HAMPTON LUMBER MILLS, INC
COWLITZ RANDLE - DIVISION

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SOUTHWEST CLEAN
AIR AGENCY

March 11, 2013

Southwest Clean Air Agency
Vannessa McClelland
Air Quality Engineer
11815 NE 99th St., Suite 1294
Vancouver, WA 98685-2454

Re: ADP #06-2691R1, Condition #41, Ponderosa Pine Wood Test

Dear Vannessa:

Hampton Lumber-Randle tested Ponderosa Pine instead of predominant Hemlock (Hem-Fir) species as per approval from SWCAA on January 22, 2013. Enclosed is the report from Oregon State University. The test was completed on February 14, 2013.

If you have any questions please contact Darlene Hardy, Environmental Engineer at 503-319-9750 or myself at (360) 497-5030.

Respectfully Submitted,

Ken Rankin
Plant Manager

cc: David Like, Hampton Environmental Manager
     Darlene Hardy, Environmental Engineer

Bob _____
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Paul _____
Wess _____
Clint _____
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Vannessa ⟋⟋⟋
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Emissions from the drying of ponderosa pine lumber

Report by

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March 7, 2013

Table of Contents

List of Figures

List of Tables

Summary

Two charges of ponderosa pine 2x4 lumber were dried in a small kiln at Oregon State University. The kiln dry- and wet-bulb temperatures were based on a schedule provided by Hampton. The maximum temperature was 180°F (82°C). The air velocity was 750 feet per minute (3.7 m/s). The kiln was indirectly heated with steam. The amount of air entering the kiln was regulated to control humidity.

A JUM VE-7 total hydrocarbon analyzer was used to measure organic emissions following EPA Method 25A. The results are shown in Table 1.

Table 1. Summary of total hydrocarbon results to 15% moisture content. VOC units are pounds per thousand board feet as carbon.

Charge	Initial MC	Final MC	Time to 15%	VOC
	%	%	hr:min	lb/mbf
Pine 1	103.9	15.0	39.23[A]	1.48
Pine 2	122.0	15.0	43:37[B]	1.72

[A] actual time to 14.1% MC was 40:55 hours
[B] actual time to 14.7% MC was 44:30 hours

NCASI Method ISS/FP-A105.01 was used to measure the MACT HAP emissions on both charges, but the charge 1 data was not satisfactory. The results for charge two are shown in Table 2. The sum of the HAPs emitted was 0.17 lb/mbf for the ponderosa pine.

Table 2. Summary of HAP results for moisture content and time shown in Table 1. Emissions units are pounds per thousand board feet.

	Methanol	Phenol[A]	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
Pine 2	0.058	0.00	0.005	0.100	0.0035	0.0055

[A] None detected

1. Description of source

The tested source is a lumber dry kiln. Lumber destined for the mill's kiln was sampled and tested in a small-scale kiln at Oregon State University.

Mill personnel reported that the logs had been stored on site since September 18, 2012 after being harvested in the Yakima area. Sawing was on January 18, 2013.

Enough wood for two charges of lumber was delivered to Oregon State by Darlene Hardy of Hampton Lumber on January 25, 2013. The wood was wrapped in plastic and lumber wrap at the mill to prevent moisture loss during transport. The wood appeared to be fresh with a small amount of blue stain in the sapwood. There was no mold on the sapwood.

At OSU, the wood was sorted into two 33-board units on January 25. It was wrapped in plastic and one charge placed in a refrigerator at 35°F and the remainder in a freezer at 10°F.

2. Date and time of test

The first charge was dried from January 31, 2013 at 6 am until 11:00 pm on February 1, 2013. The second charge was dried from February 12, 2013 at 3 pm until 11:30 am on February 14, 2013. Drying was done under the supervision of Mike Milota at Oregon State University. Students were used to monitor parts of the test.

3. Results

Total hydrocarbon

See Table 1, page 1, for a summary of the hydrocarbon results. Details for each sampling interval are tabulated and the hydrocarbon emissions are summarized graphically here. All emission data is presented in detail in electronic form in Appendix 2.

A summary for each sampling interval is in Table 3 for charge 1 and Table 4 for charge 2. An interval is the period between analyzer calibrations, about six hours of data. The interval time periods shown in the table include the calibration times and mass calculations are adjusted to account for these. Sampling occurred for approximately 95% of the drying time.

Figures 1 and 2 show total hydrocarbon concentration (left scale) and dry gas vent rate (right scale) versus time. Concentration has a small peak initially until venting increases at approximately three hours. The concentration then increases throughout the schedule as vent rate decreases.

Figures 3 and 4 show the cumulative hydrocarbon emissions (left scale, smooth line) and the rate of emissions (right scale, jagged line) 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 rate occurs at the midpoint of the schedule where the kiln temperature reaches its maximum of 180°F. It then steadily decreases as the moisture loss from the wood slows.

Figures 5 and 6 show the total hydrocarbon emissions as a function of wood moisture content. These graphs would be useful for predicting emissions at various final moisture content levels.

Charge two had higher emissions, but also had a higher starting moisture content. If one were to shift the line in Figure 5 to the right so the moisture content started at 122%, the line for charge one would be very close to the line for charge 2 in Figure 6.

Table 3. Summary of results for each sampling interval for total hydrocarbon during charge 1.

Sample Run	Time	Average Humidity	Flow rate Dry @68	Flow rate Wet @68	THC mass as C	THC concentration wet	THC concentration dry	THC mass as C	THC rate as C	Wood MC	Average Air MC	Anal. MC
	hrs	kg/kg	l/min	l/min	g	ppmv	ppmv	lbs/mbf	lb/hr/mbf	%	%	%
1	5.09	0.016	178.6	183.0	2.86	36.3	37.3	0.079	0.0155	103.9	2.4	2.4
2	4.66	0.032	259.6	273.2	3.78	33.2	34.8	0.104	0.0224	100.4	5.0	5.0
3	4.22	0.058	196.7	215.1	4.61	58.5	62.8	0.127	0.0301	94.8	8.6	8.6
4	7.80	0.147	175.1	216.5	13.03	91.5	107.0	0.359	0.0460	81.3	19.1	19.1
5	5.54	0.213	173.2	232.7	12.52	118.4	145.2	0.345	0.0623	53.1	25.6	15.4
6	5.21	0.214	116.3	156.5	8.81	134.0	164.4	0.243	0.0466	31.6	25.7	15.7
7	0.60	0.213	82.9	111.4	0.93	170.1	208.5	0.026	0.0425	23.6	25.5	16.3
8	5.21	0.214	51.2	68.9	6.21	219.0	268.8	0.171	0.0328	18.9	25.6	16.7
9	1.06	0.215	27.9	37.5	0.95	293.3	360.1	0.026	0.0249	15.4	25.7	16.4
10												
Sum	39.38				53.7			1.480				
Average		0.147	140.2	166.1		128.3	154.3		0.0359			

Table 4. Summary of results for each sampling interval for total hydrocarbon during charge 2.

