldehyde mg/L
1	5.0	0.30	1	6.1	0.25
2	3.6	0.28	2	6.7	0.21
3	1.8	0.25	3	5.2	0.24
4	2.2	0.37	4	4.2	0.34
5	3.0	0.51	5	5.1	0.50
6	5.5	0.96	6	6.7	0.70
7	8.6	1.44	7	8.4	0.66
8	14.2	1.80	8	13.4	1.14
9	11.0	1.20	9	25.0	1.94
10	21.1	1.78	10	35.6	2.40
11	30.8	2.12	11	54.7	3.06
12	42.9	2.48	12	58.7	5.02
13	53.0	2.65	13	41.2	1.80
14	54.7	2.59	14	88.1	3.61
15	60.9	2.61	15	77.1	2.71

TABLE 7A. Summary of sample runs for methanol and formaldehyde for ponderosa pine (Method 98.01).

Sample Run ID	Collection Interval	Adjusted Interval	Dry gas mass	Average Dry gas flow rate	Molar Humidity	Moisture Content		Mass 1000 board feet		Concentration in dry gas		Concentration in wet gas	
						Mid %	End %	MeOH lb/mbf	CHOH lb/mbf	MeOH ppm	CHOH ppm	MeOH ppm	CHOH ppm
	hours	hours	kg	kg/min	mol/mol	%	%	lb/mbf	lb/mbf	ppm	ppm	ppm	ppm
1	2.85	3.10	11.674	0.063	0.073	82.5	81.7	0.0006	0.00004	1.59	0.10	1.48	0.09
2	2.75	3.35	60.348	0.300	0.090	78.8	75.8	0.0027	0.00021	1.33	0.11	1.22	0.10
3	2.50	3.20	57.715	0.301	0.105	72.6	69.2	0.0015	0.00020	0.77	0.11	0.69	0.10
4	2.60	3.70	66.268	0.299	0.118	65.1	60.8	0.0019	0.00032	0.86	0.16	0.77	0.14
5	3.00	4.50	78.653	0.291	0.125	55.4	50.2	0.0029	0.00049	1.10	0.20	0.98	0.18
6	3.00	4.10	57.171	0.232	0.145	45.7	41.3	0.0037	0.00065	1.96	0.37	1.71	0.32
7	3.00	3.40	37.427	0.183	0.172	37.7	34.3	0.0040	0.00067	3.22	0.57	2.74	0.49
8	3.70	5.15	44.095	0.143	0.181	29.8	25.7	0.0079	0.00092	4.97	0.67	4.21	0.57
9	1.90	2.70	18.042	0.111	0.186	23.8	22.1	0.0038	0.00041	6.32	0.74	5.33	0.62
10	3.00	4.15	20.686	0.083	0.183	19.9	18.0	0.0053	0.00049	8.4	0.75	7.1	0.64
11	3.00	4.65	15.292	0.055	0.180	16.4	15.0	0.0061	0.00042	12.13	0.89	10.28	0.75
SUM								0.040	0.00482				

TABLE 7B. Summary of sample runs for methanol and formaldehyde for white wood (Method 98.01).

