mailed 4-4-97

AIR CONTAMINANT EVALUATION TEST REPORT

COWLITZ STUD COMPANY
Dry Kiln VOC Emission Factors

February 25-March 13, 1997

Prepared for

Cowlitz Stud Company
P.O. Box 219
Randle, Washington 98377

By

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4/3/97
EXPIRES 1/26/99

Introduction

Between February 25 and March 13, 1997, four samples of Cowlitz Stud Company lumber were dried in Horizon Engineering's laboratory dry kiln. Volatile organic compounds (VOCs) were continuously measured in the test kiln using the Dettinger Method. The laboratory test was done instead of a source test due to the expense and uncertainties involved in testing an actual dry kiln.

Charlie Allen, of Cowlitz Stud, and Heinz Dettinger, their consultant, arranged for the work. Horizon Engineering personnel David Broderick did the testing and Michael Wallace did the data processing. A copy of the test method has been included in the Appendix.

Summary of Results

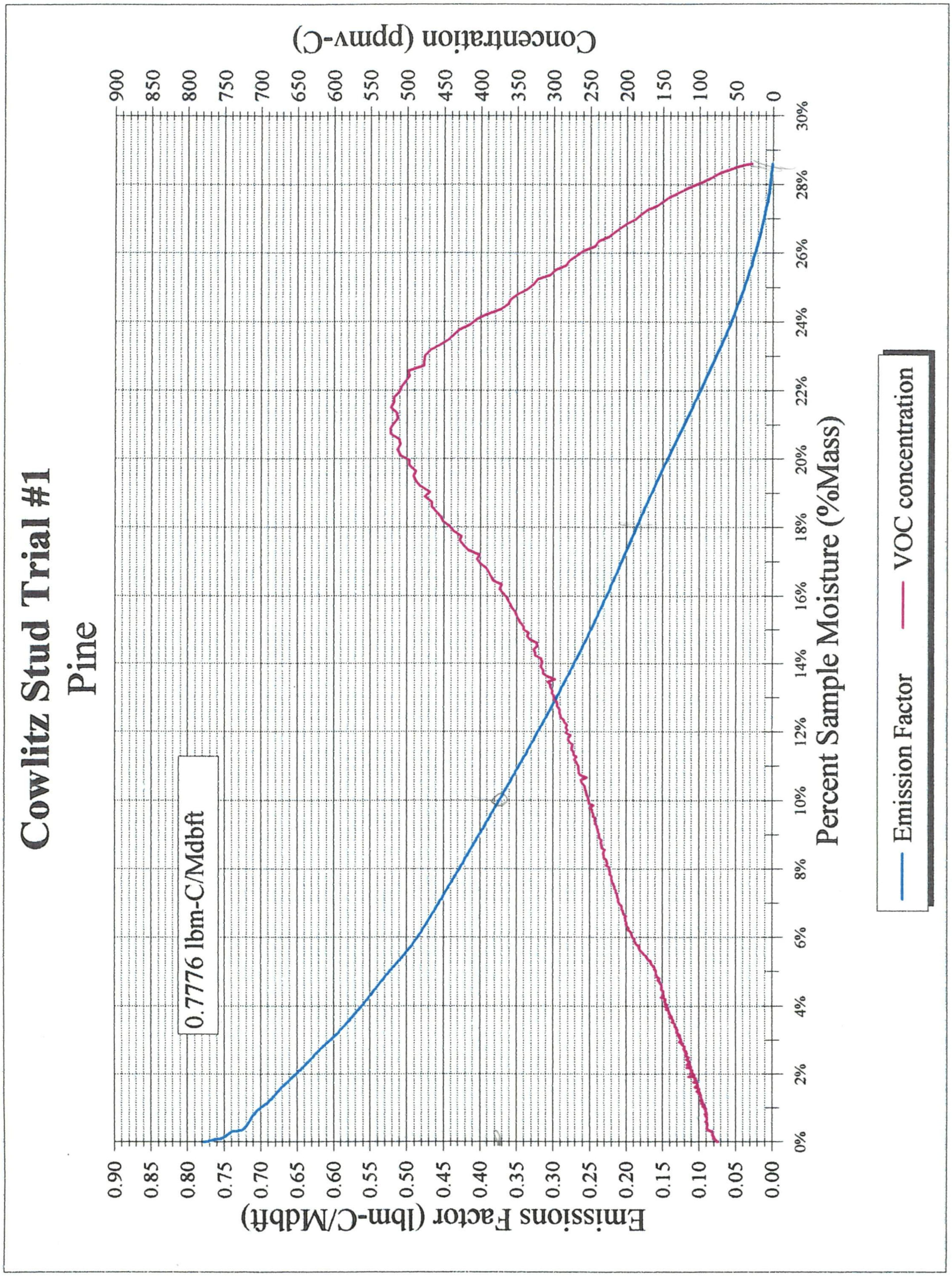
Table 1 summarizes the results of the testing. Figures 1 through 4 are plots of the calculated emission factors for the range of percentage H_2O (wet basis) of the wood samples. It should be noted that the results are based on an actual board foot basis, not the nominal dimensions of each sample board.

Detailed results and sampling parameters are included in the Appendix.

Table 1
Summary of Results

Results	**Units**				
Species		Pine	Pine	Doug Fir	Hemlock
Sample size	bd ft	8.4	8.4	7.8	8.0
Initial weight	lb	25.3	23.1	20.1	29.0
Weight loss	lb	7.5	5.3	5.5	12
Test time	hr	54	77	70	75
Avg VOC (dry)	ppmvC	181	145	86	42
Max VOC (wet)	ppmvC	361	317	362	66
Emission Factor					
@ 0% Moisture	lbC/Mbdft	0.78	0.86	0.51	0.25
@ 14% Moisture	lbC/Mbdft	0.27	0.19	0.23	0.10