Sample Run	Time	Average Humidity	Flow rate Dry @68	Flow rate Wet @68	THC mass as C	THC concentration wet	THC concentration dry	THC mass as C	THC rate as C	Wood MC	Average Air MC	Anal. MC
	hrs	kg/kg	l/min	l/min	g	ppmv	ppmv	lbs/mbf	lb/hr/mbf	%	%	%
1	5.26	0.018	122.6	126.2	3.56	85.5	87.5	0.098	0.0187	122.0	2.9	2.9
2	6.89	0.042	227.6	242.9	6.95	46.8	49.4	0.191	0.0278	117.3	6.3	4.4
3	6.65	0.086	184.6	210.3	8.90	75.0	82.8	0.245	0.0369	106.4	12.2	8.5
4	5.74	0.178	197.0	253.4	12.06	98.8	118.1	0.332	0.0579	88.5	22.3	15.6
5	5.21	0.212	190.8	256.0	11.46	104.9	128.5	0.316	0.0607	60.0	25.5	17.8
6	6.82	0.213	122.5	164.4	11.64	128.3	157.2	0.321	0.0471	35.0	25.5	12.6
7	6.50	0.213	53.6	71.9	7.40	209.2	256.4	0.204	0.0314	19.3	25.5	12.5
8	0.55	0.213	24.3	32.6	0.44	297.1	364.2	0.012	0.0219	15.4	25.5	12.5
Sum	43.61				62.4			1.720				
Average		0.147	140.4	169.7		130.7	155.5		0.0378			
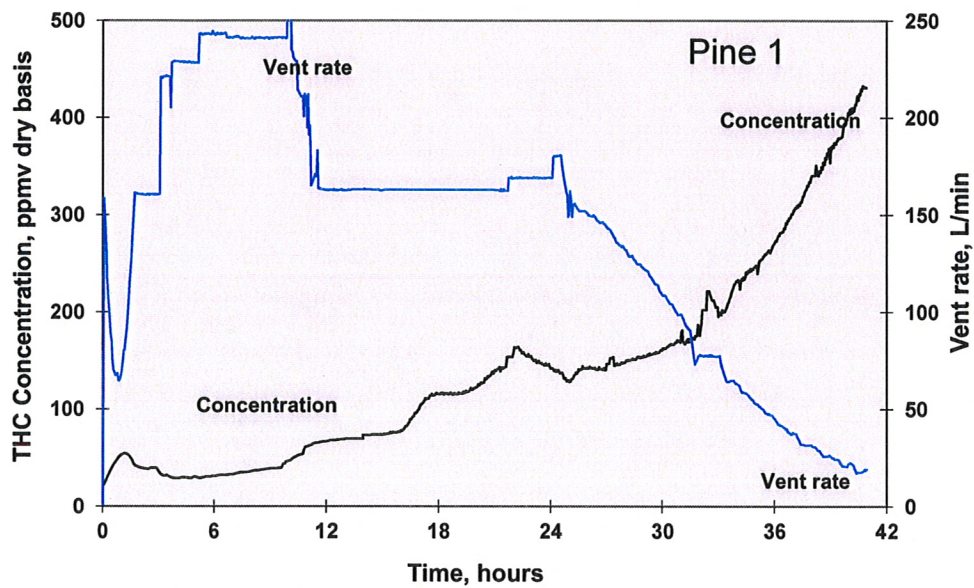
Figure 1. Hydrocarbon concentration and vent rate versus time for charge 1.
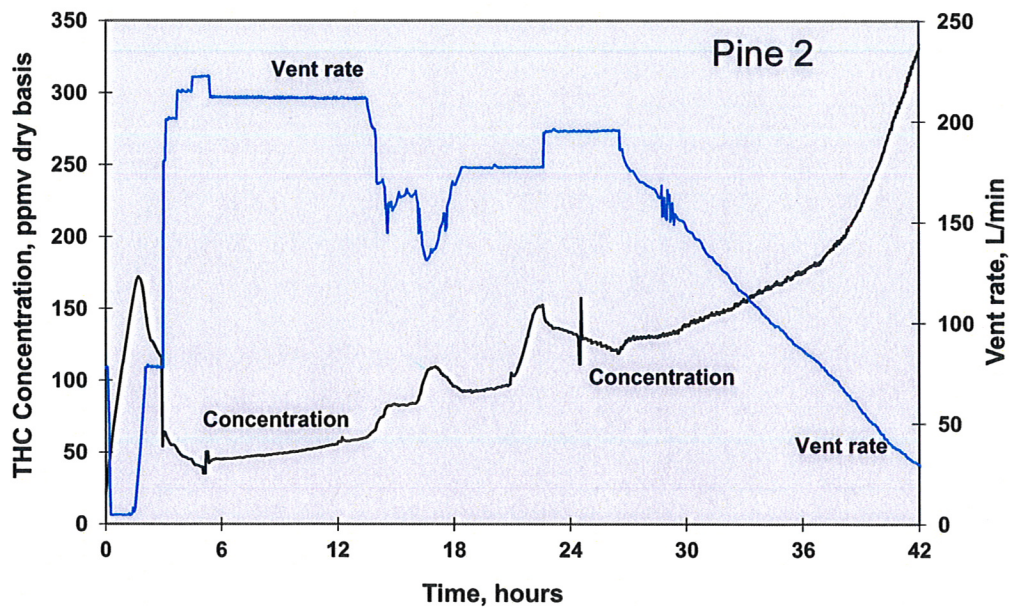
Figure 2. Hydrocarbon concentration and vent rate versus time for charge 2.
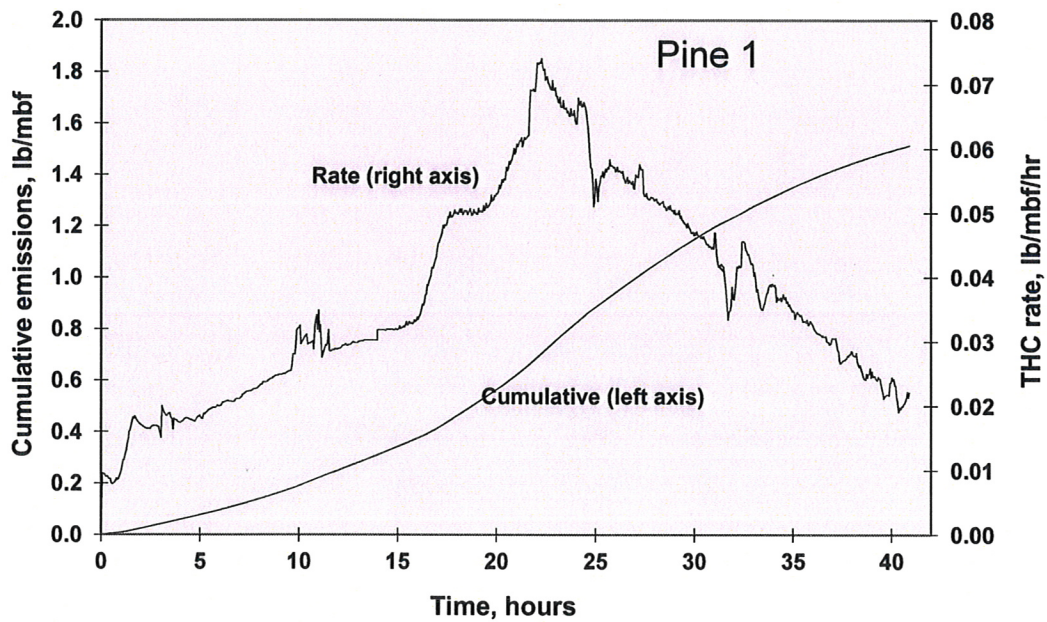
Figure 3. Cumulative hydrocarbon emissions (left scale, black line) and the rate of emissions (right scale, jagged line) versus time for charge 1.
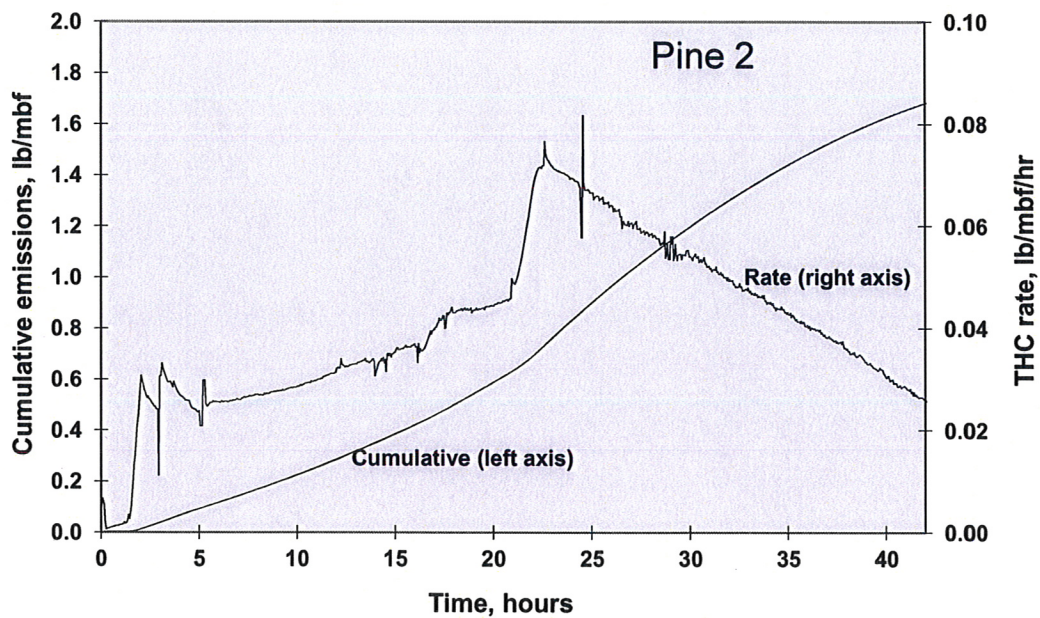
Figure 4. Cumulative hydrocarbon emissions (left scale, smooth line) and the rate of emissions (right scale, jagged line) versus time for charge 2.
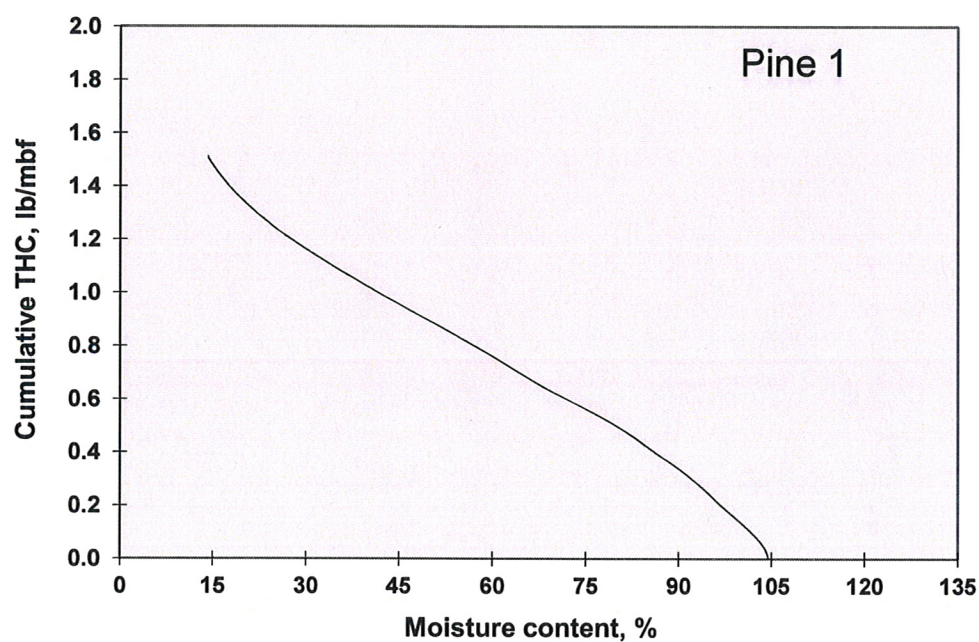
Figure 5. Total hydrocarbon emissions as a function of wood moisture content for charge 1.
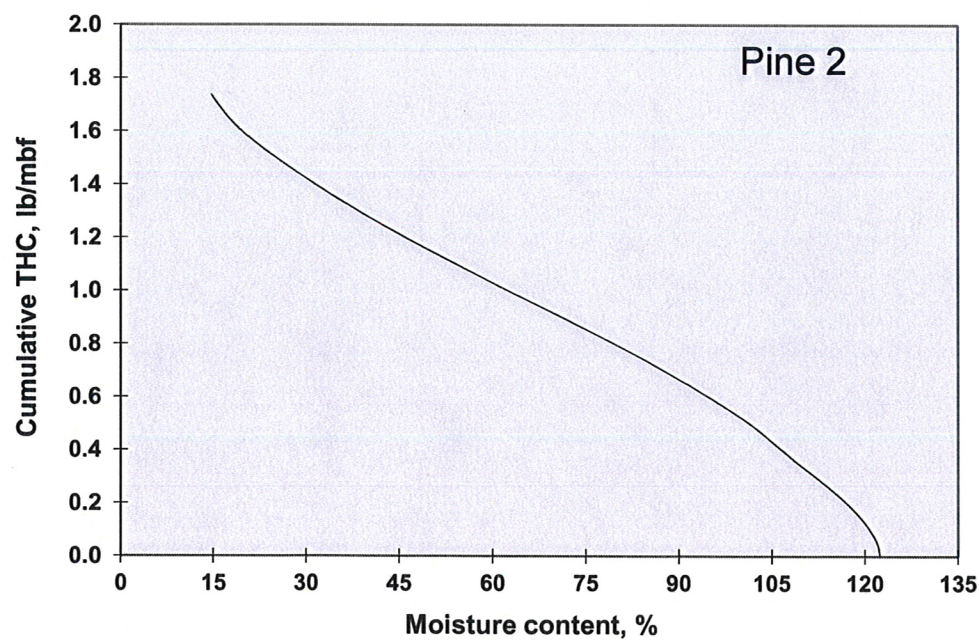
Figure 6. Total hydrocarbon emissions as a function of wood moisture content for charge 2.