Sample Run ID	Collection Interval	Adjusted Interval	Dry gas mass	Average Dry gas flow rate	Molar Humidity	Moisture Content		Mass 1000 board feet		Concentration in dry gas		Concentration in wet gas	
						Mid %	End %	MeOH lb/mbf	CHOH lb/mbf	MeOH ppm	CHOH ppm	MeOH ppm	CHOH ppm
	hours	hours	kg	kg/min	mol/mol	%	%	lb/mbf	lb/mbf	ppm	ppm	ppm	ppm
1	2.10	2.40	42.691	0.296	0.098	117.5	114.5	0.0036	0.00015	2.80	0.12	2.55	0.11
2	2.85	3.30	77.790	0.393	0.116	109.5	104.4	0.0060	0.00018	2.55	0.08	2.29	0.08
3	2.90	3.55	81.371	0.382	0.124	98.8	93.1	0.0044	0.00020	1.78	0.09	1.58	0.08
4	3.00	4.30	98.566	0.382	0.122	86.3	79.6	0.0025	0.00036	1.50	0.13	1.34	0.11
5	3.10	4.25	65.077	0.255	0.119	74.7	70.9	0.0036	0.00035	1.82	0.19	1.63	0.17
6	2.75	3.80	50.637	0.222	0.140	67.4	63.0	0.0039	0.00020	2.53	0.28	2.22	0.25
7	2.05	3.00	41.592	0.231	0.165	59.1	55.3	0.0059	0.00041	4.19	0.35	3.60	0.30
8	2.45	3.65	42.807	0.195	0.188	50.8	46.3	0.0073	0.00062	5.69	0.51	4.79	0.43
9	3.15	4.80	45.272	0.157	0.222	40.5	35.0	0.0117	0.00069	8.60	0.74	7.04	0.58
10	3.00	4.50	31.426	0.116	0.267	30.2	25.6	0.0147	0.00099	15.62	1.12	12.24	0.88
11	3.00	4.25	21.758	0.085	0.278	22.0	18.8	0.0152	0.00085	23.21	1.38	18.17	1.08
12	2.50	3.45	12.462	0.060	0.274	16.8	15.4	0.0102	0.00088	27.27	2.49	21.40	1.95
SUM								0.090	0.00631				
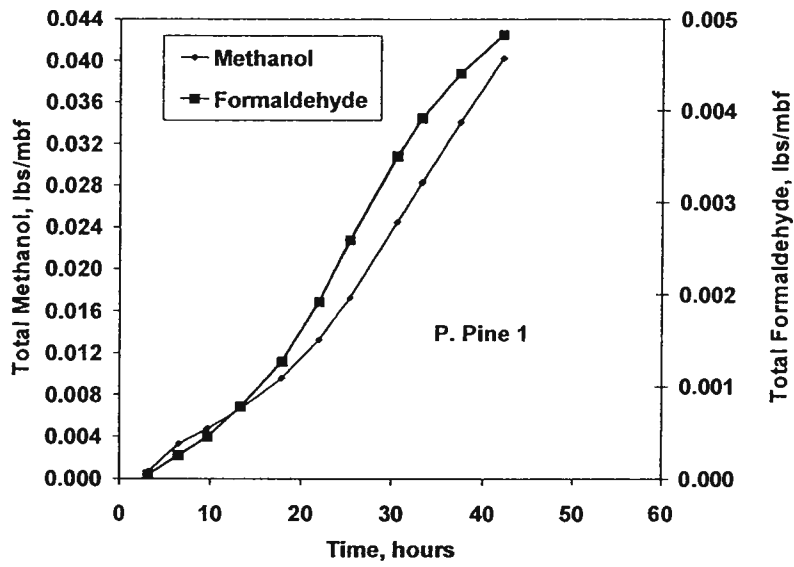
FIGURE 11A. Cumulative methanol and formaldehyde emissions versus time for ponderosa pine (Method 98.01).
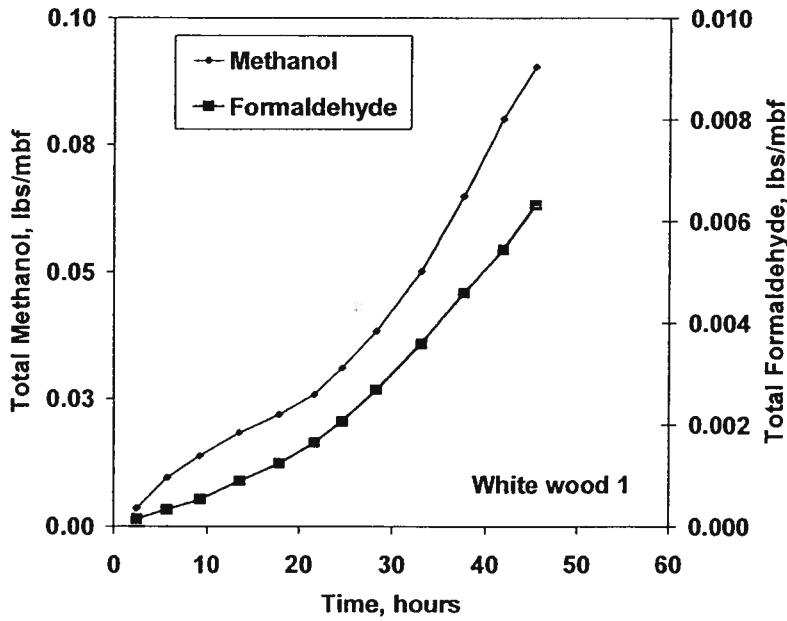
FIGURE 11B. Cumulative methanol and formaldehyde emissions versus time for white wood (Method 98.01).
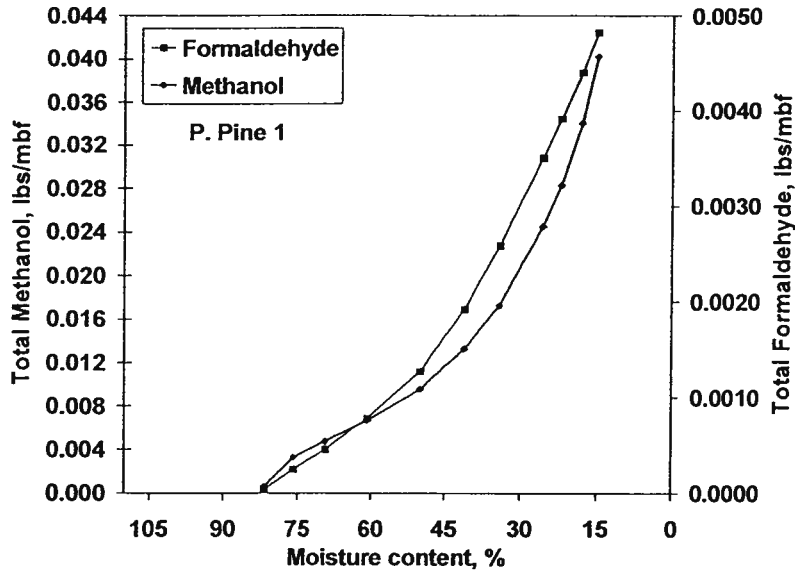
FIGURE 12A. Cumulative methanol and formaldehyde emissions versus wood moisture content for ponderosa pine (Method 98.01).
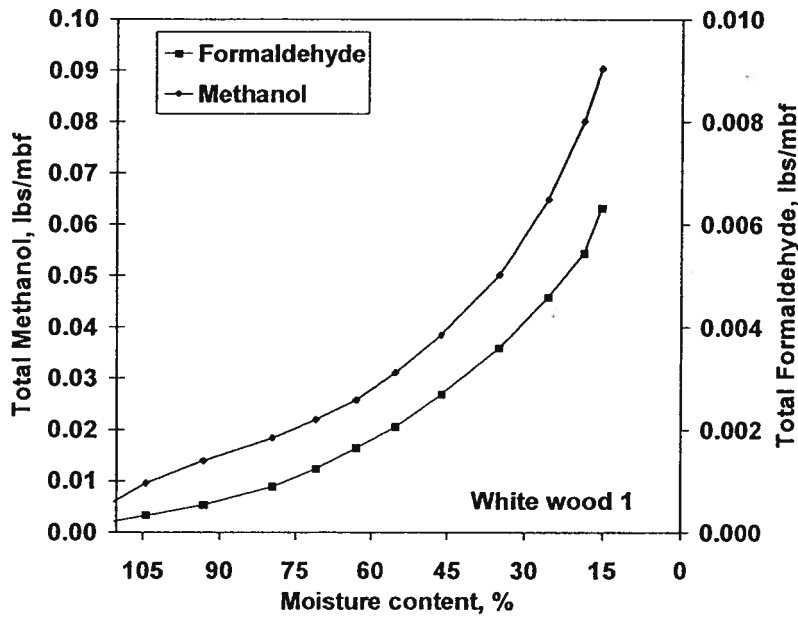
FIGURE 12B. Cumulative methanol and formaldehyde emissions versus wood moisture content for white wood (Method 98.01).

Discussion of results

Total hydrocarbon

The average values for the total hydrocarbon emissions in this study were 1.59lbs$_c$/mbf (pounds as carbon per thousand board feet) for ponderosa pine and 1.39 lbs$_c$/mbf for white wood. The total hydrocarbon value for ponderosa pine is consistent with past work. For example, we measured 1.42 lbs$_c$/mbf during the Intermountain study (results published in Milota, 2006. Hazardous air pollutant emissions from lumber drying. Forest Product Journal. (56)7/8:79-84). There is no past work to compare the white wood. White wood is a mix of species.

HAPs

The two methods, NCASI 105 and NCASI 98.01, had reasonable agreement (See Table 1, page 1) for the methanol and formaldehyde. The NCASI 105 method gave slightly lower values, especially for formaldehyde. This is consistent with the spike recoveries which tend to be lower for formaldehyde in Method 105 than Method 98.01..

Methanol - The methanol emitted from ponderosa pine, 0.035 to 0.04 lb/mbf, was lower than measure in the past. The value from the previous work (the Intermountain study) was 0.065 lb/mbf. The methanol emissions from the white wood were 0.074 to 0.099 lb/mbf. There is no past work for comparison.

Phenol - Phenol was not detected. This is consistent with past results.

Formaldehyde - The formaldehyde emitted from ponderosa pine, 0.0027 to 0.0048 lb/mbf, was consistent with the 0.0029 lb/mbf measured during the Intermountain study. The formaldehyde emitted from white wood was o.0048 to 0.0069 lb/mbf, There is no past work for comparison.

Acetaldehyde - The acetaldehyde emissions were 0.042 and 0.144 lb/mbf for ponderosa pine and white wood, respectively. This is consistent with recent unpublished work in which the acetaldehyde emissions are generally equal to or greater than the methanol emissions. There is no past work for comparison.

Propionaldehyde - The propionaldehyde emissions were 0.0019 and 0.0044 lb/mbf for ponderosa pine and white wood, respectively. There is no past work for comparison.

Acrolein - The propionaldehyde emissions were 0.0017 and 0.0050 lb/mbf for ponderosa pine and white wood, respectively. There is no past work for comparison.

