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VOC and HAP Emissions From the High Temperature Drying of Hemlock Lumber

Report to

Hampton Affiliates
PO Box 8
Willamina, OR 97396

Report by

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June 21, 2004

VOC and HAP Emissions From the High Temperature Drying of Hemlock Lumber

I. Results Summary

One charge containing 80 board feet of 2x4 hemlock lumber was dried from green to 15% moisture content in a small kiln at Oregon State University. The kiln dry- and wet-bulb temperatures were provided by Hampton Lumber. The schedule was at a high temperature, with a maximum temperature of 215°F (103°C) and a wet-bulb temperature between 150F (65°C) and 165 °F (74 C). 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 venting and the humidity.

A JUM 3-200 total hydrocarbon analyzer was used to measure organic emissions following EPA Method 25A. A chilled impinger sampling train followed by Summa canisters was used to sample for the HAPs. The results are shown in Table 1. The values in Table 1 were obtained using one half the detection limit for compounds that were not detected. If the undetected concentrations are treated as zeros, the value for acrolein in Table 1 would be 0.00104 and the 2,2,4-trimethylpentane value would be 0.00008 lb/mbf.

TABLE 1. Summary of results.

Initial MC	Time[b]	VOC[a]	Methanol	Form-aldehyde	Acrolein	Toluene	2,2,4-Trimethyl pentane
%	hrs	lb/mbf[c]	lb/mbf	lb/mbf	lb/mbf	lb/mbf	lb/mbf
119.7	38	0.34	0.138	0.0043	0.0027	0.00013	0.000013

[a] All values are reported for drying to a 15% moisture content
[b] to 15% moisture content
[c] as carbon

II. Lumber Source and Handling

Three charges of lumber were delivered to Oregon State University on May 18, 2004, one to be dried and two as backups. The wood was wrapped in plastic at the mill to prevent predying and loss of organic compounds during transit. The charge was put in the kiln one day after it was delivered.

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.

TABLE 2. Drying schedule for the high-temperature charge. Actual drying time was 38 hours.

Step time, hours	Ramp time, hours	Run time, hours	Dry-bulb, °F	Wet-bulb, °F
0	0	0	155	120
12	12	12	200	175
4	4	16	210	170
8	0	24	215	160
16	0	40	215	150
10	0	50 to dry	215	140

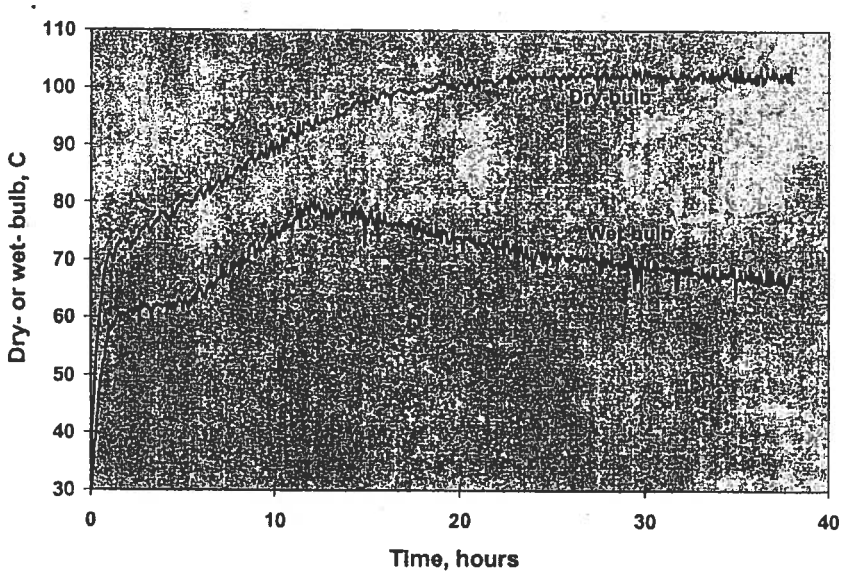

FIGURE 2. Dry- and wet-bulb temperatures during the drying cycle.

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VOC and Methanol Emissions From the Drying of Hemlock Lumber

Report to

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Report by

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August 24, 2004

VOC and HAP Emissions From the High Temperature Drying of Hemlock Lumber

I. Results Summary

Two charges, each containing 80 board feet of 2x4 hemlock lumber, were dried from green to approximately 15% moisture content in a small kiln at Oregon State University. The kiln dry- and wet-bulb temperatures were provided by Hampton Lumber. The maximum temperature was 180°F (82.2°C) with a wet-bulb temperature of 150 °F (65°C). 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 venting and the humidity.