VOC Kiln Test - V761A Feb 25-27, 1997



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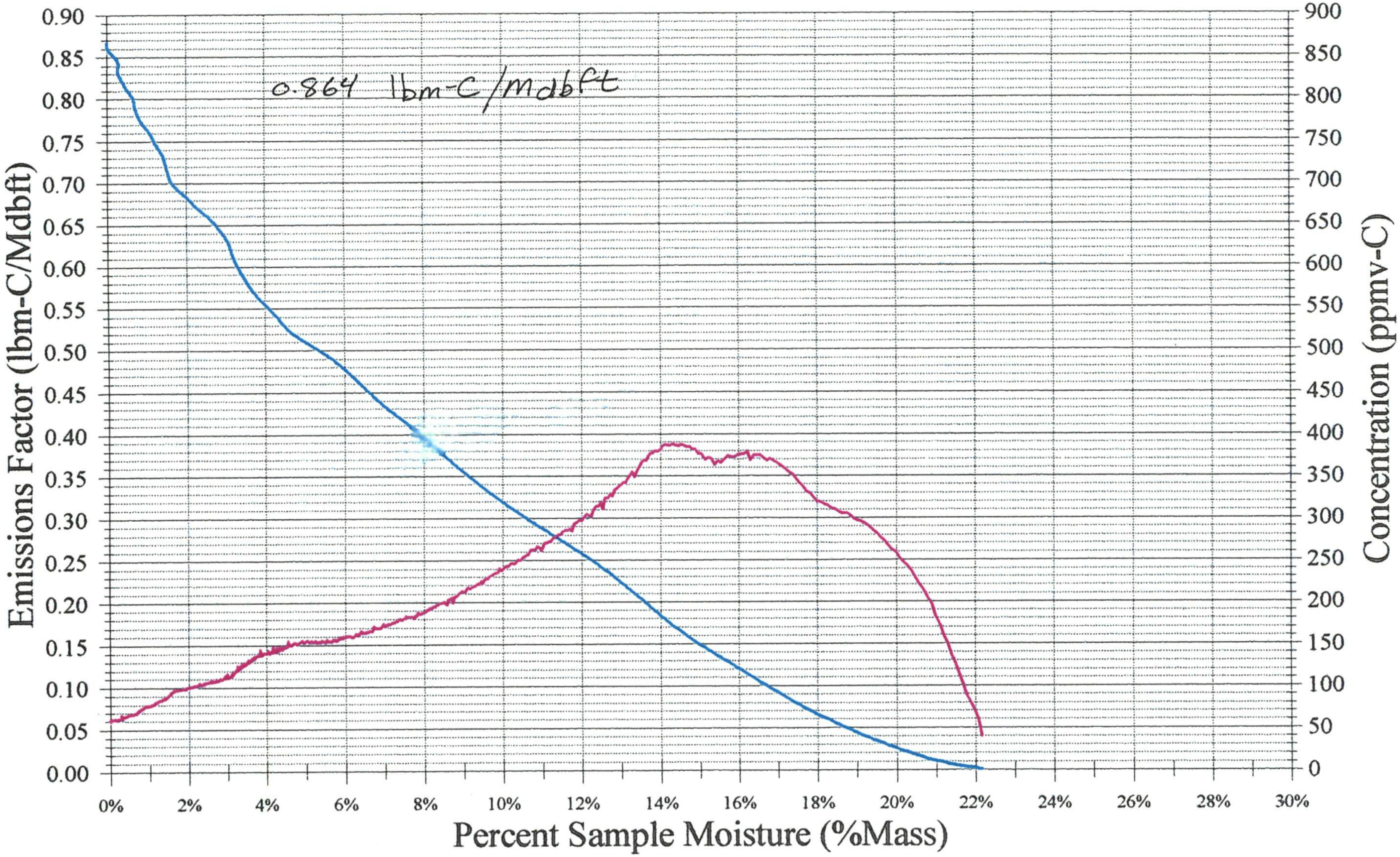
VOC Kiln Test - V761B Feb 28-Mar 3, 1997

Cowlitz Stud Trial #2

Pine



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VOC Kiln Test - V761C Mar 7-10, 1997