VII. Quality Assurance

Leak checks

Leak checks were performed on the VOC system before and after drying and on the impinger sample train before each run.

Calibration

Data for the calibration gases are given in Appendix 4. The mid gas was not named because the analyzer was within tolerance without naming.

Detection limits (105)

The instrument detection limits were -

Methanol - 0.66 µg/mL in the aqueous phase
Phenol - 0.76 µg/mL in the aqueous phase
Formaldehyde - 0.12 µg/mL in the hexane phase
Acetaldehyde - 0.19 µg/mL in the hexane phase
Propionaldehyde - 0.19 µg/mL in the hexane phase
Acrolein - 0.48 µg/mL in the hexane phase

All samples were present in the aqueous or hexane phase at concentrations above the instrument detection limits except for propionaldehyde and acrolein in a few samples.

For ponderosa pine, propionaldehyde concentrations in the first five samples were below the instrument detection limit. Calculating the propionaldehyde emissions with ½ the instrument detection limit for these samples does not change the results.

For ponderosa pine, acrolein concentrations in the first five samples were below the instrument detection limit. Calculating the acrolein emissions with ½ the instrument detection limit for these samples changes the acrolein emissions from 0.0017 lb/mbf to 0.0020 lb/mbf.

For white wood, propionaldehyde concentrations in the first two samples were below the instrument detection limit. Calculating the propionaldehyde emissions with ½ the instrument detection limit for these samples does not change the results.

For white wood, the acrolein concentrations in one sample was slightly below the instrument detection limit. Calculating the acrolein emissions with ½ the instrument detection limit for this sample does not affect the results.

The method detection limit varies with gas flow through the impingers and the amount of water collected. We have calculated these for each sample in each charge by using the instrument method detection limit to calculate the concentration in the kiln gas) and averaged them below:

Ponderosa pine:
Methanol - mean = 0.40 ppmvd standard deviation = 0.05 ppmvd
Phenol - mean = 0.16 ppmvd standard deviation = 0.02 ppmvd
Formaldehyde - mean = 0.03 ppmvd standard deviation = 0.01 ppmvd
Acetaldehyde - mean = 0.03 ppmvd standard deviation = 0.01 ppmvd
Propionaldehyde - mean = 0.020 ppmvd standard deviation = 0.004 ppmvd
Acrolein - mean = 0.06 ppmvd standard deviation = 0.011 ppmvd

White wood:
Methanol - mean = 0.38 ppmvd standard deviation = 0.06 ppmvd
Phenol - mean = 0.15 ppmvd standard deviation = 0.04 ppmvd
Formaldehyde - mean = 0.03 ppmvd standard deviation = 0.01 ppmvd
Acetaldehyde - mean = 0.02 ppmvd standard deviation = 0.004 ppmvd
Propionaldehyde - mean = 0.06 ppmvd standard deviation = 0.01 ppmvd
Acrolein - mean = 0.33 ppmvd standard deviation = 0.08 ppmvd

Detection limits (98.01)

The detection limits are the same as above for methanol and formaldehyde. No samples were below the detection limits for this method.

Spikes, duplicates, and blanks

Spikes were run by putting a known quantity of water containing methanol, phenol, formaldehyde, acetaldehyde, propionaldehyde, and acrolein into the first impinger of a duplicate sampling train. Both trains were run simultaneously and the difference between the recovered chemicals and the expected recovery without the spike was calculated. The results are shown in Table 8 and 9.

Methanol had spike recoveries of 119.3% and 94.3% for ponderosa pine and 92.7% and 88.7% for white wood for Method 105. Methanol had spike recoveries of 100.7% for ponderosa pine and 106.6% and 101.5% for white wood for Method 98.01. These were all well within the +/-30% in the method.

Formaldehyde had spike recoveries of 186.4% and 69.4% for ponderosa pine and 86.5% and 88.4% for white wood for Method 105. The first Method 105 spike for the pine was outside the method limits of +/-40%. The first ponderosa pine spike was problematic for all aldehydes and will not be further discussed. Methanol had spike recoveries of 114.2% for ponderosa pine and 85.5% and 94.0% for white wood for Method 98.01. The corresponding sample was consistent with the other data. The Method 98.01 spikes were all within the +/-30% in the method.

Acetaldehyde had spike recoveries of 72.4% for the ponderosa pine and 75.2% and 85.3% for the white wood. The range of 70% to 130% is acceptable for gas concentrations greater than 1.5 ppmvd.

Propionaldehyde had spike recoveries of 72.4% for the ponderosa pine and 79.0% and 100.2% for the white wood. The range of 50% to 150% is acceptable for gas concentrations greater less than 0..5 ppmvd.

Acrolein had spike recoveries of 51.1% for the ponderosa pine and 72.2% and 84.4% for the white wood. The range of 50% to 150% is acceptable for gas concentrations greater less than 0.5 ppmvd.

Duplicate sample runs were made for each charge. These results of these are shown in Tables 8 and 9. All values under 30% are acceptable for methanol and acetaldehyde and 50% for the other compounds.

The differences between duplicates in Method 105 were less than 18.8% for methanol. In Method 98.01 the differences were less than 15.1%.

The difference between duplicates in Method 105 was 40.0% and 0.5%, and 7.1% for formaldehyde. The 40% difference occurred on a very low concentration sample and is within the method limits. In Method 98.01 the differences were 4.3% and 2.3%.

The difference between duplicates for acetaldehyde was 0.5 and 0.3%

The difference between duplicates for propionaldehyde was 3.2 and 2.6%

The difference between duplicates for acetaldehyde was 5.5%%. In the second duplicate run, one sample was a "no detect" so a second recovery could not be calculated.

Field blanks (samples of the impinger water) indicated the water used in the impingers was clean. Lab blanks of the water used for formaldehyde analysis indicated that it contained no formaldehyde.

Anomalies

There were no anomalies during the schedule that would significantly affect the total hydrocarbon data.

There were no anomalies that would significantly affect the HAPs results. One Method 105 spike did not work. The matching sample appeared to give consistent values with the samples before and after, so we believe the problem was with the spike, not the sample.

TABLE 8a. Summary of quality assurance for the ponderosa pine charge (NCASI 105).

Alcohol Spike (105)										
Run	Mass in impinger		Impinger flow	Corrected mass		Spike mass	Spike concentrations		Spike recoveries	
	Methanol	Phenol		Methanol	Phenol		Methanol	Phenol	Methanol	Phenol
	µg	µg	mL/min	µg	µg	g	µg/mL	µg/mL	%	%
8	246.2	0.0	435.5	242.0	0.0					
108	2639.2	0.0	428.2	2639.2	0.0	2.01	1000.0	0.0	119.3	#DIV/0!