A JUM 3-200 total hydrocarbon analyzer was used to measure organic emissions following EPA Method 25A. A chilled impinger sampling train was used to sample for methanol and formaldehyde following NCASI Method CI/WP-98.01. The results are shown in Table 1.

TABLE 1. Summary of results.

Run	Initial MC	Time[a]	VOC[b]	Methanol[c]	Formaldehyde[c]
	%	hr:min	lb/mbf	lb/mbf	lb/mbf
1	56.8	38:21	0.198	0.0312	0.00082
2	51.1	35:45	0.122	0.0304	0.00082

[a] to a 15% moisture content
[b] as carbon from green to 15% moisture content
[c] from green to 15% MC

II. Lumber Source and Handling

Enough wood for two charges of lumber was delivered to Oregon State University on August 10, 2004, one charge to be dried and one as a backup. The wood was wrapped in plastic at the mill to prevent predying and loss of organic compounds during transit. The first charge was put in the kiln on the day it was delivered. Due to an irregularity in during the first charge, the second charge was also dried. This was started on August 16. The second charge was stored in plastic at 4°C from delivery until the kiln was loaded.

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.

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 schedule supplied by the mill is 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. The difference in the initial part of the schedule is because the kiln had not cooled from the previous charge when charge 1 was started.

Charge Sequence

After unwrapping the shipping package, 2" were trimmed from each end of each board to give 44" samples. These were then weighed, placed in the kiln, and dried according to the schedule 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. A intermediate weighing was done at 42 hours during charge 1. This is the downward spike in Figure 2. This occurred after 15% moisture content had been reached.

TABLE 2. Drying schedule for the charge. Actual drying time was 38.35 hours to 15% and 48 hours to 11.2% for charge 1 and 35.75 hours to 15% and 42 hours to 11.9% for charge 2.

Step time, hours	Ramp time, hours	Run time, hours	Dry-bulb, °F	Wet-bulb, °F
0	0	0	80	70
15	15	15	165	150
8	8	23	180	150
Until	dry	-	180	150

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VOC, Methanol, and Formaldehyde Emissions From the Drying of Hemlock Lumber

Report to

Hampton Affiliates
PO Box 8
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Report by

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October 15, 2004

VOC, Methanol, and Formaldehyde Emissions From the Drying of Hemlock Lumber

I. Results Summary

One charge, containing 80 board feet of 2x4 hemlock lumber, was dried from green to approximately 15% moisture content in a small kiln at Oregon State University. The kiln dry- and wet-bulb temperatures were provided by Hampton Lumber. The maximum temperature was 200°F (93.3°C) with a wet-bulb temperature of 150 °F (65°C). 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 venting and the humidity.

A JUM 3-200 total hydrocarbon analyzer was used to measure organic emissions following EPA Method 25A. A chilled impinger sampling train was used to sample for methanol and formaldehyde following NCASI Method CI/WP-98.01. The results are shown in Table 1.

TABLE 1. Summary of results.

Initial MC	Time[a]	VOC[b]	Methanol[c]	Formaldehyde[c]
%	hr:min	lb/mbf	lb/mbf	lb/mbf
76.0	30:15	0.204	0.057	0.0014

[a] to a 15% moisture content
[b] as carbon from green to 15% moisture content
[c] from green to 15% MC

II. Lumber Source and Handling

Enough wood for two charges of lumber was delivered to Oregon State University on September 25, 2004, one charge to be dried and one as a backup. The wood was wrapped in plastic at the mill to prevent predying and loss of organic compounds during transit. The charge was put in the kiln on October 27. The second charge was stored in plastic at 4°C but was not used.

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.

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 schedule supplied by the mill is 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.

Charge Sequence

After unwrapping the shipping package, 2" were trimmed from each end of each board to give 44" samples. These were then weighed, placed in the kiln, and dried according to the schedule 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.

TABLE 2. Drying schedule for the charge. Actual drying time was 30.25 hours (30:15) to 15% and 37.8 hours to 9.8%.

Step time, hours	Ramp time, hours	Run time, hours	Dry-bulb, °F	Wet-bulb, °F
0	0	0	140	100
15	15	15	185	165
8	8	23	200	150
Until	dry	-	200	150