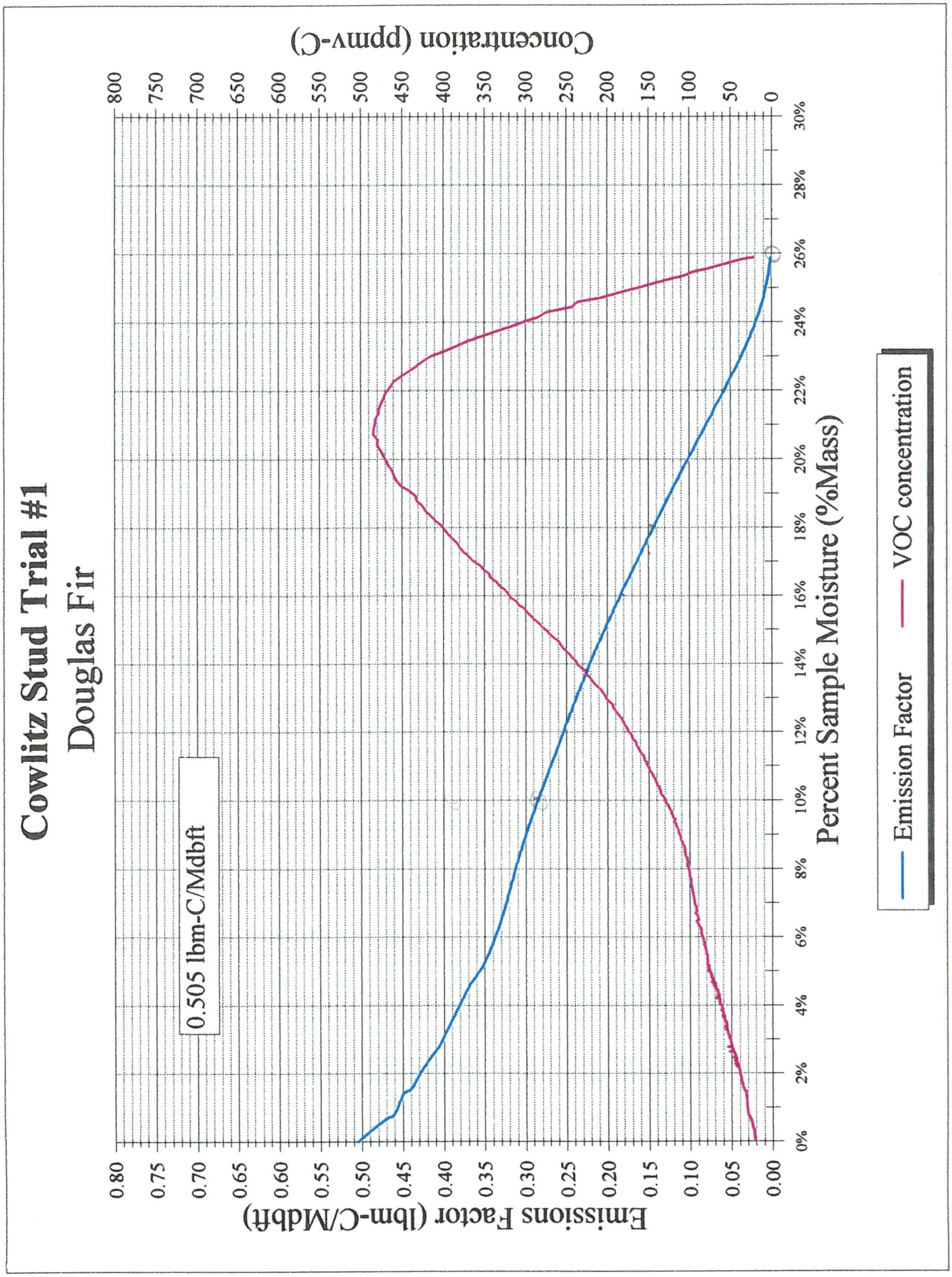

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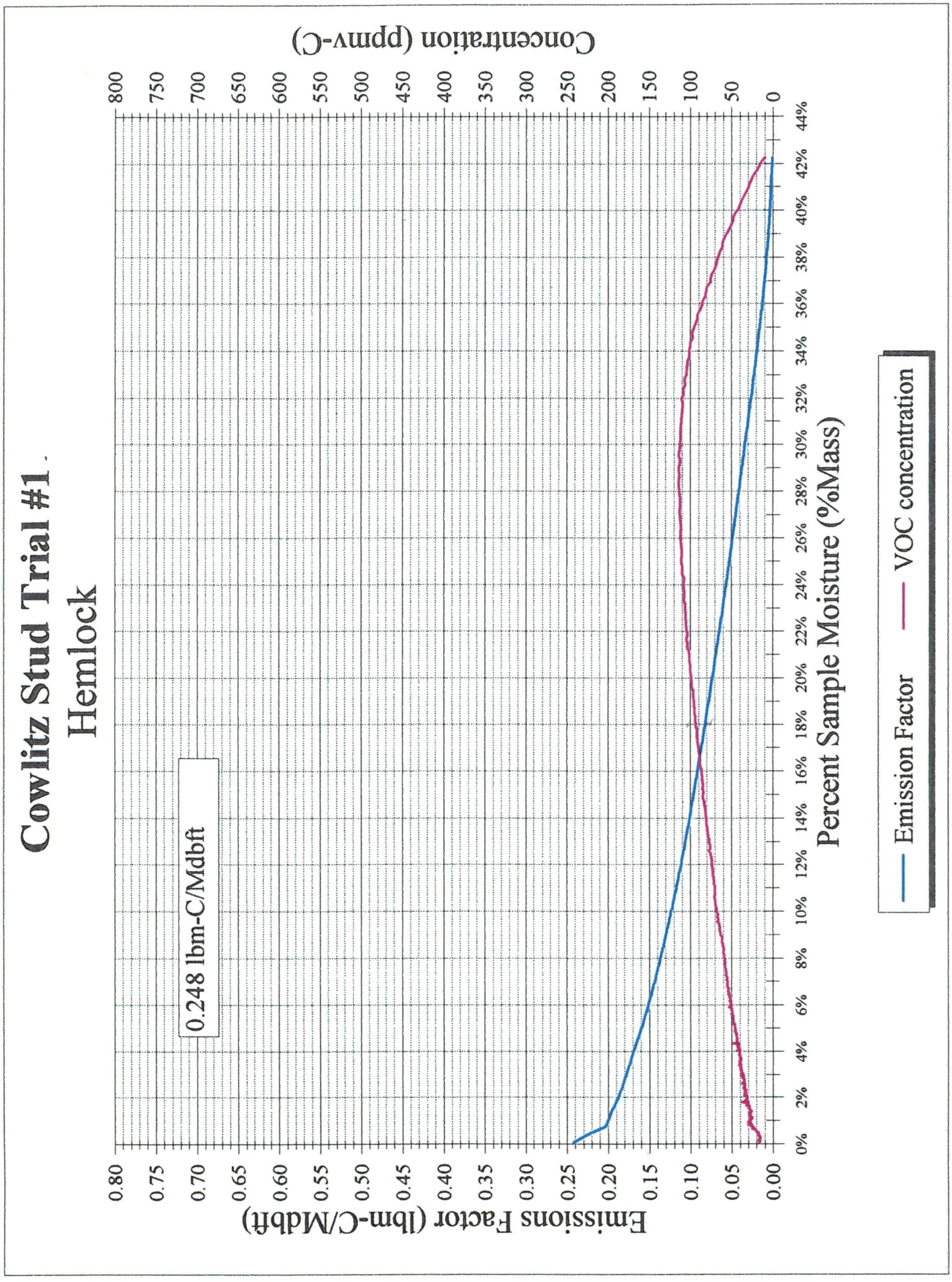
Figure 4

VOC Kiln Test - V761D Mar 10-13, 1997



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Rationale for the Test Method

Testing a dry kiln is difficult, costly, and there are many uncertainties when using the standard EPA Method 25A, because of the following conditions:

a.) Lumber drying can take over 100 hours to process one load.

b.) Most dry kilns have multiple vents and often have significant leakage around the loading doors.

c.) The venting process is periodic. The vents open to release moisture and VOC's in an irregular pattern.

The multiple vent configuration of most dry kilns and the periodic venting makes it difficult to quantify the total exhaust rate. Leakage from doors and other gaps is difficult to measure and therefore will produce inaccurate results. In addition, tests would need to be repeated for every species of wood the plant dries.

Testing Method

The Dettinger method, applied to the test kiln, employs EPA Method 25A in a controlled manner to measure VOC emissions. The method is assumed to be a worst case analysis, drying to the highest temperature for a normal drying cycle. The test chamber humidity is not controlled but inlet air humidity and volume rate is measured. Normal maximum temperature in a dry kiln is about 200°F but this varies for species and by kiln site. This method allows sample drying times of approximately 36 to 48 hours. Actual drying cycles may take between 36 to over 100 hours.

General The test kiln schematic is outlined in the test procedure. An industrial convection oven was used to dry the wood. A 0-100 lb load cell monitors the weight of the drying lumber.

A J.U.M. Engineering VE-7 total hydrocarbon analyzer with heated flame ionization detector and heated sample line was used to measure VOC concentrations at oven conditions. Data was recorded every five minutes by a Rustrak Ranger II data logging system. The accompanying software for the data logger was used to calculate averages for the gas concentrations. Graphic printouts of the data logger information are in the Appendix.

Sample for the analyzers was taken from a fixed sampling probe in the oven. Sample gas was routed through a heated sample line to the continuous analyzer.

Calibrations Zero, span, calibration error (linearity) and bias checks were made on the VOC monitor at the beginning and end of each test.

Calculations The results from the data logger are corrected for minor instrument drift according to the time when they were calibrated and when the test run was made. System calibration response (bias check) values are used as the basis for these corrections.

Flow Rate Air is supplied to the kiln at a constant rate and the total air flow for the entire drying cycle is calculated from dry gas meter readings, in cubic feet. The air in-flow, corrected to a dry standard volume (dscf), is the same as the out-flow dscf (the kiln is kept slightly pressurized). This in-flow rate was used in the pounds of VOC calculation.

Moisture The test kiln moisture was calculated from the weight loss of the sample plus the humidity (which is monitored) in the in-flow air. From the total water vapor volume and the total dry air volume, a percentage moisture (by volume) was calculated. Due to the nature of the scale used, the weight loss was not a perfectly smooth curve. The jumps in weight loss caused swings in the ongoing calculated internal moisture of the kiln. To remove these swings, Newton's best fit method was used to derive a smooth (conditioned) curve for the weight loss.