Aldehyde Spike									
Run	Mass in impinger				Impinger flow	Mass corrected for flow			
	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein		Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
	µg	µg	µg	µg	mL/min	µg	µg	µg	µg
8	20.8	183.3	11.9	12.5	435.5	20.4	180.2	11.7	12.3
108	72.9	2526.5	51.8	47.3	428.2	72.9	2526.5	51.8	47.3

Spike mass	Spike concentrations					Spike recoveries			
	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein		Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
g	µg/mL	µg/mL	µg/mL	µg/mL		%	%	%	%
2.01	14.0	1347.7	11.3	8.6		186.4	86.6	176.6	202.4

Duplicate							
Run	Mass in impinger						Impinger flow
	Methanol	Phenol	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein	
	µg	µg	µg	µg	µg	µg	mL/min
3	75.6	0.0	4.9	181.5	1.1	0.0	420.8
103	82.8	0.0	6.8	162.2	1.0	0.0	378.2
Difference, %	18.8	#DIV/0!	40.0	0.5	3.2	#DIV/0!	

Field blank					
Methanol	Phenol	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
ppm	ppm	ppm	ppm	ppm	ppm
0.0	0.0	0.0	0.0	0.0	0.0

TABLE 8a continued. Summary of quality assurance for the ponderosa pine charge (NCASI 105).

Run	Mass in impinger		Impinger flow	Corrected mass		Spike mass	Spike concentrations		Spike re
	Methanol	Phenol	flow	Methanol	Phenol	mass	Methanol	Phenol	Methanol
	µg	µg	mL/min	µg	µg	g	µg/mL	µg/mL	%
9	440.7	0.0	437.8	433.3	0.0				
109	2744.2	0.0	434.0	2744.2	0.0	2.45	1000.0	0.0	94.3

Alcohol Spike (105)

Run	Mass in impinger				Impinger flow	Mass corrected for flow			
	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein	flow	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
	µg	µg	µg	µg	mL/min	µg	µg	µg	µg
9	33.2	266.7	25.7	25.8	437.8	32.9	264.4	25.5	25.6
109	56.7	2656.5	42.9	36.3	434.0	56.7	2656.5	42.9	36.3

Aldehyde Spike

Spike mass	Spike concentrations					Spike recoveries			
	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein		Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
g	µg	µg	µg	µg		%	%	%	%
2.45	14.0	1347.7	11.3	8.6		69.4	72.4	63.0	51.1

Run	Mass in impinger						Impinger flow
	Methanol	Phenol	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein	flow
	µg	µg	µg	µg	µg	µg	mL/min
7	350.8	0.0	40.7	389.3	19.1	20.2	436.9
107	337.3	0.0	36.9	354.6	17.0	17.5	399.3
Difference, %	4.9	#DIV/0!	0.5	0.3	2.6	5.5	

Duplicate

TABLE 8b. Summary of quality assurance for the white wood charge (NCASI 105).

Run	Alcohol Spike (105)									
	Mass in impinger		Impinger flow	Corrected mass		Spike mass	Spike concentrations		Spike recoveries	
	Methanol	Phenol	flow	Methanol	Phenol	mass	Methanol	Phenol	Methanol	Phenol
	µg	µg	mL/min	µg	µg	g	µg/mL	µg/mL	%	%
8	393.6	0.0	413.2	413.3	0.0	▓▓▓	▓▓▓	▓▓▓	▓▓▓	▓▓▓
108	4817.3	0.0	433.8	4817.3	0.0	4.75	1000.0	0.0	92.7	#DIV/0!

Run	Aldehyde Spike								
	Mass in impinger				Impinger flow	Mass corrected for flow			
	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein	flow	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
	µg	µg	µg	µg	mL/min	µg	µg	µg	µg
8	35.7	793.5	28.5	32.3	413.2	37.5	833.0	30.0	34.0
108	83.1	5819.9	76.0	72.2	433.8	83.1	5819.9	76.0	72.2

Spike mass	Spike concentrations					Spike recoveries			
	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein		Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
g	µg/mL	µg/mL	µg/mL	µg/mL		%	%	%	%
4.75	11.1	1396.2	12.3	12.7		86.5	75.2	79.0	63.4

Run	Duplicate						
	Mass in impinger						Impinger flow
	Methanol	Phenol	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein	flow
	µg	µg	µg	µg	µg	µg	mL/min
1	155.9	0.0	3.4	176.7	2.5	3.3	418.7
101	155.2	0.0	3.8	190.1	1.0	0.0	435.4
Difference, %	4.5	#DIV/0!	7.1	3.5	88.9	208.0	▓▓▓

Field blank					
Methanol	Phenol	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
ppm	ppm	ppm	ppm	ppm	ppm
0.0	0.0	0.0	0.0	0.0	0.0

Run	Alcohol Spike (105)									
	Mass in impinger		Impinger flow	Corrected mass		Spike mass	Spike concentrations		Spike recoveries	
	Methanol	Phenol	flow	Methanol	Phenol	mass	Methanol	Phenol	Methanol	Phenol
	µg	µg	mL/min	µg	µg	g	µg/mL	µg/mL	%	%
9	853.9	0.0	418.1	896.5	0.0	▓▓▓	▓▓▓	▓▓▓	▓▓▓	▓▓▓
109	3451.3	0.0	431.4	3451.3	0.0	2.88	1000.0	0.0	88.7	#DIV/0!

Run	Aldehyde Spike								
	Mass in impinger				Impinger flow	Mass corrected for flow			
	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein	flow	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
	µg	µg	µg	µg	mL/min	µg	µg	µg	µg
9	58.9	987.1	68.4	77.8	418.1	60.8	1018.5	70.6	80.3
109	88.4	4447.8	106.1	111.2	431.4	88.4	4447.8	106.1	111.2

Spike mass	Spike concentrations					Spike recoveries			
	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein		Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
g	µg	µg	µg	µg		%	%	%	%
2.88	11.1	1396.2	12.3	12.7		86.6	85.3	100.2	84.4

TABLE 9a. Summary of quality assurance for the ponderosa pine charge (NCASI 98.01).

Spike								
Methanol Run	Mass in impinger	Impinger flow	Corrected mass	Mass difference	Spike mass	Spike Concentration	Mass in Spike	Recovery
	µg	mL/min	µg	µg	g	ppmw	µg	%
10 101	939.2 3909.0	434.4 4105	8876 3909.01	302.4	3.00	1000	3000	100.7

Spike								
Formaldehyde Run	Mass in impinger	Impinger flow	Corrected mass	Mass difference	Spike mass	Spike Concentration	Mass in Spike	Recovery
	µg	mL/min	µg	µg	g	ppmw	µg	%
10 101	79.0 126.0	484 4105	747 126.0	51.4	3.00	15	45	114.2

Duplicate				
Methanol Run	Mass in impinger	Impinger flow	Corrected mass	Mass difference
	µg	mL/min	µg	%
4 41	83.8 80.3	4362 4085	78.5 80.3	2.4

Field blank	
Concentrations	
Methanol	Formald.
ppm	ppm
0.0	0.0

Duplicate				
Formaldehyde Run	Mass in impinger	Impinger flow	Corrected mass	Mass difference
	µg	mL/min	µg	%
4 41	14.4 12.9	4362 4085	84 12.9	4.3

TABLE 9b. Summary of quality assurance for the white wood charge (NCASI 98.01).