HAPs

See Table 2, page 1, for a summary of the HAP results. Details for each sampling interval are tabulated and the HAP emissions are summarized graphically here. All emission data is presented in detail in electronic form in Appendix 2.

A summary of the kiln conditions for each sampling interval is in Table 5. A collection interval is the time the impingers were on and sampling occurred, approximately 1:25 to 1:35. An adjusted interval is the period spanning the midpoints between collection intervals, about three hours. For example, if the impingers were on from 1:30 to 3:00, 4:30 to 6:00, and 7:30 to 9:00, the 4:30 to 6:30 impinger set represents the adjusted interval from 3:45 to 6:45. The mass calculations are adjusted proportionally to represent emissions during the adjusted interval. For example, if a collection interval was 90 minutes and the adjusted interval was three hours, the amount of HAPs in the impinger is multiplied by two. Sampling occurred for approximately 50% of the drying time.

The MACT HAP emissions and the emissions of ethanol and acetic acid are shown in Table 6. The total HAP emissions were 0.17 lb/mbf for the ponderosa pine (does not include the non-HAPs, ethanol and acetic acid). Acetaldehyde is the HAP emitted in the greatest quantity followed by methanol. The other HAPs are present, but comprise only 8% of all the HAPs. Phenol was not detected in any sample.

The HAP emissions as a function of time and wood moisture content during the cycle are shown in Figures 7 and 8, respectively. The rate of HAP emissions decreases with time while the kiln temperature is increasing (lines are concave upward in Figure 7), then decreases with time later in the schedule (lines are concave downward). The HAP emissions per percent moisture content change generally increase as moisture content decreases except for acetaldehyde.

Table 5. Summary of HAP sampling intervals for charge 2.

Sample Run ID	Collection Interval	Adjusted Interval	Dry gas mass	Average Dry gas flow rate	Molar Humidity	Moisture Content Mid	Moisture Content End
	hours	hours	kg	kg/min	mol/mol	%	%
1	1.50	2.26	4.413	0.033	0.017	122.4	122.3
2	1.50	2.76	38.052	0.230	0.032	121.8	121.0
3	1.50	2.81	46.524	0.276	0.043	120.0	118.6
4	1.50	3.24	53.303	0.274	0.058	116.8	114.4
5	1.55	3.43	54.074	0.263	0.077	111.4	108.4
6	1.53	3.22	37.957	0.197	0.107	105.2	102.2
7	1.50	3.00	40.970	0.228	0.135	97.9	93.4
8	1.50	3.07	44.013	0.239	0.209	86.9	78.2
9	1.50	2.95	44.654	0.252	0.226	69.7	61.6
10	1.50	3.00	38.529	0.214	0.225	54.2	47.3
11	1.50	3.10	31.992	0.172	0.226	41.2	35.5
12	1.50	3.26	25.420	0.130	0.226	30.3	26.0
13	1.60	3.14	17.360	0.092	0.226	22.4	19.6
14	1.53	3.00	9.162	0.051	0.226	17.6	16.2
SUM		43.61					

Table 6. Summary of the HAP, acetic acid, and ethanol emissions for charge 2..

| Sample Run ID	Interval Endpoint	Wood Moisture Content	Methanol	Phenol	Ethanol	Acetic acid	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein
	hours	%	lb/mbf	lb/mbf	lb/mbf	lb/mbf	lb/mbf	lb/mbf	lb/mbf	lb/mbf
1	2.26	122.3	0.0003	0.0000	0.0039	0.0009	0.00001	0.0008	0.00000	0.00000
2	5.02	121.0	0.0012	0.0000	0.0302	0.0057	0.00000	0.0001	0.00000	0.00000
3	7.82	118.6	0.0030	0.0000	0.0361	0.0098	0.00003	0.0046	0.00003	0.00000
4	11.06	114.4	0.0027	0.0000	0.0516	0.0097	0.00005	0.0069	0.00005	0.00000
5	14.50	108.4	0.0023	0.0000	0.0664	0.0091	0.00006	0.0086	0.00007	0.00000
6	17.71	102.2	0.0012	0.0000	0.0684	0.0081	0.00008	0.0119	0.00010	0.00010
7	20.71	93.4	0.0032	0.0000	0.0775	0.0105	0.00017	0.0146	0.00018	0.00021
8	23.78	78.2	0.0062	0.0000	0.1219	0.0245	0.00052	0.0154	0.00039	0.00065
9	26.74	61.6	0.0103	0.0000	0.1243	0.0268	0.00074	0.0116	0.00048	0.00085
10	29.74	47.3	0.0092	0.0000	0.1062	0.0184	0.00067	0.0076	0.00042	0.00075
11	32.83	35.5	0.0054	0.0000	0.0505	0.0100	0.00064	0.0058	0.00038	0.00071
12	36.10	26.0	0.0045	0.0000	0.0409	0.0130	0.00072	0.0057	0.00054	0.00092
13	39.24	19.6	0.0054	0.0000	0.0354	0.0097	0.00056	0.0042	0.00051	0.00082
14	42.24	16.2	0.0035	0.0000	0.0131	0.0054	0.00028	0.0026	0.00039	0.00050
		Sums:	0.058	0.000	0.826	0.162	0.005	0.100	0.0036	0.0055
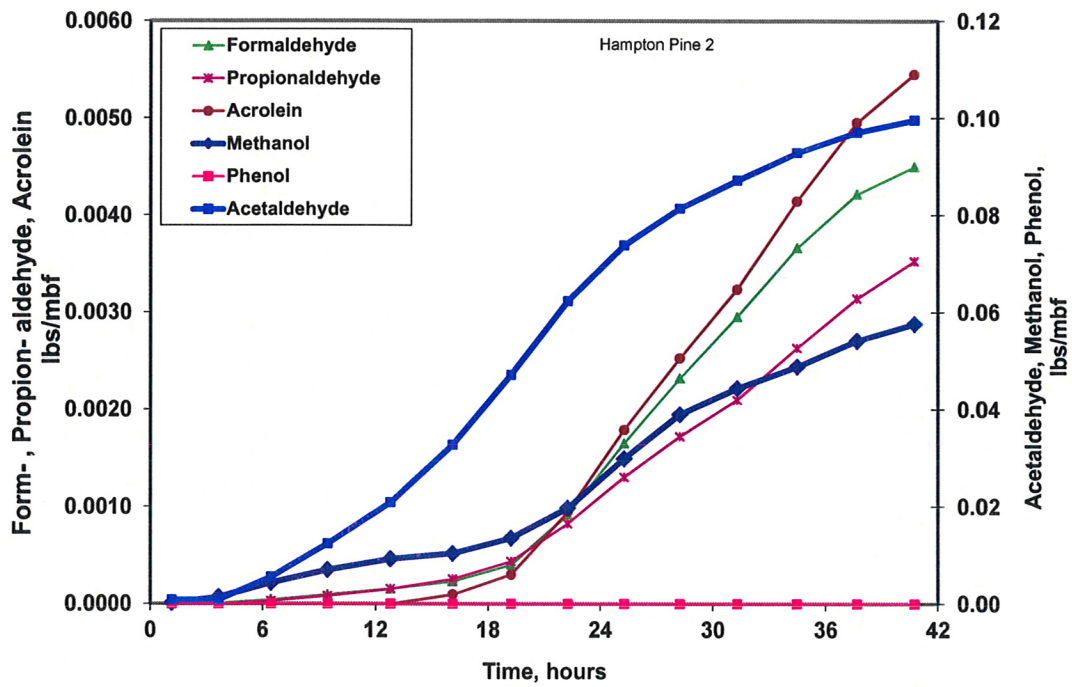
Figure 7. HAP emissions as a function of time for charge 2.
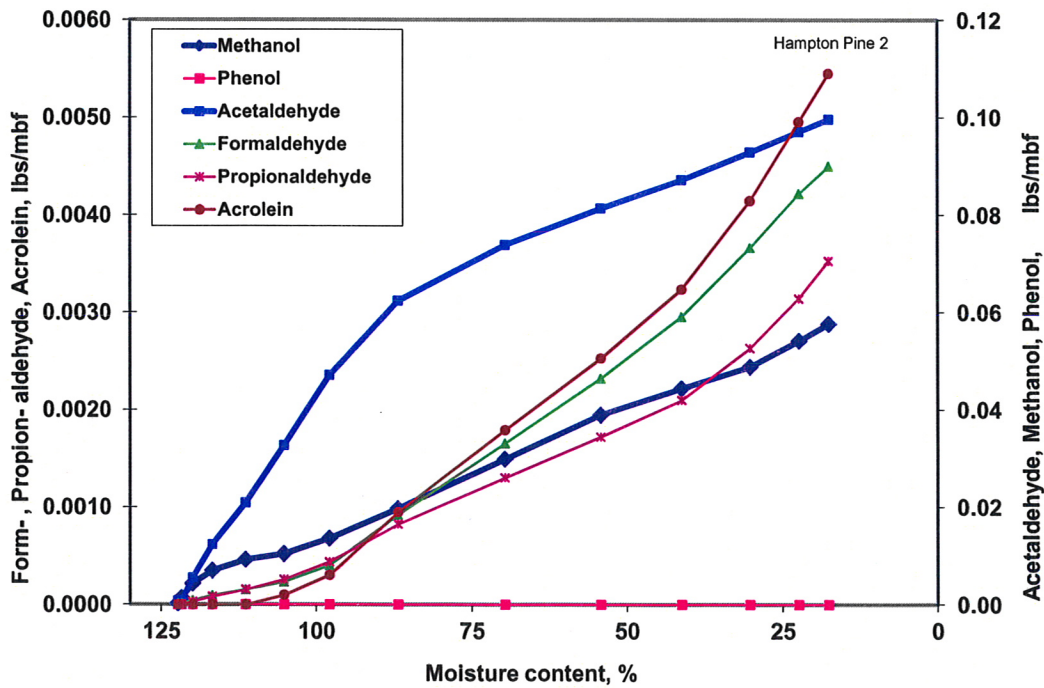
Figure 8. HAP emissions as a function of moisture content for charge 2.