Board Volume The sample boards, as received, were of uniform length. Each sample load was stacked tightly together and measured. The board foot amount of the sample was based on a board foot being 144 cubic inches of wood.

Discussion

The final moisture content of the actual kiln dried lumber should be used to enter the plots of the results figures. Annual emissions of VOC (as carbon) can be calculated based on production of dried lumber.

APPENDIX

Nomenclature

- Lab Data
- VOC Concentration Plot
- Temperature-Humidity Plot
- Weight-Moisture Plot

Calibration Information

- Meter Box
- Standard meter
- Thermocouples
- Drift Correction

Test Method

Client: Cowlitz Stud
Species: Pine
Run: 2
Start Time: 10:20 am
Start Date: 2/28/97
Y of meter: .983

Pbar	30.0	30.0				
Date	2/28/97	3/3				

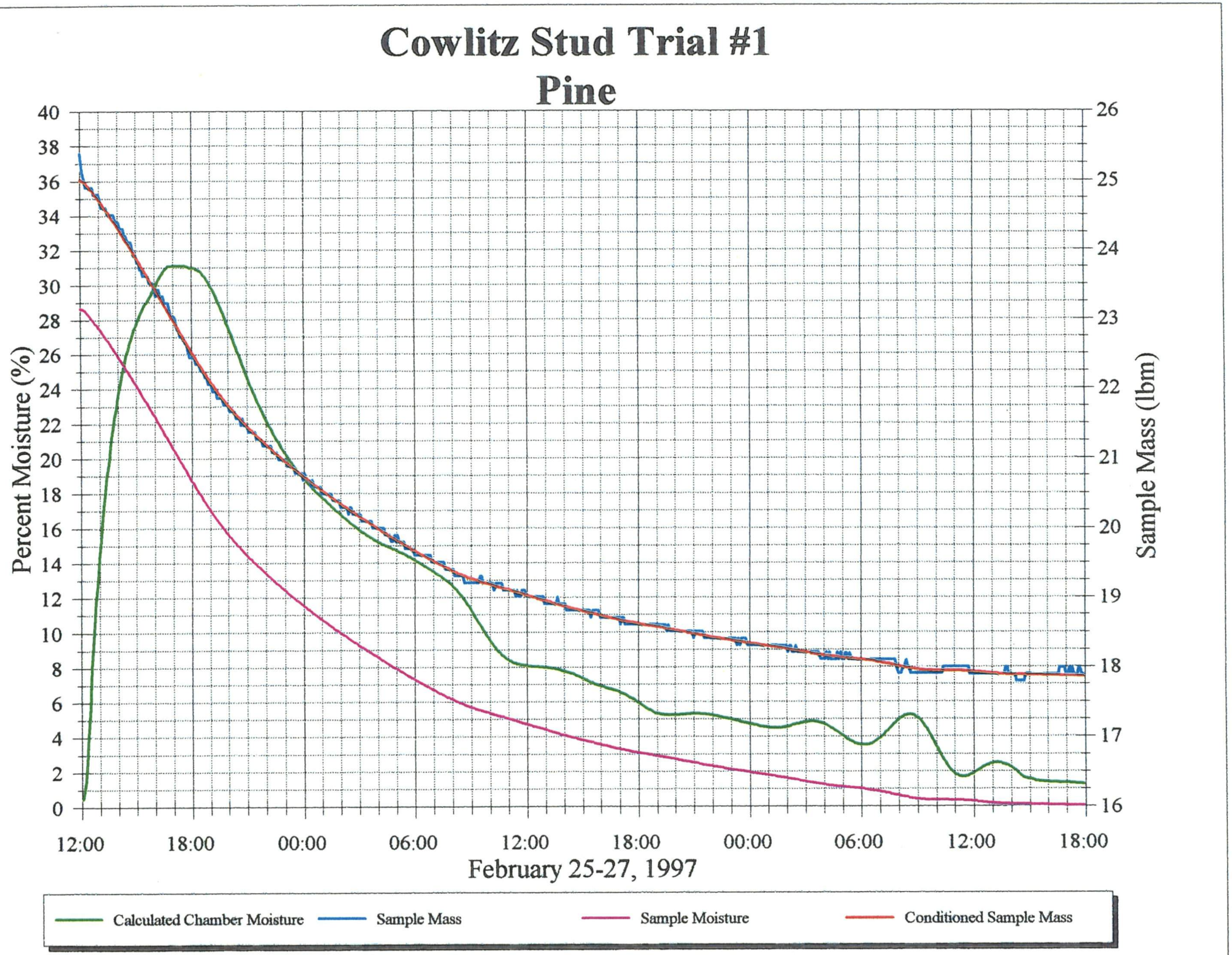
# of boards: 8
dim of boards: 3¾" x 1⅝" x 2'
dim of total load: 6¾" x 7⅜" x 2'
Bdft (note if dry or wet):

JUM # 2	actual	start bias	end bias
span CH_4	952	951.2	949.0
mid C_3H_8	601.2	576.0	580.4
mid CH_4	90.5	91.4	92.0
zero N_2	0.0	-.4	-2.0
time & date		10:00am/2-28	15:25/3-3

LOAD CELL	actual	start check	end check
high	49.7	51.0	51.0
zero	0.0	0.0	-.1
time & date		10:00am/2-28	15:20 / 3-3

Meter Reading	Time	Date	Load Weight
608.050	10:23am	2/28	23.8
628.801	11:21	2/28	23.3
651.250	12:25	2/28	23.0
735.600	4:26pm	2/28	22.1
55.409	8:25 am	3/3	18.3
199.500	1519	3/3	18.3