Methanol	Spike							
Run	Mass in impinger	Impinger flow	Corrected mass	Mass difference	Spike mass	Spike Concentration	Mass in Spike	Recovery
	µg	mL/min	µg	µg	g	ppmw	µg	%
14	4226.2	434.6	4079.4					
141	6009.1	419.4	6009.1	1929.9	1.81	1000	1810	106.6

Formaldehyde	Spike							
Run	Mass in impinger	Impinger flow	Corrected mass	Mass difference	Spike mass	Spike Concentration	Mass in Spike	Recovery
	µg	mL/min	µg	µg	g	ppmw	µg	%
14	173.0	434.6	167.0					
141	184.1	419.4	184.1	17.2	1.81	11.1	20.06586	85.5

Methanol	Duplicate			
Run	Mass in impinger	Impinger flow	Corrected mass	Mass difference
	µg	mL/min	µg	%
2	2717.2	436.0	2642.4	
21	2297.5	424.2	2297.5	15.1

Field blank	
Concentrations	
Methanol	Formald.
ppm	ppm
0.0	0.0

Formaldehyde	Duplicate			
Run	Mass in impinger	Impinger flow	Corrected mass	Mass difference
	µg	mL/min	µg	%
2	8.4	436.0	8.1	
21	8.0	424.2	8.0	2.3

Methanol	Spike							
Run	Mass in impinger	Impinger flow	Corrected mass	Mass difference	Spike mass	Spike Concentration	Mass in Spike	Recovery
	µg	mL/min	µg	µg	g	ppmw	µg	%
15	3037.0	440.1	2939.8					
151	5821.1	426.1	5821.1	2881.3	2.84	1000	2840	101.5

Formaldehyde	Spike							
Run	Mass in impinger	Impinger flow	Corrected mass	Mass difference	Spike mass	Spike Concentration	Mass in Spike	Recovery
	µg	mL/min	µg	µg	g	ppmw	µg	%
15	106.8	440.1	103.4					
151	133.0	426.1	133.0	29.6	2.84	11.1	31.48455	94.0

Appendix 1. Detailed Sampling Procedures

INSTRUCTIONS FOR CHECKS OF EMISSIONS KILN

Purpose: Ensure kiln is operating correctly

Clock time: Record from computer

Run time: Record from computer. Check the box if the computer screen being refreshed and time is advancing.

Box temperature: Read from metal electrical box under desk, left controller. The top and bottom numbers should be similar on the box should be similar, about 126 C..

Valve temperature: Read from metal electrical box under desk, right controller. The top and bottom numbers should be similar on the box should be similar, about 154 C..

Dry-bulb temperature: Read from computer screen. Compare to graph to be sure it's correct. If it's not within a degree or two of the chart, check again in a few minutes. During startup (the first 3 or so hours), it may not be able to track. If it's too high, the heat valve should be closed, too low and the heat valve should be open. If it does not appear to be working correctly, call Mike or Mark.

Wet-bulb temperature: Read from computer screen. Compare to graph to be sure it's correct.

If it is too low, it means that the kiln atmosphere is too dry. Check the flow meters. If Flow1 is about 10 L/min (its lower limit), make sure that Flow2 and Flow3 are turned off

If it's too high, then either the kiln atmosphere is too humid or the sock is not being wetted. If Flow 1 is near 200 L/min (its upper limit) add venting by opening Flow2 and/or Flow 3. The maximum for Flow2 is 50 L/min, if it reads over this value for several readings, reduce it to about 45 L/min. Don't change Flow3 often, rather set it and leave it for several hours if possible. Keep the Flow 3 reading constant by small adjustments. As Flow1 decreases or Flow2 turned down, there is more pressure behind Flow3 and the flow increased. Check for water in the wet-bulb reservoir (push the float down and make sure it's getting water).

Check both Wet-bulb1 and Wet-bulb2 and make sure they are reading about the same. If they differ by more than 2 C, call Mike or Mark.

If both wet-bulbs are reading the same as the dry-bulb, check the wet-bulb water.

If these procedures do not correct the wet-bulb temperature within 30 minutes, call Mike or Mark.

Line temperature: Read from gray box on wall above analyzer. It should read about 275°F.

Chiller temperature: Read the chiller temperature. It should be about -1°C.

Flow 1: Read from computer. The value of Flow1 changes depending on the wet-bulb. If Flow 1 is 10 L/min and the wet-bulb is too low, there's probably nothing we can do. If it's 200 L/min and the wet-bulb is too high, Flow2 and/or Flow3 can be opened. Flow2 and Flow3 should be adjusted so that Flow1 stays below 175 to 200 L/min.

Flow 2: Read from computer. The value of Flow2 is set by you. It will vary a little - as flow 1 goes down, flow 2 will go up. Do not set it to < 40 L/min if you think Flow1 is going to decrease or it will go off scale and not be read by the computer

Flow 3: Read from meter. The value of Flow3 is set by you. It will vary a little - as flow 1 goes down, flow 2 will go up.   Be sure to clearly record this value and when you change it

Dilution flow: Read dilution flow meter. It should read the same setting as the red flag. Do not adjust. If significantly different, investigate.

F/M Flow: Read from rotometer. This should be about 400 to 500 cc/min.

Line vacuum: Read from the vacuum gauge. This should be about 20"Hg.

INSTRUCTIONS - FIELD DATA SHEET FOR TOTAL HYDROCARBON ANALYZER
PRE-SAMPLE PROCEDURE

BACKGROUND INFORMATION

Get the dry- and wet-bulb temperatures from the kiln schedule or off the computer. Use the highest expected values for the run.

Read absolute humidity off the psychrometric chart or table.
Calculate or read from tables -
    Percent moisture = 100 / [1 + 1 / 1.61*AbHum]
    Target Dilution Ratio (TDR) = 15 / Percent Moisture

Event = the name of the drying cycle.
Run = the number of the 3-hour interval.
Operator, that's you.
Date and time are now, as you start the data collection process.

AMBIENT DATA

Call 9-754-0081 and get altimeter setting.
Read the laboratory temperature from the thermometer.

ANALYZER CALIBRATION

Set valves so that 1, 2 = off; 3=on; 4=vent. This allows gas to flow out of the vents from the calibration tanks and shuts off all other sources. Only calibration gas should go through the detector.

Open the zero gas tank valve
    zero toggle switch up (on), others down (off)
    set flow to 3.5 L/min using regulator on tank
    wait for a stable reading (about 30 to 60 seconds)
    use the zero dial (pot) on THA to get a zero reading
    read the analyzer
    read computer
    note pot setting
    close valve on zero gas tank

Open span gas tank valve
    span toggle switch up (on), others down (off)
    set flow to 3.5 L/min using regulator on tank
    set analyzer to range 3
    wait for a stable reading (about 30 to 60 seconds)
    use the span dial (pot) on THA to get a reading of 905 ppm
    read the analyzer, record, for example, 9.05 or 900

read computer (should read about 905)
note pot setting

Open mid gas tank valve
> mid toggle switch up (on), others down (off)
> set flow to 3.5 L/min using regulator on tank
> wait for a stable reading (about 30 to 60 seconds)
> read analyzer (do not adjust pot settings), record, for example, 4.12 or 412
> read computer (should about 412)
> check for within tolerance
> turn off mid gas
> all toggle switches off

SET DILUTION FLOW BEFORE RUN

Set valves so that 1, 2, 3 = off; 4=meter. This allows gas to flow only from the meter to the detector.