The detection limits for the GC instrument were

Methanol – 1.63 µg/mL in the aqueous phase
Phenol – 0.78 µg/mL in the aqueous phase
Ethanol – 1.60 µg/mL in the aqueous phase
Acetic acid – 4.28 µg/mL in the aqueous phase
Formaldehyde - 0.04 µg/mL in the hexane phase
Acetaldehyde – 0.08 µg/mL in the hexane phase
Propionaldehyde – 0.08 µg/mL in the hexane phase
Acrolein – 0.24 µg/mL in the hexane phase

The method detection limit varies with gas flow through the impingers and the amount of solution in the impingers. Typical (based on the flow conditions and impinger volumes for sample 11) method detection limits in the sampled gas are

Methanol -1.5 ppm in the kiln exhaust
Phenol -0.24 ppm in the kiln exhaust
Ethanol – 1.01 in the kiln exhaust
Acetic acid – 2.10 in the kiln exhaust
Formaldehyde -0.01 ppm in the kiln exhaust
Acetaldehyde - 0.02 ppm in the kiln exhaust
Propionaldehyde - 0.01 ppm in the kiln exhaust
Acrolein - mean = 0.04 ppm in the kiln exhaust

All ethanol, acetic acid, and acetaldehyde samples were above the detection limits. The second, fifth, and sixth methanol, the second formaldehyde, the first five acrolein, and the first two propionaldehyde samples were below the detection limits. All phenol samples were no detects. If one-half the detection limit is substituted for all samples below the detection limit, the total HAPs remain unchanged (with rounding) at 0.17 lb/mbf.

Methanol	Phenol	Ethanol	Acetic acid	Form- aldehyde	Acet- aldehyde	Propion- aldehyde	Acrolein
lb/mbf	lb/mbf	lb/mbf	lb/mbf	lb/mbf	lb/mbf	lb/mbf	lb/mbf
0.058	0.000	0.826	0.162	0.005	0.100	0.0036	0.0055

Field spikes were run by operating two impinger trains simultaneously. An aliquot of the compounds was added to one impinger train. Spike recovery percentage is the mass of a compound detected in the lab compared to mass added to the impinger. Table 7 shows the field spike recoveries. The method requires between 70% and 130% recovery if the concentration of the analyte in the gas phase is greater than 1.5 ppm in the dry gas. This was not met for formaldehyde, however, the concentration was only 0.07 to 1.13 ppm in the gas, and the method only requires

60% to 140% recovery in this case. Also, ethanol had a -93% recovery; however, the spike level was too low (235 µg) compared to the amount in the impinger collected from the gas (~2500 µg). The method would have allowed up to 12,500 µg to be in the spike rather than 235 µg. On one of the acetic acid spikes we are slightly over 5 times the amount in the impinger catch and on the other we are 10 times the amount in the impinger catch. Otherwise all spikes were within the method range. It is hard to spike correctly because the amounts collected in the samples are not known until drying is completed and the sample are tested in the lab. In addition, the ratios of the amounts change making a single spike solution not suitable for multiple intervals. Therefore, we do two or three spikes at various levels to try to meet the method requirements.

The results for a field blank collected are shown in Table 8. None of the target compounds were detected in the blank.

Duplicate samples were run by operating two impinger trains simultaneously. The results of duplicates are shown in Table 9. The percentage is the difference between the gas concentrations detected by each impinger. Phenol was not detected so duplicates could not be compared. Differences ranged from 2.3 to 26%, all within the limits of the method.

Table 7. Example of spike test results.

Alcohol Spike

Run	Mass in impinger				Impinger flow	Mass corrected for flow			
	Methanol	Phenol	Ethanol	Acetic		Methanol	Phenol	Ethanol	Acetic
	µg	µg	µg	µg	mL/min	µg	µg	µg	µg
8	194.4	0.0	3805.0	765.3	325.3	132.1	0.0	2586.6	520.2
803	419.8	91.2	2365.4	2806.2	221.1	419.8	91.2	2365.4	2806.2

Spike mass	Spike concentrations					Spike recoveries			
	Methanol	Phenol	Ethanol	Acetic		Methanol	Phenol	Ethanol	Acetic
g	µg/mL	µg/mL	µg/mL	µg/mL		%	%	%	%
1.37	177.2	82.5	172.9	1496.8		118.5	80.7	-93.4	111.5

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	16.3	479.2	12.3	20.3	325.3	21.9	643.4	16.5	27.3
802	78.8	1198.4	80.7	85.9	436.7	78.8	1198.4	80.7	85.9

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		%	%	%	%
1.16	50.5	264.6	52.8	49.8		64.0	119.2	69.2	66.8

Alcohol Spike

Run	Mass in impinger				Impinger flow	Mass corrected for flow			
	Methanol	Phenol	Ethanol	Acetic		Methanol	Phenol	Ethanol	Acetic
	µg	µg	µg	µg	mL/min	µg	µg	µg	µg
9	313.4	0.0	3797.9	819.3	323.1	212.6	0.0	2576.3	555.8
903	704.9	242.5	3282.0	5188.5	219.2	704.9	242.5	3282.0	5188.5

Spike mass	Spike concentrations					Spike recoveries			
	Methanol	Phenol	Ethanol	Acetic		Methanol	Phenol	Ethanol	Acetic
g	µg/mL	µg/mL	µg/mL	µg/mL		%	%	%	%
3.16	177.2	82.5	172.9	1496.8		87.9	93.0	129.2	97.9

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
14	43.7	394.0	59.8	77.1	326.3	29.8	268.0	40.7	52.4
1403	122.4	808.2	145.4	152.6	222.0	122.4	808.2	145.4	152.6

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		%	%	%	%
1.51	50.5	264.6	52.8	49.8		80.1	89.1	86.6	87.8

Table 8. Results for the field blank.

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

Table 9. Results for duplicate runs.

Duplicate									
	Mass in impinger								Impinger flow
Run	Methanol	Phenol	Ethanol	Acetic acid	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein	
	µg	µg	µg	µg	µg	µg	µg	µg	mL/min
5	60.6	0.0	1786.1	244.9	1.6	231.3	1.9	0.0	333.4
502	91.1	0.0	2232.5	330.5	2.0	322.8	2.9	0.0	439.8
Difference, %	13.0	#DIV/0!	5.4	2.3	9.4	5.6	11.9	#DIV/0!	

Duplicate									
	Mass in impinger								Impinger flow
Run	Methanol	Phenol	Ethanol	Acetic acid	Form-aldehyde	Acet-aldehyde	Propion-aldehyde	Acrolein	
	µg	µg	µg	µg	µg	µg	µg	µg	mL/min
13	459.9	0.0	3023.1	827.6	47.8	363.0	43.9	69.7	329.4
1302	819.8	0.0	4751.8	1185.8	49.6	383.5	47.9	71.6	441.4
Difference, %	28.4	#DIV/0!	15.9	6.7	25.4	23.7	20.5	26.4	

4. Control system and operating conditions

A schematic of the kiln is shown in Figure 9(top). 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 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 a commercial kiln. A minimum of 5 L/min entered the kiln at all times, more than removed by the analyzer (1.6 L/min). 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. Flow meter two was used between hours 3 and 11 during charge 1 and flow meter three was used from hours 4 to 10. Flow meter two was used between hours 3 and 14 and between 22 and 26 during charge 2 and flow meter three was used from hours 4 to 5.