Roto Meter set at ≈12 LPM



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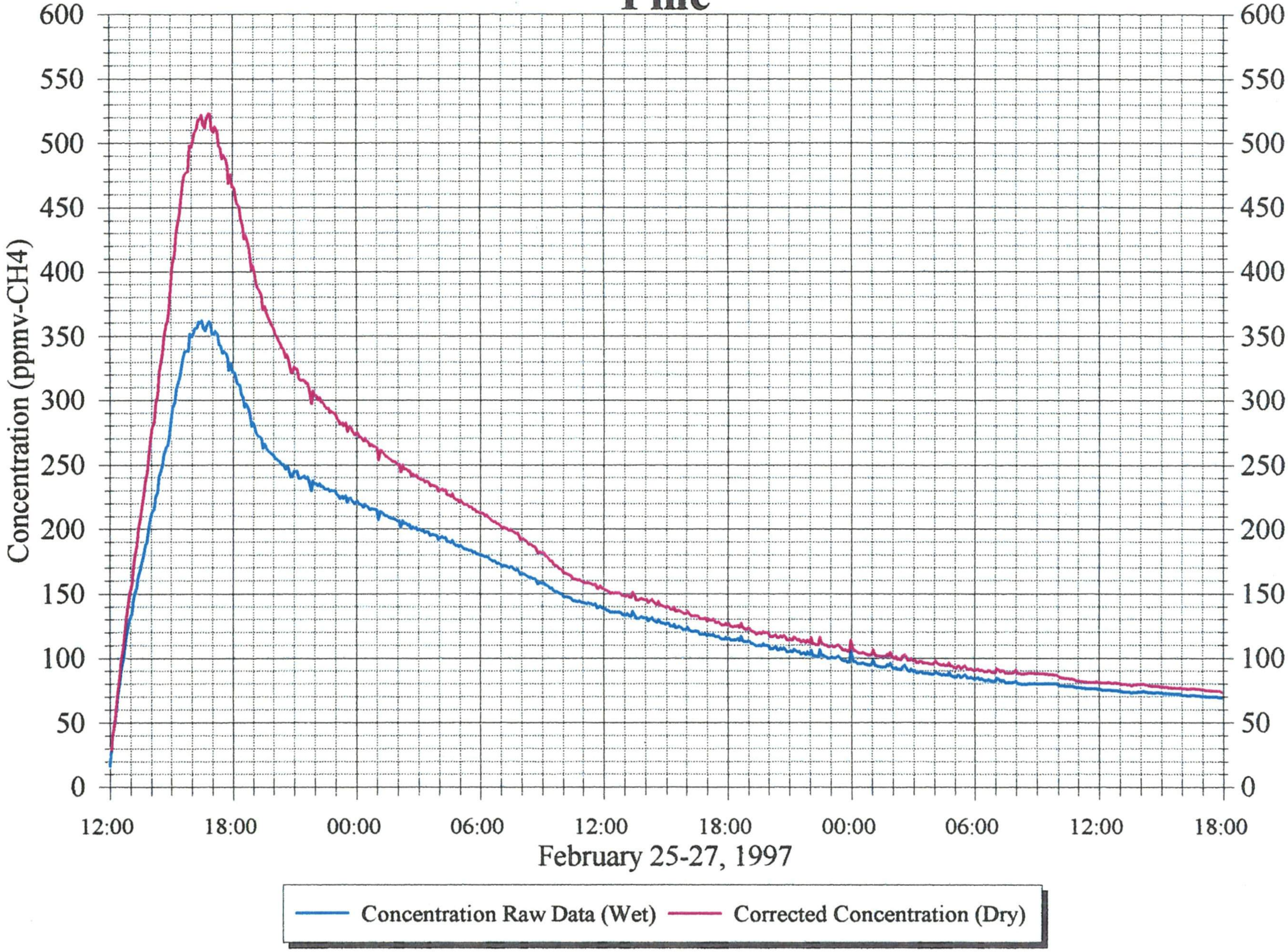
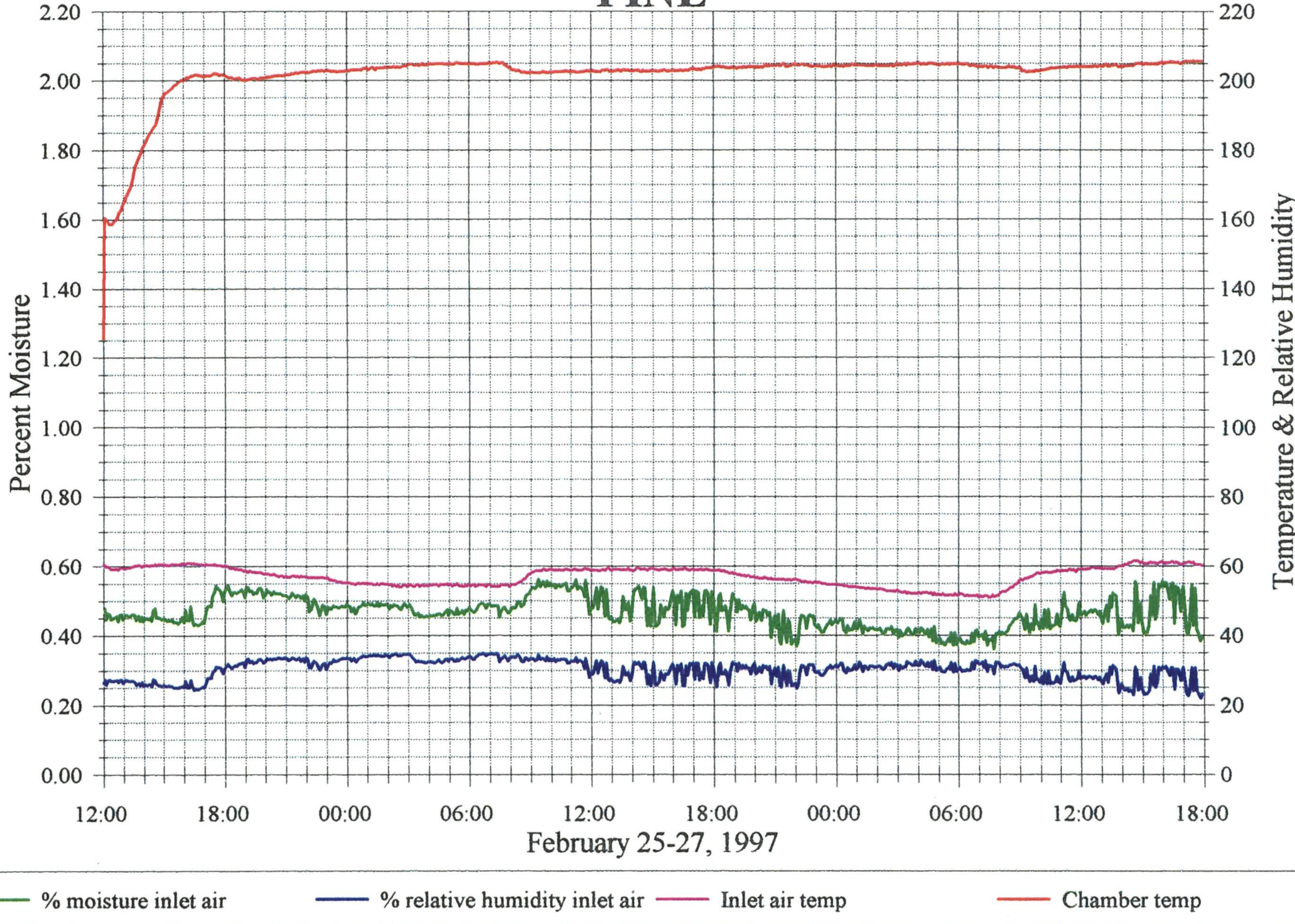
Cowlitz Stud Trial #1
Pine