Use the Gilibrator to take 4 readings of the total flow rate (TFR). This is the total flow drawn by the analyzer and should be about 2.6 L/min
> Make sure the average does not include any "bad" readings
> Record the average, L/min = cc/min / 1000
> Write the Event, Run, and "Pre-TFR" on the Gilibrator printout.

Calculate the next two values –
> Target dilution flow rate (TDFR)   is the TFR x (1 – DR)
> Target sample flow rate (TSFR)   is the TFR x DR
> Check that the sum of these is the Total Flow Rate

Set dilution flow
> Set red pointer to desired dilution flow (on meter with valve 1)
> Slowly open lower valve on dilution flow meter (1=on; 2, 3=off; 4=meter)
> Use upper valve on dilution flow meter to adjust flow
> Do not adjust this meter after this point
> Read the meter that you just set and record the value

Use the Gilibrator to take 4 readings of the sample flow rate (SFR). This is the flow through the analyzer after dilution is set. It will vary, depending on the dilution setting.
> Make sure the average does not include any "bad" readings
> Record the average, L/min = cc/min / 1000
> Write "Pre-SFR" on the Gilibrator printout.

CHECK DILUTION FLOW BEFORE RUN

Set valves so that 1, 3 = on; 2=off; 4=vent. This allows gas to flow out of the vent from the calibration tank and shuts off all other sources. Calibration gas and dilution air will go through the detector.

Open span gas tank valve
> span toggle switch up (on), others down (off)
> set flow to 3.5 L/min using regulator on tank
> set analyzer to range 3
> wait for a stable reading (about 30 to 60 seconds)   record
> turn off all calibration gas tank valves
> all toggle switches off

Calculate the dilution ratio based on gas flow by dividing the Sample Flow Rate by the Total Flow Rate.

Calculate the dilution ratio based on span gas by dividing the Diluted span by the undiluted span.

If the Dilution ratios do not agree within 5% - DO NOT PROCEED****. Use $100*(DR_{Span} - DR_{Flow})/DR_{Flow}$ to calculate the % difference.

**** check calculations, check that values for ppm and flows make sense, remeasure everything. If it still does not agree, call Mike or Mark

START RUN

Set valve so that 1, 2, 5 = on; 3, 4=off; all calibration tank valves off

Record the start time. Use the computer clock for all times or set your watch to the computer time.

Make sure analyzer is on appropriate range, usually range 3, to keep THC reading on computer between 60 and 750.

Monitor system, as needed. Record system condition at least hourly.

End time should be no more than 3 hours from start time.

POST-SAMPLE PROCEDURE

AT END OF RUN

Record your name as the operator.
Event = the drying cycle. Run = the 3-hour interval.
Operator, that's you. Date and time are now, as you start the data collection process.

AMBIENT DATA

Call 9-754-0081 and get temperature and altimeter
Local pressure = (Altimeter - 0.23) x 3.3867
Read the laboratory temperature from the thermometer.

Fill out appropriate information on Pre-sample side of data sheet for next run. This will save time in between runs.

END TIME

Record computer time.
DO NOT adjust dilution gas yet.

CHECK DILUTION FLOW AFTER RUN

Set valves so that 1, 3 = on; 2=off; 4=vent. This allows gas to flow out of the vent from the calibration tank and shuts off all other sources. Calibration gas and dilution air will go through the detector.

Open span gas tank valve
       span toggle switch up (on), others down (off)
       set flow to 3.5 L/min using regulator on tank
       wait for a stable reading (about 30 -60 seconds)
       record
       all toggle switches off

Sample flow rate. Set valves so that 1=on; 2, 3 = off; 4=meter. This allows gas to flow only from the meter and the dilution to the detector.

       Use the Gilibrator to take 5 readings of the sample flow rate (SFR). This is the
          flow through the analyzer with dilution on.
       Make sure the average does not include any "bad" readings
       Record the average, L/min = cc/min / 1000
       Write "Post-SFR" on the Gilibrator printout.

Read dilution flow meter
To calculate the L/min, divide scfh by 2.12
Turn off dilution flow meter using valve 1

Total flow rate. Set valves so that 1, 2, 3 = off; 4=meter. This allows gas to flow only from the meter to the detector.

Use the Gilibrator to take 5 readings of the total flow rate (TFR). This is the
total flow drawn by the analyzer and should be about 2.6 L/min
Make sure the average does not include any "bad" readings
Record the average, L/min = cc/min / 1000
Write "Post-TFR" on the Gilibrator printout.

CHECK CALIBRATION OF ANALYZER

Set valves so that 1, 2 = off; 3=on; 4=vent. This allows gas to flow out of the vents from the calibration tanks and shuts off all other sources. Only calibration gas should go through the detector.

Span gas tank valve should be open
span toggle switch up (on), others down (off)
set flow to 3.5 L/min using regulator on tank
set analyzer to range 4
wait for a stable reading (about 30 -60 seconds)
read analyzer (do not adjust pot settings), record, for example, 1.50 as 1500
read computer (should read about 152 due to range 4 setting)
note pot setting
check for within tolerance - between 1483 and 1573

Open mid gas tank valve
mid toggle switch up (on), others down (off)
set flow to 3.5 L/min using regulator on tank
set analyzer to range 3
wait for a stable reading (about 30 -60 seconds)
read analyzer (do not adjust pot settings), record, for example, 8.50 as 850
read computer (should read same as analyzer)
check for within tolerance

Open the zero gas tank valve
zero toggle switch up (on), others down (off)
set flow to 3.5 L/min using regulator on tank
wait for a stable reading (about 30 -60 seconds)
read analyzer (do not adjust pot settings)

read computer
note pot setting

Calculate the dilution ratio based on gas flow by dividing the Sample Flow Rate by the Total Flow Rate.

Calculate the dilution ratio based on gas flow by dividing the Sample Flow Rate by the Total Flow Rate.

Calculate % difference as $100 * \{Absolute\ Value\ (DR_{Span}-DR_{Flow})\} / DR_{Flow}$

Record the time now as the end time for check.

Tear off the four sets of Gilibrator readings (Pre-TFR, Pre-SFR, Post-SFR, Post-TFR) and staple to paper with other records.

Start Pre-Sample procedure for next run.

INSTRUCTIONS FOR FORMALDEHYDE / METHANOL
COLLECTION AND HAPS SAMPLING

BACKGROUND DATA
Operator, that's you.
Date and time are now, as you start the data collection process.
Event = Kiln Charge
Run = sequence of HAP measurement

PRE RUN DATA
Call 9-754-0081 and get altimeter setting.
Read the laboratory temperature from the thermometer.

IMPINGER WEIGHTS
Lab wash impingers, Dry the outside.
Weigh the impingers.