Temperature control

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

The dry- and wet-bulb temperatures recorded for each charge are shown in Figure 10. The schedule provided by the mill is also shown. The agreement is close. We did not ramp fast enough on charge two after 15 hours, then ramped more steeply to reach 180°F at the correct time.
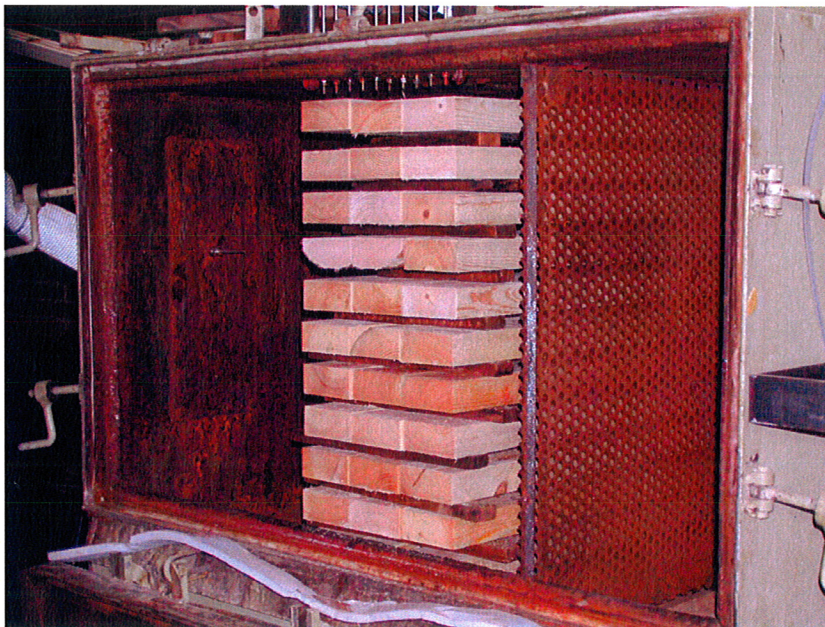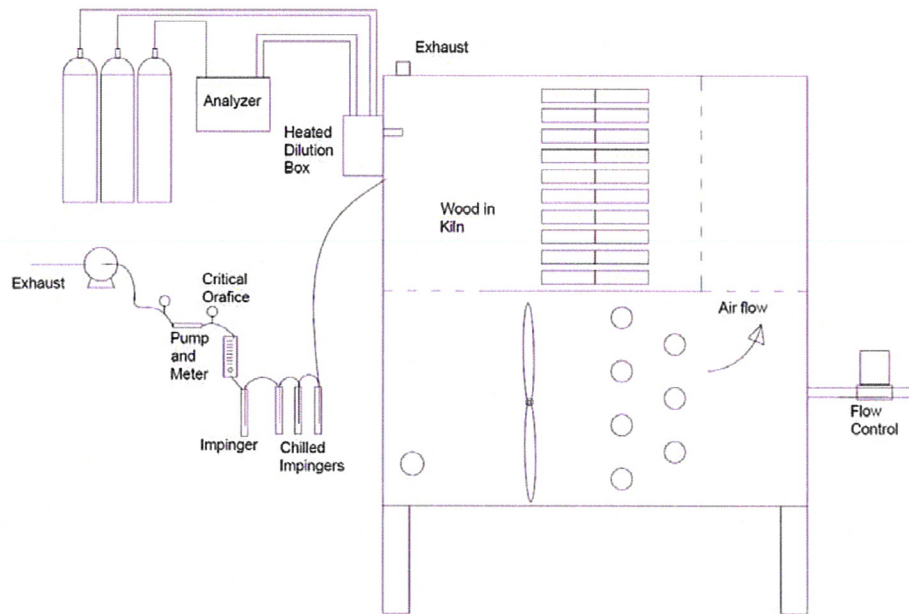
Figure 9. Schematic of kiln and sampling system (top) and photo of kiln charge (bottom).

5. Production-related parameters

Wood quantity

The wood properties were determined using the nominal wood dimensions (2x4 in this case) which provides for 0.66 board feet per lineal foot. There were 33 pieces in the kiln at 44" in length. The board footage was therefore 80 board feet. This quantity was used to express the emissions from the drying cycle on a production basis of lb/mbf (pounds per thousand board feet).

Wood properties

The wood property measurements are shown in Table 10. Individual measurements can be found in the Excel file "Hampton, Pine *, Weights.XLS" in Appendix 2.

Heartwood percentage was determined by estimating the heartwood percent at each end of the board and averaging all pieces.

The average ring count was determined by counting the rings over a 2" radial distance, dividing by two, and averaging for all boards.

The knots were counted on the top face of each board and averaged. This was a count of all knots. Knot diameter is an average of the knots present. The knots occupied less than 1% of the boards' faces.
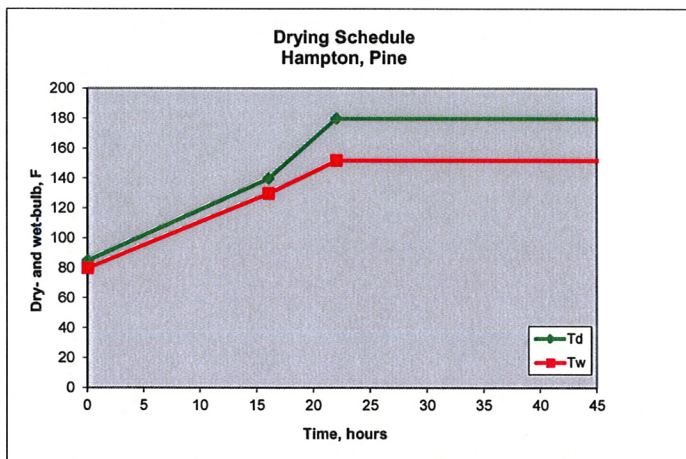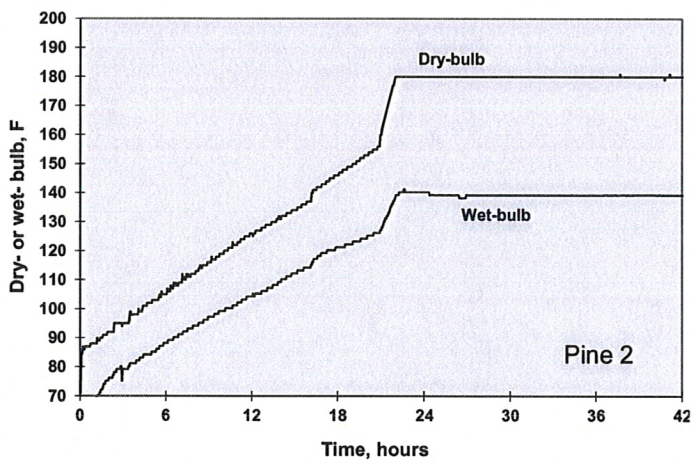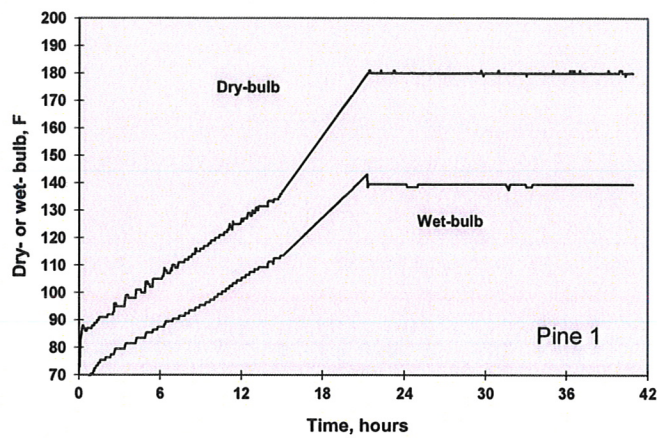
Figure 10. Schedules followed (top) and schedule provided by mill (bottom).

Table 10. Wood properties.

Charge	Knots		Heartwood	Ring count	Pith In
	Number	Size			
	#	In.	%	#/in	# with pith
Pine 1	4.3	0.6	19	11	10
Pine 2	4.4	0.7	15	10	11

6. Test methods

Charge Sequence

The lumber was unwrapped and 2" were trimmed from each end of each board to give 44" samples. These were then weighed, placed in the kiln and dried. 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).

Sampling Methodologies

Hydrocarbon

Sampling for total hydrocarbon is done directly from the kiln as shown in Figure 9 (top). The concentration obtained from the hydrocarbon analyzer and the amount of air entering the kiln allow the total hydrocarbon emissions to be calculated.

Figure 11 shows the hydrocarbon sampling system. Unlike stack testing, all necessary equipment is located in a lab 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 through a heated sampling line and into a heated dilution/filter box. The box was heated to 250°F. Heated dilution gas can be added to the hydrocarbon sample gas to lower the gas moisture content to the detector. Dilution air would have been 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 275°F. The 3-way valve at the back of the analyzer was heated to 295°F.

The fuel gas was hydrogen. The span gas was EPA Protocol 99 or 609 ppm propane in air, the mid-gas was EPA Protocol 25 or 99 ppm propane. The zero gas was <0.1 ppm air. Detailed sampling procedures are in Appendix 1.
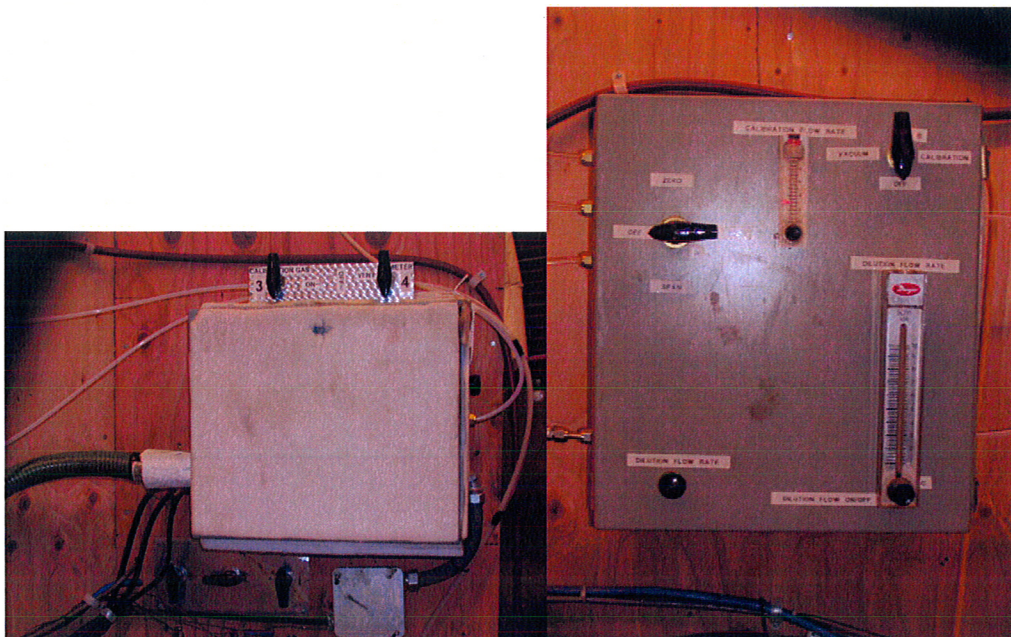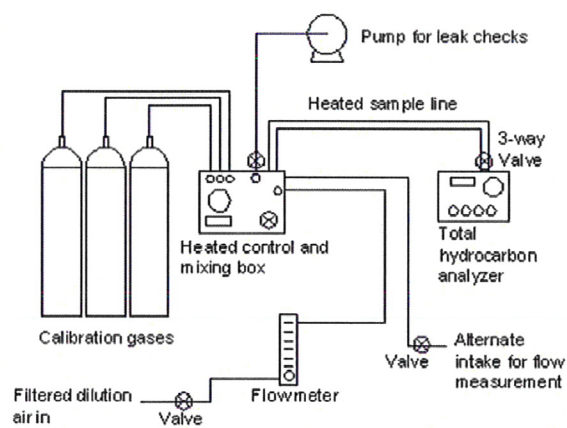
Figure 11. Schematic of heated filter box with air dilution system, heated sample line, and analyzer (top). Sample enters heated box from back of drawing through a heated sampling line. Photo (left) of heated box and (right) of calibration gas valves and dilution air valves. Line to analyzer is the green line in right photo.