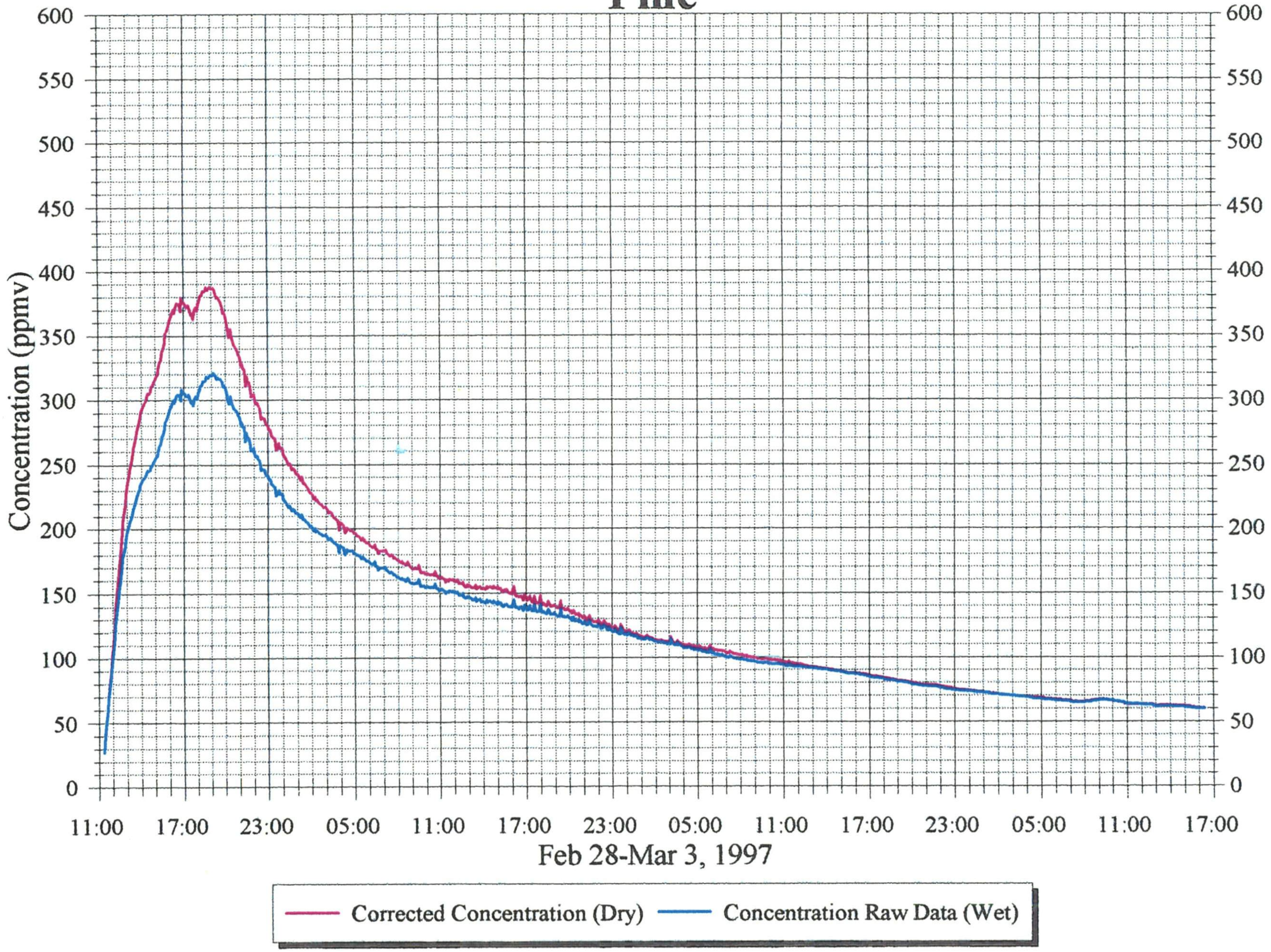


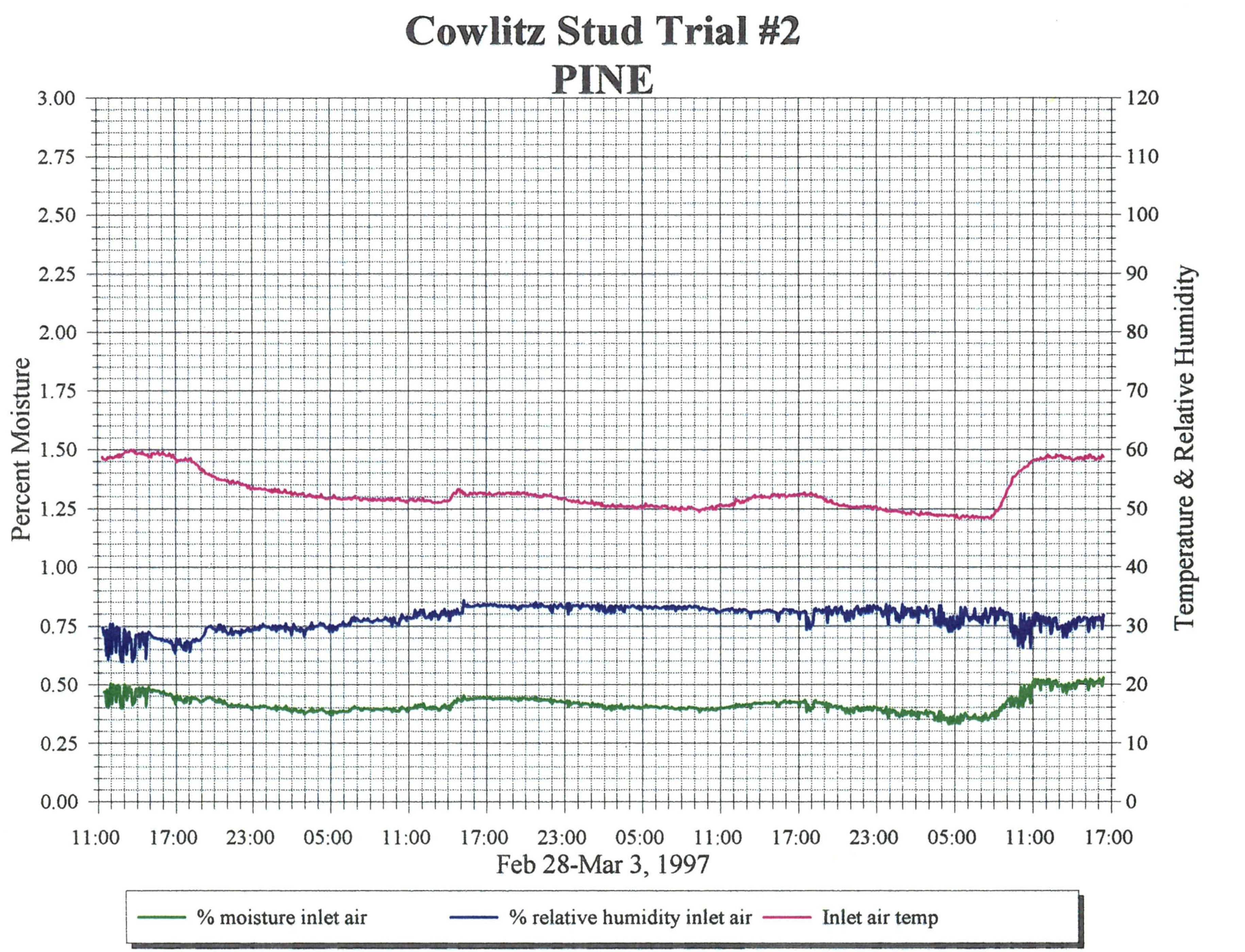
Cowlitz Stud Trial #1
PINE

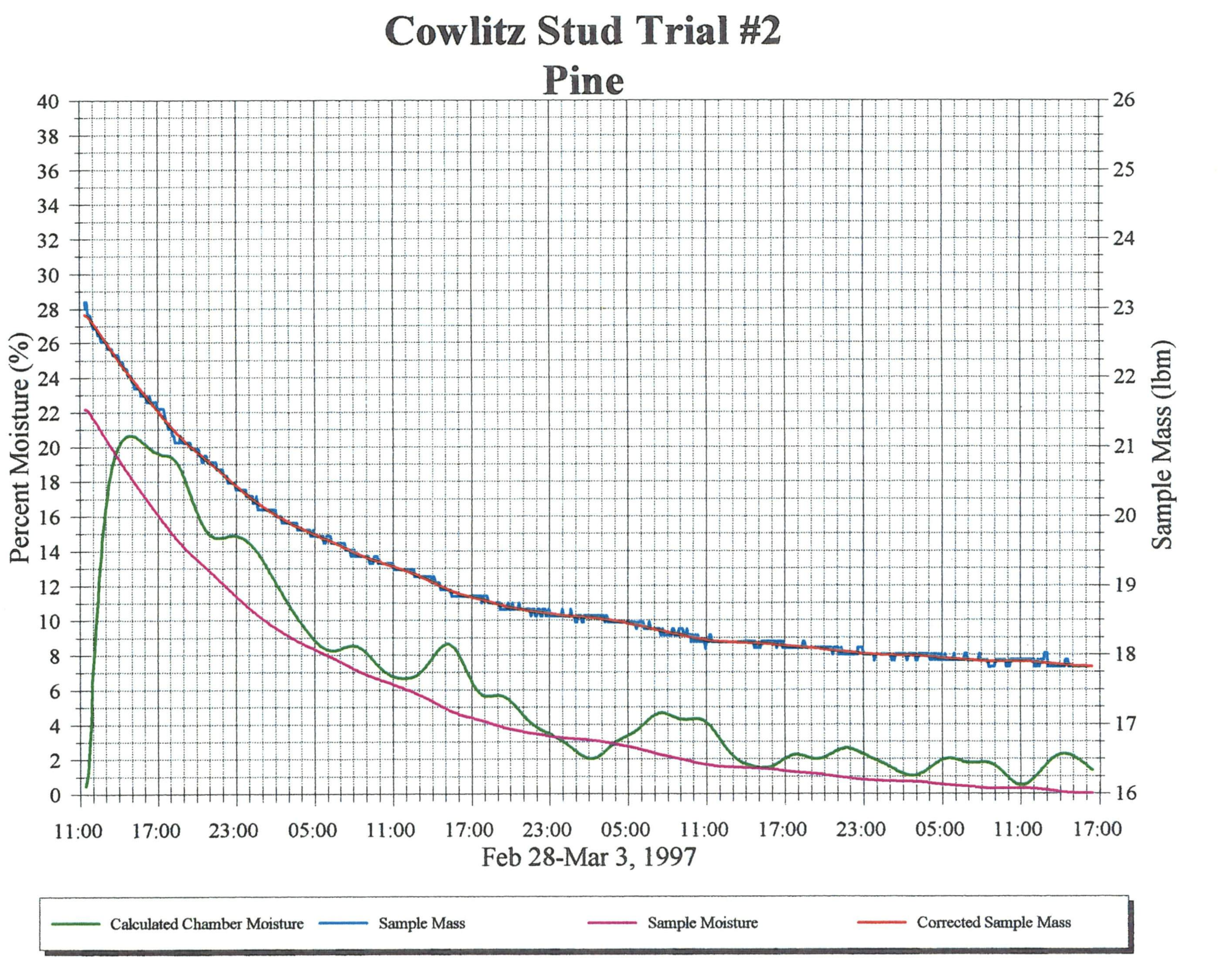


Cowlitz Stud Trial #2

Pine




Cowlitz Stud Trial #2
PINE
Percent Moisture
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Temperature & Relative Humidity
120
110
100
90
80
70
60
50
40
30
20
10
0
11:00 17:00 23:00 05:00 11:00 17:00 23:00 05:00 11:00 17:00 23:00 05:00 11:00 17:00
Feb 28-Mar 3, 1997
% moisture inlet air
% relative humidity inlet air
Inlet air temp



Cowlitz Stud Trial #2
Pine
Percent Moisture (%)
Sample Mass (lbm)
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
26
25
24
23
22
21
20
19
18
17
16
11:00 17:00 23:00 05:00 11:00 17:00 23:00 05:00 11:00 17:00 23:00 05:00 11:00 17:00
Feb 28-Mar 3, 1997
Calculated Chamber Moisture
Sample Mass
Sample Moisture
Corrected Sample Mass

Client: Cowlitz Studs
Species: D. Fir
Run: 3
Start Time: 1600
Start Date: 3/7/97
Y of meter: .983