Put 15 mL BHA solution in impinger #1.   (10 mL distilled water for 98.01 and 99.02)
Put 15 mL BHA solution impinger #2   (20 mL distilled water for 98.01 and 99.02)
Put 15 mL BHA solution in impingeer   (Empty for 98.01 and 99.02)

Reweigh the impingers.
Install impingers and lower into chiller

LEAK CHECK
Close valve to sample probe.
Turn on pump
Evacuate to 15 to 18 " Hg
Close valve that is near pump
Turn off pump
Note pressure and start timer
Allowable pressure change is 1" Hg in 2 minutes, if it is much more than this, find the source of the leak.
Slowly open valve near probe tip. When bubbles are no longer seen, open completely
Open valve near pump

SAMPLE FLOW RATE
Attach probe tip to Gilibrator
Take 4 readings
Make sure all readings in average are "good" readings
Record the average

START TIME

Put probe into kiln
Open port on Summa canister (99.02 only)
Record time.

FLOW READINGS DURING TEST

Note flow meter reading at least every hour
Run test for 3 to 6 hours, less if impingers fill (98.01). 99.02 is limited by Summa
canister time limit. Run < 3 hours for 98.01.

POST RUN DATA

Call 9-754-0081 and get altimeter setting.
Read the laboratory temperature from the thermometer
Label a clean vial with the Event and Run numbers

END TIME

Remove probe from kiln
Close Summa cannister
Record time

SAMPLE FLOW RATE

Rinse probe with 5 mL of DI water (weighed)
Attach probe tip to Gilibrator
Take 4 readings
Make sure all readings in average are "good" readings
Record the average
Lift impingers from chiller
Remove impingers

IMPINGER WEIGHTS

Pre weigh and label sample bottle and lid
Dry the outside of the impingers
Weigh the impingers with the water (no tops) and record
Combine the water from the two (or three) impingers into the labeled bottle
Weight the bottle with its lid (105 only)
Rinse the impingers with 10 mL distilled water - #3 then #2 then #1 (105 only)
Put the rinse into the vial and weigh the vial with its lid (105 only)
Rinse the impingers with 5 mL hexane - #3 then #2 then #1 (105 only)
Put the rinse into the vial and weigh the vial with its lid (105 only)
Place sealed vial into refrigerator
Note any liquid lost during this procedure

Appendix 3. Samples of field data sheets.

Charge:	Hampton, P.Pine		Date	Time
		Start	June 3 2007	7:21
Page:	1	End		

Clock time	Run time	Run #	Temperatures						Flows							Line 1	Line 2	Line 3
			Box	Valve	Dry-bulb	Wet-bulb	Line	Chiller	Flow 1	Flow 2	Flow 3	Dilution	Line 1	Line 2	Line 3	Vac.	Vac.	Vac.
hrs	hrs	#	°C	°C	°C	°C	°C	°C	L/min	L/min	SCFH	SCFM	ml/min	ml/min	ml/min	inHg	inHg	inHg
7:23	0:02	1	124	145	22.2	23.7	135	-1	7	–	–	0	500	450	–	28	27.3	–
7:44	0:44	1	125	145	38.7	29.2	135	-1	7	–	–	0	510	450	–	28	27.3	–
8:10	0:49	1	125	145	43.4	33.6	135	-1	8	–	–	0	500	450	–	28	27.5	–
9:23	2:02	1	125	145	49.0	38.8	135	-1	8	–	–	0	500	450	–	28	27.5	–
10:08	2:47	1	125	145	51.6	44.1	135	-1	165	44	–	0	500	450	–	28	27.5	–
10:54	3:32	2	125	144	53.3	46.3	135	-1	186	38	–	0	500	450	–	28	28	–
11:13	3:51	2	126	145	52.6	47.7	1	-1	197	40	–	0	500	450	–	28	28	–
12:02	4:41	2	125	145	55.5	48.9	135	-1	197	40	–	0	500	450	–	28	28	–
13:16	5:55	3	125	145	56.2	49.4	135	-1	198	40	–	0	500	450	–	28	28	–
14:53	7:31	3	124	145	57.9	49.8	135	-1	196	40	–	0	500	450	–	28	28	–
16:50	9:29	3	124	145	60.0	50.2	135	-1	195	39	–	0	500	450	480	28	28	39
17:38	10:18	4	125	145	57.6	52.0	135	-1	194	39	–	0	500	450	480	28	39	39
19:23	12:02	4	125	145	64.2	53.4	135	-1	195	39	–	0	500	450	480	28	27.5	29
20:23	13:07		121	541	64.29	53.1	135	-1	195	35	–		500	450	480	28	28	29
21:31	14:10	5	125	145	65.8	53.8	135	-1	195	39			500	450		28.5	28	
22:13	14:52	5	124	145	66.5	53.6	135	-1	195	39			500	450		28.5	28	
23:10	15:49	5	125	145	66.3	53.6	135	-1	195	39			500	450		28.5	28	

FIELD DATA SHEET, 105 HAPS MEASUREMENT - BEFORE SAMPLING

BACKGROUND INFORMATION

Operator: _Milong_

Date: _May June 3, 02_

Time now : _6:15A_

TRAIN #1 - BEFORE

Event (kiln charge): Hampton, P.Pine

Run (sample): _1A_

PRE RUN DATA

Altimeter setting: _29 92_ inHg   Laboratory temperature: _24.3_ °C

Isopropanol rinse or lab wash: ☒

IMPINGER WEIGHTS

	Dry Weight, g	Wet Weight, g	Water added, g
Impinger #1	42.87	56.97	(~15 mL)
Impinger #2	42.22	54.60	(~15 mL)
Impinger #3	39.65	53.08	(~15 mL)
		Total added:	

LEAK CHECK _23.4_   _0_   inHg after 2 minutes

SAMPLE FLOW RATE : _486.3_ mL/min   [Average of 4. Label printout]

START   **CLOCK TIME:** _7:21 A_

EVENT TIME: _0_   (elapsed time)

FLOW READINGS DURING TEST (hourly)

Clock time			
Flow rate, mL/min			
Vent flow, L/min			

/

FIELD DATA SHEET, 105 HAPS MEASUREMENT - AFTER SAMPLING

BACKGROUND INFORMATION

Operator: _Milan_

Time now : _10:10_

TRAIN #1 - AFTER

Event (kiln charge): Hampton, P.Pine

Run (sample): _1A_

POST RUN DATA

Altimeter setting: _2993_ inHg   Laboratory temperature: _27.2_ °C

END   **CLOCK TIME:** _~~AM~~ 10:16_

EVENT TIME: _254_ (elapsed time)

EMPTY BOTTLE WEIGHT: _~~138~~ 96.27_ g

SAMPLE LINE RINSE : _17.73_ g   _13.43_ g   (~5 mL)

SAMPLE FLOW RATE : _501.6_ mL/min   [Average of 4. Label printout]

IMPINGER WEIGHTS

	Wet Weight, g	Dry Weight, g	Water removed, g
Impinger #1	63.16		
Impinger #2	54.71		
Impinger #3	53.12		

BOTTLE WEIGHT WITHOUT RINSE: _142.22_ g

BOTTLE WEIGHT WITH RINSE: _153.25_ g

HEXANE RINSE: ☒

FILLED BOTTLE WEIGHT: _159.64_ g

Water lost during handling: _0_ mL   [estimate]

Comments:

_____

_____

_____

FIELD DATA SHEET, 98.01 HAPS MEASUREMENT - BEFORE SAMPLING

BACKGROUND INFORMATION

Operator: S. Kruber

Date: 6/3/67

Time now: 20:45

TRAIN #2 - BEFORE

Event (kiln charge): Hampton, P.Pine

Run (sample): 5b

PRE RUN DATA

Altimeter setting: 2998 inHg

Laboratory temperature: 29.3 °C

IMPINGER WEIGHTS

	Dry Weight, g	Wet Weight, g	Water added, g
Impinger #1	41.93	52.15	10.22 (~10 mL)
Impinger #2	40.90	57.42	16.52 (~15-20 mL)
Impinger #3	40.57	——	——
		Total added:	26.74

LEAK CHECK ___ø___ inHg after 2 minutes

SAMPLE FLOW RATE : 0.4943 mL/min   [Average of 4. Label printout]

START   **CLOCK TIME:** 21:30

    EVENT TIME: 14:09   (elapsed time)

FLOW READINGS DURING TEST (hourly)

Clock time			
Flow rate, mL/min			
Vent flow, L/min			

FIELD DATA SHEET, 98.01 HAPS MEASUREMENT - AFTER SAMPLING

BACKGROUND INFORMATION

Operator: J.Veiber

Time now : 00:33

TRAIN #2 - AFTER

Event (kiln charge): Hampton, P.Pine

Run (sample): 56

POST RUN DATA

Altimeter setting: 2998 inHg

Laboratory temperature: 28.4 °C

END   CLOCK TIME: 00:30

          EVENT TIME: 17:09 (elapsed time)

SAMPLE LINE RINSE ☒   (~5 mL)

SAMPLE FLOW RATE : 0.4980 mL/min   [Average of 4. Label printout]

IMPINGER WEIGHTS

	Wet Weight, g	Dry Weight, g	Water removed, g
Impinger #1	65.86		
Impinger #2	57.57		
Impinger #3			

Water lost during handling: ∅ mL   [estimate]

Comments:

_____

_____

_____

FIELD DATA SHEET FOR TOTAL HYDROCARBON ANALYZER - BEFORE

BACKGROUND INFORMATION

Event (kiln charge): Hampton, P.Pine

Run (sample): 6

Operator: J. Kerber

Date: 6/4/07

Time now : 1:51

Dry-bulb temperature: 70.4°C

Wet-bulb temperature: 55.5°C

Target Dilution Ratio (TDR): /

AMBIENT DATA

Laboratory temperature: 27.5 °C

ANALYZER CALIBRATION   [1, 2 = off; 3=on; 4=vent]

	Analyzer, ppm	Computer	Within range	Pot settings
zero	2 (0)	2	does not apply	470
span	611 (611)	611	does not apply	494
mid	304 (300)	303	280 to 322	none

SET DILUTION FLOW BEFORE RUN

Total flow rate (TFR): 1.691 L/min   [1, 2, 3 = off; 4=meter]

Target
    dilution flow rate (TDFR) _____ L/min $[TFR \times (1 - DR)]$

    sample flow rate (TSFR) _____ L/min $[TFR \times DR]$

Set and read dilution meter: _____ scfh $[scfh = L/min * 2.12]$

Sample flow rate (SFR): _____ L/min   [1 = on; 2, 3 = off; 4=meter]

CHECK DILUTION FLOW BEFORE RUN   [1, 3=on; 2=off; 4=vent]

	Analyzer	DR_{Span} [$Span_{Diluted}$/Span]	DR_{Flow} [SFR / TFR]	Difference, % 100*(DR_{Span} - DR_{Flow})/DR_{Flow}
$Span_{Diluted}$				

START TIME: 2:00   [1, 2, 5 = on;   3, 4 = off; tank valves off]

ANALYZER RANGE: 2   [60 < computer reading < 750]

FIELD DATA SHEET FOR TOTAL HYDROCARBON ANALYZER - AFTER

Operator: _Milora_

Event (kiln charge): Hampton, P.Pine

Time now: _4:50_

Run (sample): _6_

AMBIENT DATA

Laboratory temperature: _26.6_ °C

END TIME: _4:51_

CHECK DILUTION FLOW AFTER RUN   [1, 3=on; 2=off; 4=vent]

	Analyzer	Computer
Span$_{Diluted}$		

Sample flow rate (SFR) : _1.698_ L/min   [1= on, 2, 3 = off, 4=meter]

Read dilution meter: _0_ scfh _____ L/min   [L/min = scfh*0.472]

Total flow rate (TFR): _____ L/min   [1, 2, 3 = off; 4=meter]
(attach print out with all four sets of data)

Dilution ratio (DR$_{Flow}$): _____   [SFR / TFR]

CHECK OF ANALYZER CALIBRATION   [1, 2=off; 3=on, 4=vent]

	Analyzer	Computer	Within range	Pot settings
span	627	628	593 to 629	494
mid	311	310	287 to 313	none
zero	0	0	-18 to +18	470

Dilution ratio (DR$_{Span}$): _____   [Span$_{Diluted}$ / Span]

Dilution ratio difference: _____ %   [100*(Abs(DR$_{Span}$ - DR$_{Flow}$))/DR$_{Flow}$]

End time for check: _4:53_

Comments: _____

_____

_____

_____

Appendix 4. Calibration Data

Airgas

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number: E02AI99E15A0453
Cylinder Number: XC031356B
Laboratory: ASG - Chicago - IL
Analysis Date: Feb 09, 2007

Reference Number: 54-124086894-1
Cylinder Volume: 146 Cu.Ft.
Cylinder Pressure: 2015 PSIG
Valve Outlet: 590

Expiration Date: Feb 09, 2010

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 150 psig.i.e. 1 Mega Pascal

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty
PROPANE	300.000 PPM	299.9 PPM	G1	+/- 1% NIST Traceable
Air	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM	51919	SG9101963ALB	483.6PPM PROPANE/	Jul 01, 2009

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
VARIAN CP3800	FID	Feb 02, 2007

Triad Data Available Upon Request

Notes:

QA Approval

Airgas

Certificate of Analysis: EPA Protocol Gas Mixture

Cylinder Number: CC44350 Reference Number: 54-124076439-1
Cylinder Pressure: 2000.6 PSIG Expiration Date: 10/4/2009
Certification Date: 10/4/2006 Laboratory: ASG - Chicago - IL

Certified Concentrations

Component	Concentration	Accuracy	Analytical Principle	Procedure
PROPANE	611.3 PPM	+/- 1%	FID	G1
Air	Balance			

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences.

Notes:

Do not use cylinder below 150 psig. Approval Signature _____

Reference Standard Information

Type	Balance Gas	Component	Cyl.Number	Concentration
NTRM 51919		PROPANE	SG91019634-B	483.6 PPM

Analytical Results

1st Component PROPANE

1st Analysis Date: 10/04/2006

R 310807	S 391575	Z 0	Conc 609.7 PPM
S 393458	Z 0	R 310893	Conc 612.6 PPM
Z 0	R 316077	S 392797	Conc 611.6 PPM
			AVG: 611.3 PPM