HAPs

The sampling train for NCASI Method 105 is shown in Figure 10. 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 the first and second impingers. The third impinger was left empty. The fourth impinger was present in the system to prevent any overflow from reaching the critical orifice. 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 for each interval. The flow rate through the system was then measured using a Gilibrator flow meter to take four flow readings at the probe tip. This was approximately 240-500 mL/min, depending on the sampling train. A valve at the probe tip was then turned to saple from the kiln and the sampling interval begun. The collection interval time was approximately 1:30 and an interval was started approximately every three hours.

The flow rate was measured after each sampling interval. The fluid in the three impingers was weighed and placed in a glass bottle. The impingers were then rinsed with 10 mL of water followed by 3 to 5 mL of hexane. The rinses were also placed in the bottle and it was sealed. Samples were kept refrigerated and in the dark until lab analysis was done. Lab analysis was done within one week of 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.
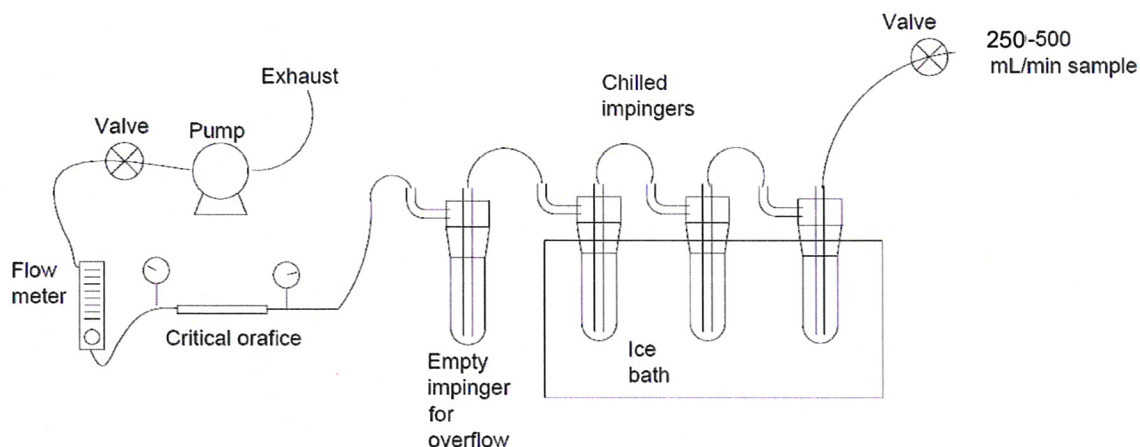
Figure 12. HAPs sampling train.

7. Analytical procedures

Hydrocarbon

Leak checks of the VOC sampling train were conducted before and after the charge was dried. A valve was closed at the probe tip and a 3-way valve was closed at the back of the analyzer. All components from just behind the probe tip to the valve at the back of the analyzer were placed under a 15-20 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 and is equal to both the sample flow from the kiln when the dilution is off and the total volume drawn by the analyzer. Sample flow is measured with dilution gas on (if used for that interval) and is the volume of gas sampled from the kiln when the dilution gas is 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 analyzer reading for span gas with the dilution gas off and on. The dilution ratio calculated based on the analyzer readings was always within 5% of that determined by the flow meter and usually within 2%. Note that dilution was not actually used for the entire test because the kiln wet-bulb was low enough initially that the gas moisture content was less than 15% until the wet-bulb temperature was greater than 130°F.

Calibration of the zero and span of the detector was done at the beginning of each run (about every three to six hours). The calibration gas was introduced by setting the valves so the calibration gas entered the system in the white heated mixing box at ambient pressure. The calibration was checked at the end of each run with no adjustments made to the instrument's zero or span during the run. A span drift less than 10% of the span value was acceptable. A zero drift of less than 3% of the span value was acceptable. A total calibration drift less than 10% was acceptable for a sampling run. These criteria were met.

HAPs

Lab analysis for aldehydes

Aldehyde standards were prepared by the volumetric dilution of neat aldehydes in water (to 250 ppm for formaldehyde, propionaldehyde, acrolein and acetaldehyde). This stock solution was mixed with 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 six hours to allow for derivatization of the aldehydes into aldoximes. The derivatized aldehyde solution was extracted with three aliquots of hexane to create a 400 ppm stock solution in hexane. This was volumetrically (but calculations based on mass) diluted to make standards down to 0.2 ppm. 1 mL aloquates were place in GC autosampler vials with 20 µL of 8800 ppm nitrobenzene added to each as an internal standard.

The samples (from the bottles collected in field) were prepared by three extractions in a separatory funnel. The first extraction was with the hexane added in the field. The second extraction was with a 7-mL aliquot of hexane after using it to rinse the sample bottle. The final extraction was done with 7 mL of clean hexane. The total hexane volume was approximately 20 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 0.25 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

Standards for methanol, phenol, ethanol, and acetic acid were prepared by the volumetric dilution of neat reagents in water. The mixed standard was prepared at a concentration of 1000 milligrams per liter (mg/L). Additional standards were prepared by the volumetric dilution of the mixed standard at a range from 1 mg/L to 500 mg/L. Aliquots of these were placed into autosampler vials with 20 mL of 20,000 ppm cyclohexanol internal standard..

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

8. Field data sheets and sample calculations

Field data sheets

Samples of field data sheets are shown in Figures 13 to 16. All field data sheets are in Appendix 2 this report in electronic format (pdf).

Figure 13. Sample of field data sheet for hydrocarbon analyzer.

Figure 14. Sample of field data sheet for HAPs collection.

FIELD DATA SHEET, 105 HAPS MEASUREMENT
TRAIN #2 – BEFORE SAMPLE

Operator: MRM   Event (kiln charge): Hampton Pine 2
Date: 2-13-13   Run (sample): 7-B

Altimeter setting: 30.47 inHg
Isopropanol rinse or lab wash: ✓

IMPINGER WEIGHTS (add BHA to impingers)

	Dry Weight, g	Wet Weight, g	BHA added, g
Impinger #2A	41.92	52.39	(~15 mL)
Impinger #2B	40.88	55.32	(~15 mL)
Impinger #2C	40.55	------	------
		Total BHA added:	

Optional Spike: _____ g   Spike type: Alcohol ☐ Aldehyde ☐
(take impingers to kiln from scale)
Lab (ambient) temperature: 79 °F

Leak check: Vacuum 15.4 inHg   ☒ Vacuum check ok
Sample flow rate: 4856 mL/min [Average of 4. Label printout]
Set probe valve to sample from kiln   CLOCK TIME: 9:30 A
ELAPSED TIME: 18 30

Is the gas probe valve set to sample?
Is gas flowing (look at flow meters)?

FLOW METER READINGS DURING TEST (every 20 minutes)

Clock time	9:31	9:42	10:22
Vacuum, inHg	28	28	29
Flow rate, mL/min	425	425	425

FIELD DATA SHEET, 105 HAPS MEASUREMENT
TRAIN #2 – AFTER SAMPLE

Operator: MRM   Event (kiln charge): Hampton Pine 2
Run (sample): 7 -B

Altimeter setting: 30.51 inHg

Lab (ambient) temperature: 79 °F
Change position of valve at the kiln   Clock time: 11:00
Elapsed time: 20:00

Set probe valve to measure sample flow rate. Shut off other flows using lower valves.
Sample flow rate: 4922 mL/min [Average of 4. Label printout]
(take impingers to scale from kiln)

Empty bottle weight: 132.26 g (with lid)

IMPINGER WEIGHTS (transfer sample to bottle)

	Wet Weight, g	Dry Weight, g	Water removed, g
Impinger #2A	63.29		
Impinger #2B	55.42		
Impinger #2C	40.68		

Bottle weight without impinger rinse: 168.05 g (with lid)
(rinse impingers with 10 mL DI water)
Bottle weight with impinger rinse: 173.29 g (with lid)
(rinse impingers with 5 mL hexane)
Filled bottle weight: 176.83 g (with lid)
Fluids lost during handling: 0 mL   [estimate]
Comments:

Figure 15. Sample of kiln log data sheet.

Charge: Hampton pine 2

	Date	Time	Page: 3
Start	2/12/2013		
End			

Clock time	Elapsed time	Run #	Temperatures								Flows				Line 1 ml/min	Line 2 ml/min	Line3 ml/min	Vacuum		
			T dry °F	T wet °F	Valve °C	G. line °C	Box °C	Bef. Box °C	Line 2 °C	Line 1 °C	Chiller °C	Flow 1 L/min	Flow 2 L/min	Flow 3 L/min	Dilution SCFM	Line 1 ml/min	Line 2 ml/min	Line3 ml/min	Line 1 inHG	Line 2 inHG	Line3 inHG
13:16	22:16	4	180	153	135	135	130	125	120	115	~1	180	0 0.	0	1	350	425	375	28	28	28
13:35	22:35	4	180	154	135	135	130	125	120	115	~1	180	0/27	0/0	1	350	425	375	28	28	28
14:39	23:39	4	180	153	135	135	131	125	120	115	-1	170	27	0	1	---					
15:39	24:39	5	180	152	135	135	129	125	120	116	-1	171	27	0	1.8	350	425	375	28	28	28
16:26	25:26	5	180	152	135	135	130	125	120	115	-1	171	27	0	1.8	350	425	375	28	28	28
5:29	26:29	5	180	151	135	135	130	125	120	115	-1	184	146	0	1.8	---					
6:25	27:25	5	180	152	135	135	130	125	120	115	-1	172	0	0	1.8	350			29		
7:25	28:25	5	180	153	135	135	130	125	120	115	-1	168	0	0	1.8	350			29		
8:25	29:25	5	180	152	135	135	130	125	120	115	-1	160	0	0	1.8	350			29		
10:05	31:25	6	180	152	135	135	130	125	120	115	-1	127	0	0	1.8	350			29		
11:25	32:25	6	180	152	136	135	130	125	120	115	-1	121	0	0	1.8	3					
12:40	33:40	6	180	152	135	35	130	125	120	115	-1	108	0	0	1.8	350			29		
1:40	34:40	6	180	152	135	135	130	125	120	115	-1	99.5	0	0	1.8	350			29		
2:30	35:30	6	180	152	135	135	130	125	120	115	-1	91.7	0	0	1.8	---					
3:23	36:23	6	180	152	135	135	130	125	120	115	-1	846	0	0	18	---					
3:57	36:57	7	180	152	135	135	130	125	119	115	-1	775	0	0	1.8	350	425		28	28	
5:26	38:26	7	180	152	135	135	130	125	120	115	-1	636	0	0	1.8	350	425		28	28	

Hampton, Pine

24

March, 2013

Figure 16. Sample of flow measurement record.

Calculations

The "FlowCalc" worksheet in the Excel files "Kiln, Wood.XLS in Appendix 2 shows the calculations for each 3-minute interval during the charges. Column A is a reading number. Columns B and C are the clock and charge times, respectively. Columns D/E and F/G are the average dry- and wet-bulb temperatures.

Humidity

Column H is the vapor pressure (P_{vp}, Pa) of water at the wet-bulb temperature. The absolute humidity (AbHum, $kg_{water} \cdot kg_{air}^{-1}$) is shown in column I and the molal humidity ($mol_{water} \cdot mol_{air}^{-1}$) in column J. These are calculated based on the dry-bulb temperature (T_d, °C) and wet-bulb temperature (T_w °C),

$$P_{vp,} = P_{ambient} * 10^{(16.373 - 2818.6/(Td+273.16) - 1.6908*LOG10(Td +273.16) - }$$

$$_{0.0057546*(Td +273.16) + 0.0000040073*(Td +273.16)**2)}$$

$$AbHum = (MW_{water} / MW_{air}) * (1 / (P_{kiln}/P_{vp}-1)) - ((T_d - T_w) * R_{psy}) / \lambda$$

$$MolHum = AbHum * MW_{air} / MW_{water}$$

where MW are molecular weights ($kg \cdot kgmol^{-1}$), R_{psy} is the psychrometric ratio ($0.95\ kJ \cdot kg^{-1} \cdot K^{-1}$), and λ is the latent heat ($2419\ kJ \cdot kg^{-1}$).

Flows

The volumetric dry gas flow rate (DryGasV, $L \cdot min^{-1}$) in column K 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 L this has been converted to a mass flow rate (DryGasM, $kg \cdot min^{-1}$) and in column M is the same information is expressed as a molal flow rate (DryGas, $kgmol \cdot min^{-1}$). These values are for the dry gas vented from the kiln.

$$DryGasV = (FlowMeter1 + FlowMeter2 + FlowMeter3) * (1/(1+MolHum_{In}))$$

$$DryGasM = (DryGasV \ L \cdot min^{-1}) * 1/(22.4 \ m^3 \cdot kgmol^{-1}) * MWair / (1000 \ L \cdot m^{-3})$$

$$DryGas \ (kgmol/min) = DryGasM / MW_{air}$$

The water removal rate (WaterVented, $g \cdot min^{-1}$) (column N) is calculated from the humidity (column I) and the gas flow (column L). The total water (column O) is an integration of column N over time.

$$WaterVented = (MolHum - AbHum_{In} * MW_{Air}/MW_{Water}) * (DryGasM * 1000 \ g \cdot kg^{-1})$$

Moisture content

The moisture content of the wood at each three-minute interval (column P) was determined by reducing the moisture content of the wood from the previous value by accounting for the amount of water leaving the kiln during the interval.

$$MC = MC_{Previous} - 100 * (WaterVented / (1000 \ g \cdot kg^{-1}) / ODWoodWt)$$

This amount is then adjusted by adjusting the wet-bulb temperature to make the ending moisture content match that measure by ASTM D4222.

Hydrocarbon

The original total hydrocarbon analyzer reading is shown in column Q. In column R this has been corrected to compensate for the range setting switch on the analyzer. Also in column R, the THA data between sampling runs (rows labeled "test" in column AA) has been adjusted to the average of the data during the 9-minute period before and the 9-minute period after the analyzer testing and calibration time.

The dilution THA (column S) is the corrected THA reading divided by the dilution ratio (from column AA). In column T we have the opportunity to compensate for the effect of moisture on the JUM detector. Column T equals column S because dilution was used and no compensation was made. Finally in column U, the hydrocarbon concentration is converted to a dry gas basis concentration using the molar humidity (column J).

$$THC_{Dry}, ppm = THC * (1 + MolHum)$$

In column V, the hydrocarbon flow rate (THC$_{Vented}$, $g_{Carbon} \cdot min^{-1}$) is calculated in a manner analogous to the water flow rate using the dry gas flow rate and the hydrocarbon concentration.

$$THC_{Vented} = DryGas * (THC_{Dry} / 10^6) * MW_{Propane} * (1000\ g \cdot kg^{-1}) * (0.81818\ g_{Carbon} \cdot g_{Propane}^{-1})$$

Column W is the integral of column V over time, the cumulative hydrocarbon released up to that point in the schedule (in grams). Column X is the cumulative unit emissions, that is, column W divided by the oven-dry weight of the wood in the kiln. Column AI is the cumulative emissions in pounds per thousand board feet and column AH is the rate of emissions release ($lb \cdot mbf^{-1} \cdot hr^{-1}$)

Column Z indicates the hydrocarbon sampling run and column AA is the dilution ratio during that run.

The remaining columns are used not used in the hydrocarbon calculations. They are for graphing shown on other worksheets in the workbook.

At the end of the FlowCalc spreadsheet (at the bottom) are summaries by run of the flow data for the total hydrocarbon run intervals (interval summary button will reposition spreadsheet).

Moisture content and board weight data are on the "Define" worksheet and the original data are in the files named "Weights, Wood.XLS".

HAPs

Within the file "HAPs, Wood.xls", the summary page presents the data by run interval. The data is copied from the other pages to make the spreadsheet more readable.

The "Field Data" page is data transcribed from the field data sheets (copies of the sheets are included in Appendix 2 in PDF format) and includes the ambient pressure, lab temperature, flow rate through the impingers, and run start and stop times.

The "Laboratory Data" page contains results from the lab analysis for HAPs. These values come from the files "AQU, Wood.xls" and "ALD, Wood.xls" in the "Lab Data" directory. The GC retention times and peak areas and the GC calibrations are in these files.

On the "Impinger Calculations" page, the field data and laboratory data are used to give a dry gas flow rate through the impingers (columns J and K) and the mass of target compounds in the impingers (columns L to Q). Flow rates were adjusted to standard conditions in columns F and G.

$$ImpgrFlow_{Std\_mL} = ImpgrFlow * (273.16K / T_{meter}) / (P_{meter} / 101.33\ kPa)$$

A dry gas flow rate is calculated in columns H and I

$\text{ImpgrFlow}_{Dry\_mL} = \text{ImpgrFlow}_{Std\_mL} * (1\text{-MolHum} / (1 + \text{MolHum}))$

The average of the before and after gas flow measurements through the impingers (column J) is then converted to a mass basis in column K.

$\text{ImpgrFlow}_{Dry\_g} = \text{MWair}* \text{ImpgrFlw}_{Dry\_mL} * P / (T * R)$

Finally, the mass of each compound recovered from the impinger is calculated in columns L to S.

$\text{Mass}_i = (\text{Concentration}_i) / (\text{DenSolvent}) * (\text{Mass solvent})$

The "Kiln Calculations" page uses a ratio of the dry gas flow through the kiln (calculated in the spreadsheets named "Kiln, Wood.xls" and copied to column D) 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 P).

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 of wood (columns B-I) or per mbf basis (columns J-Q). Concentrations leaving the kiln are given in columns R to AG.

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 after adjusting for impinger flow.

The remaining pages in "HAPs, Wood.xls" are for graphing purposes.

9. Chain of custody information

Wood was collected by mill personnel and delivered to Oregon State by Hampton. The wood was retained by Oregon State after delivery as documented in section 1. Field samples remained at Oregon State University.

10. Calibration documentation

Sensidyne, LP
CALIBRATION CERTIFICATE

Cell S/N: 1302015-S   Date: February 07, 2013

This is to certify that the above referenced Gilibrator Flow Cell was calibrated using film flowmeter MCS-102, which has been calibrated by instruments directly traceable to the National Institute of Standards and Technology. NIST Report 8361604.
Results:

REFERENCE MCS-102 cc/min	S/N 1302015-S cc/min	RELATIVE DIFF. cc/min	PERCENT DIFF.
1998	2001	3	0.15
2002	2001	-1	-0.05
1996	2004	8	0.40
2004	2005	1	0.05
1996	2004	8	0.40
2001	2002	1	0.05
2000	2004	4	0.20
2001	2002	1	0.05
1994	2004	10	0.50
2001	2004	3	0.15

MAX		10.0	0.5
MEAN	1999.3	2003.1	

Calibrated by _____   Date: February 07, 2013

CODE 100

Figure 17. Flow meter calibration.

Airgas

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Airgas Specialty Gases
11711 S. Alameda Street
Los Angeles, CA 90059-1721
(323) 357-6691
Fax (323) 357-3606
www.airgas.com

Part Number:	E02AI99E15A0557	Reference Number:	48-124230531-2
Cylinder Number:	CC123614	Cylinder Volume:	145 Cu Ft.
Laboratory:	ASG - Los Angeles - CA	Cylinder Pressure:	2015 PSIG
Analysis Date:	Aug 19, 2010	Valve Outlet:	590

Expiration Date: Aug 19, 2013
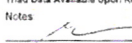
Certification performed in accordance with EPA Traceability Protocol (Sept. 1997) using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. The uncertainty is the analytical uncertainty as stated below with a confidence level of 95%. There are 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	25.00 PPM	24.85 PPM	G1	+/- 1% NIST Traceable
Air	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM	36C612	CC262755	49.62 PPM PROPANE AIR	Jul 15, 2012

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
Nicolet 6700 Propane	FTIR	Aug 18, 2010

Triad Data Available Upon Request

Notes

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Approved for Release

Airgas

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number:	E02AI99E15A0465
Cylinder Number:	SG9107334
Laboratory:	ASG - Los Angeles - CA
Analysis Date:	Aug 19, 2010

Reference Number:	48-124230531-1
Cylinder Volume:	146 Cu.Ft.
Cylinder Pressure:	2015 PSIG
Valve Outlet:	590

Expiration Date: Aug 19, 2013

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	100.0 PPM	98.79 PPM	G1	+/- 1% NIST Traceable
Air	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM	090617	CC301749	97.82PPM PROPANE/AIR	Oct 02, 2013

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
Nicolet 6700 Propane	FTIR	Aug 18, 2010

Triad Data Available Upon Request

Notes:

Approved for Release

Airgas

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number:	E02AI99E15A1472
Cylinder Number:	SG9133852
Laboratory:	ASG - Los Angeles - CA
Analysis Date:	Jun 04, 2010

Reference Number:	48-124221446-2
Cylinder Volume:	146 Cu.Ft.
Cylinder Pressure:	2015 PSIG
Valve Outlet:	590

Expiration Date: Jun 04, 2013

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	500.0 PPM	509.5 PPM	G1	+/- 1% NIST Traceable
Air	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM	C00519	SG9107376	483.6PPM PROPANE/	Jul 01, 2013

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
Nicolet 6700A Propane	FTIR	Jun 02, 2010

Triad Data Available Upon Request

Notes:

Approved for Release

Figure 18. Certificates for calibration gases.

11. Anomalies

The VOC concentration went outside the analyzer calibration range for a 20-minute period during charge 1. We switched to higher level calibration gases and corrected the problem.

HAPs run four had all low concentrations. We assumed the sample was lab air and not kiln exhaust so the samples from runs 3 and 5 were averaged to get values for run 4.

HAP sample 2B was spilled in the lab. It was a duplicate and sample 2A was still available.

12. Statement of validity

The statements in this report accurately represent the testing that occurred.

Michael R Milota

Michael R. Milota

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Appendix 1. Detailed sampling procedures

Checks of kiln to record on log

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 plastic electrical enclosure on wall or on computer screen. The top and bottom numbers on controller should be similar and greater than the kiln temperature, 230-250°F.

Box temperature: Read from plastic electrical enclosure on wall or on computer screen. The top and bottom numbers on controller should be similar and greater than the box temperature, 255-275°F.

Valve temperature: Read from plastic electrical enclosure on wall or on computer screen. The top and bottom numbers on controller should be similar and greater than the line temperature, 290-300°F.

Dry-bulb temperature: Read from computer screen. Compare to paper 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.

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

If the wet-bulb is too low, it means that the kiln atmosphere is too dry. Check the flow meters. If Flow1 is about 6 L/min (its lower limit), make sure that Flow2 and Flow3 are turned off. Flow2 records automatically. Enter any Flow3 change into the computer. Otherwise, call Mike.

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. Enter any Flow3 change into the computer. 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°F, call Mike

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.

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 6 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. Change it on the computer screen (click on it and type the new value).

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

Impinger flows: Read from rotometers. This should be about 250 to 500 cc/min.

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

Total hydrocarbon analyzer

BACKGROUND INFORMATION

Get the dry- and wet-bulb temperatures from the kiln schedule or off the computer. Use the highest expected values for the next three to six hours.

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 – use date VOC run will start if close to midnight

AMBIENT DATA

Read the laboratory temperature from the computer or thermometer.

ANALYZER CALIBRATION (BEFORE SIDE OF SHEET)

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
 set analyzer to range 3
 zero valve on, others off
 set flow to 3 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 (may be 99 instead of 610)
 span valve on, others off
 set flow to 3 L/min using regulator on tank
 wait for a stable reading (about 30 to 60 seconds)
 use the span dial (pot) on THA to get a reading of 610ppm
 read the analyzer and record, eg, record 6.10
 read computer (should read about 610)

record pot setting
Leave span tank valve open

Open mid gas tank valve
       mid valve right on, others off
       set flow to 3 L/min using regulator on tank
       wait for a stable reading (about 30 to 60 seconds)
       read and record analyzer and computer (do not adjust pot settings)
       check for within tolerance
       switch analyzer to range 2
       read analyzer and computer
       check for within tolerance
       switch analyzer back to range 3
Turn off mid gas tank valve

SET DILUTION FLOW BEFORE RUN (BEFORE SIDE OF SHEET)

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 1.6 L/min
Make sure the average does not include any "bad" readings
Record the average in mL/min; It should be 1500-1600 mL/min
Write the 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
Slowly open lower valve on dilution flow meter (1=ON)
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 in SCFH
Calculate and record L/min

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 in mL/min
Write "Pre-SFR" on the Gilibrator printout.

CHECK DILUTION FLOW BEFORE RUN (BEFORE SIDE OF SHEET)

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 (should already be open)
>span panel valve right (on), others down (off)
>set flow to 3 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 calibration gas panel valves off

All tank valves off

Calculate the dilution ratio based on gas flow by dividing the Sample Flow Rate by the Total Flow Rate. DR = Absolute value of [100*(DR Span - DR Flow)/DR Flow]

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 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

START RUN (BOTTOM OF BEFORE SIDE OF SHEET)

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

Record the start time. Use the computer clock or stopwatch time.

Make sure analyzer is on appropriate range, usually range 3, to keep THC reading on computer between 60 and 600.

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

End time should be no more than 3-6 hours from start time.

POST-SAMPLE PROCEDURE - AT END OF RUN (AFTER SIDE OF SHEET)

Record your name as the operator.
Event = the drying cycle.

Run = number of the 3-hour interval.
Operator, that's you. .

AMBIENT DATA

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 or analyzer pots until the instructions tell you to.

CHECK DILUTION FLOW AFTER RUN (AFTER SIDE OF SHEET)

Measure diluted span gas: 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 panel valve ON, others OFF
    set flow to 3 L/min using regulator on tank
    set analyzer to range 3
    wait for a stable reading (about 30 -60 seconds)
    record

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 4 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 in L/min
Write Run # and "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 (lower dilution valve)

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 4 readings of the total flow rate (TFR). This is the total flow drawn by the analyzer and should be about 1.6 L/min

Make sure the average does not include any "bad" readings
Record the average
Write Run # and "Post-TFR" on the Gilibrator printout.

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

CHECK CALIBRATION OF ANALYZER (AFTER SIDE OF SHEET)

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 panel valve ON, others down OFF
       set flow to 3 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, 6.05 as 605
       read computer (should read about the same)
       note pot setting
       check for within tolerance - between 582 and 619

Open mid gas tank valve
       mid panel valve = ON, others OFF
       set flow to 3 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, 2.97 as 297
       read computer (should read same as analyzer)
       check for within tolerance

Open the zero gas tank valve
       zero panel valve = ON, others OFF
       set flow to 3 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

Close all tank valves if charge is ending

Calculate the dilution ratio based on gas concentration by dividing the Diluted span by the Span

Calculate % difference in the two dilution ratios as 100 * {Absolute Value (DRSpan-DRFlow)} / DRFlow

Record the time now as the end time for check.

Start Pre-Sample procedure for next run.

HAP 105 Collection

BACKGROUND DATA

Begin about 15 minutes before run should start
Operator, that's you.
Date, today or tomorrow if sample will start after midnight
Event = Kiln Charge
Run = sequence of M/F measurement (1-A, or 5-C, etc)

PRE RUN DATA

Call 9-541-754-0081 and get altimeter setting.

IMPINGER WEIGHTS

Dry and weigh the impingers (weight may already be on data sheet).

Put 15 mL of BHA solution in impinger #1.
Put 10 mL of BHA solution in impinger #2.
Impinger #3 is not filled. It is for overflow.

Reweigh the impingers with the BHA solution.
Place BHA stock back into cooler
Install impingers and lower into chiller

LEAK CHECK

Read the laboratory temperature.
Close valve to sample probe.
Turn on pump (it may already be on)
Evacuate to 15 to 18 " Hg, record
Close valve that is near 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. Record change.
Slowly open valve near probe tip so that pressure is slowly relieved.
Completely open valve near probe tip
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 and record time.
Check meters to make sure gas is flowing

FLOW READINGS DURING TEST

Note flow meter reading at least 20-30 minutes
Run test for 1:30 or less if impingers fill

POST RUN DATA

Begin about 10 minutes before run should end
Label a sample bottle with the Event and Run numbers and record the weight.
Call 9-541-754-0081 and get altimeter setting.

END TIME

Remove probe from kiln
Record time

SAMPLE FLOW RATE

Rinse probe with 5 mL of DI water
Read the laboratory.
Attach probe tip to Gilibrator
Take 5 readings
Make sure all readings in average are "good" readings
Record the average

IMPINGER WEIGHTS

Lift impingers from chiller, take to scale, and place onto rack
Dry the outside of the impingers
Remove U tubes connecting the impingers together
Weigh sample bottle
Weigh the impingers (without stoppers) with the catch and record
Transfer the impinger contents to the sample bottle
Weigh the sample bottle and record
Rinse impingers (last to first) with 10 mL DIW (save in the sample bottle)
Weigh the sample bottle and record
Rinser impingers (last to first) with 5 mL hexane (save in the sample bottle)
Weigh the sample bottle and record
Place the sample bottle into cold storage
Record the volume of any liquids lost during this procedure.
Wash glassware with phosphate-free detergent and set out to dry.

Appendix 2. Electronic copy of data and calculations