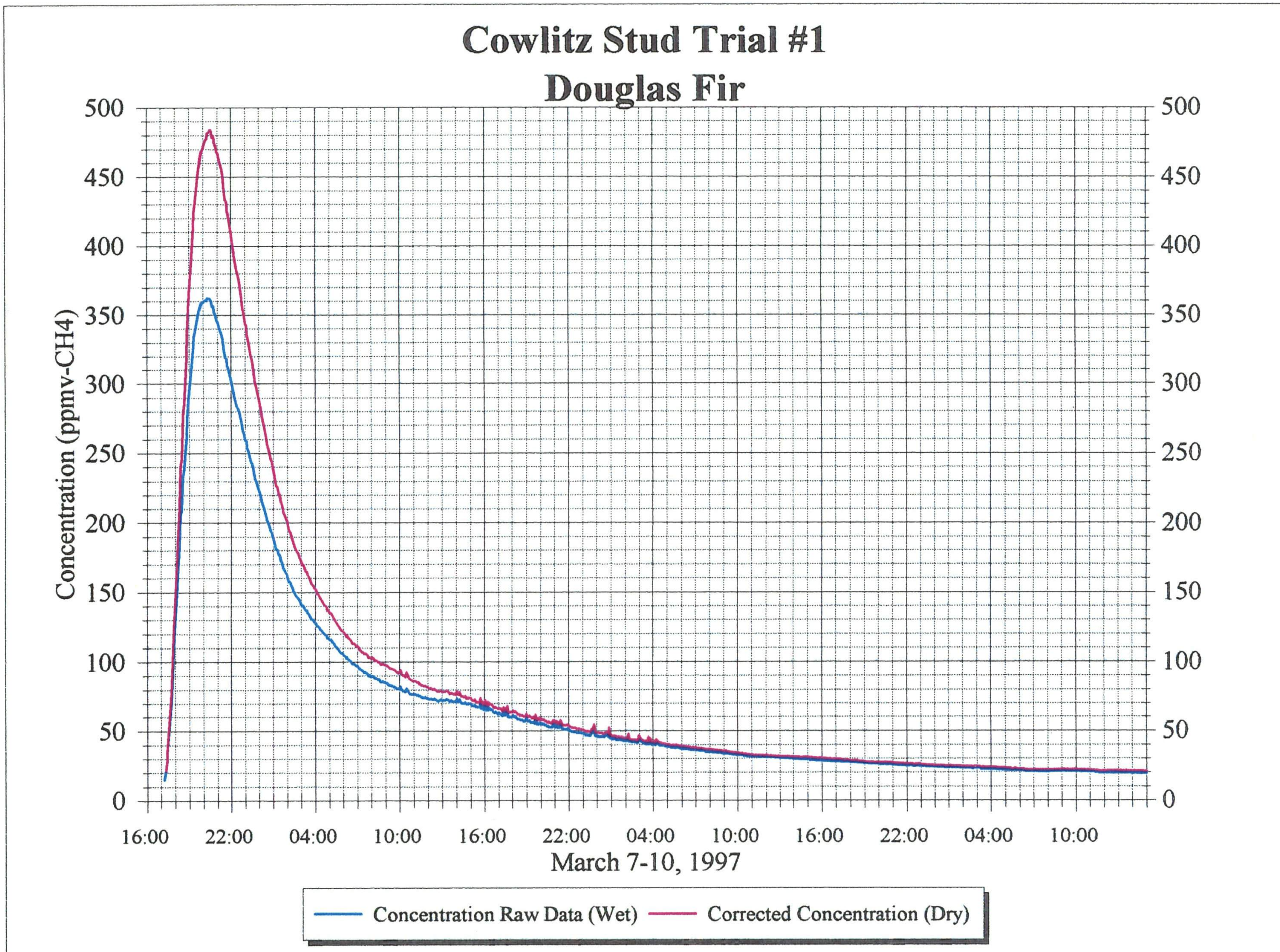
Pbar	30.1	30.1	30.1			
Date	3/7/97	3/9	3/10			

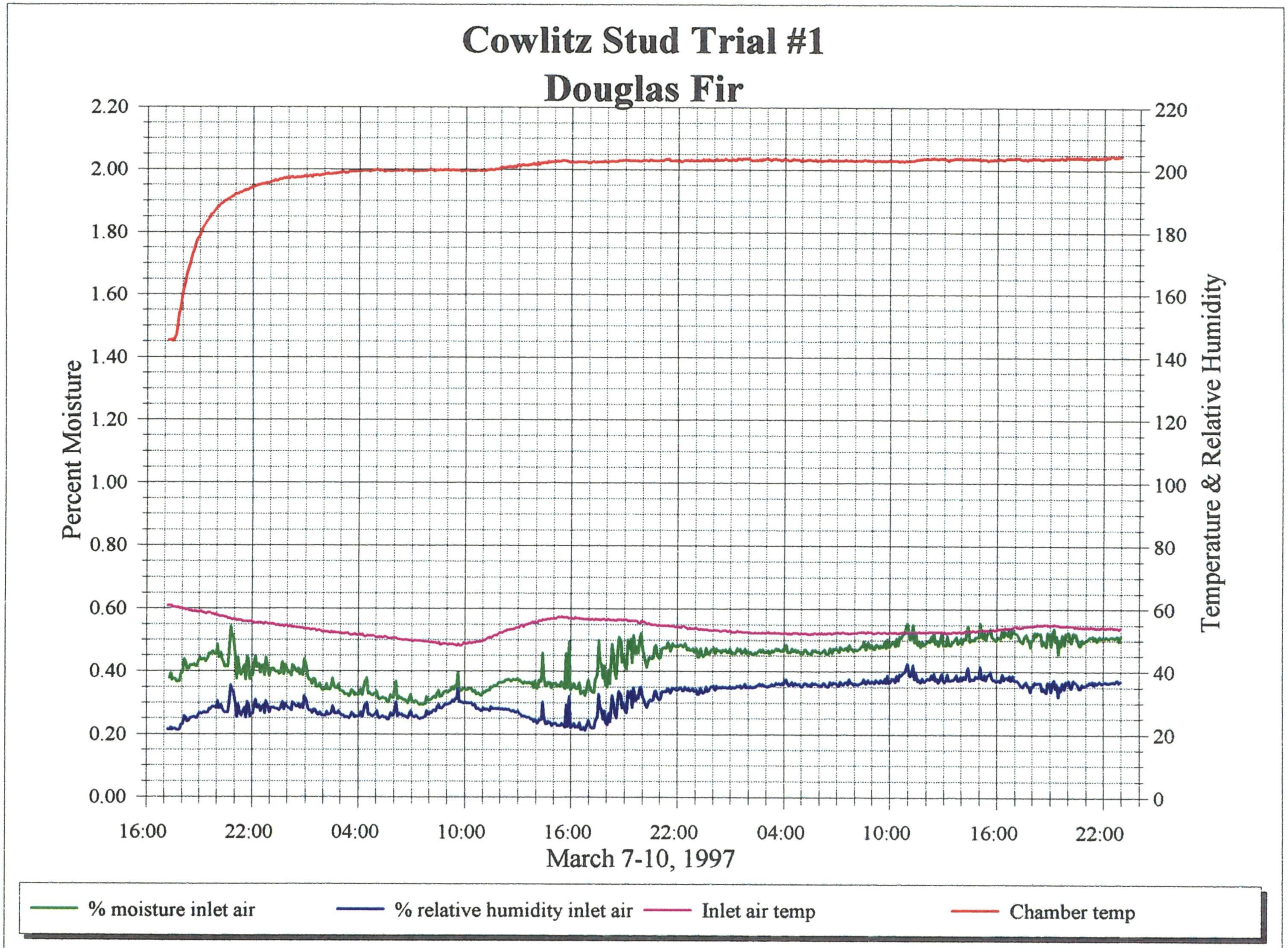
\# of boards: 8
dim of boards:
dim of total load: 6 3/8 × 7 3/8 × 2
Bdft (note if dry or wet):

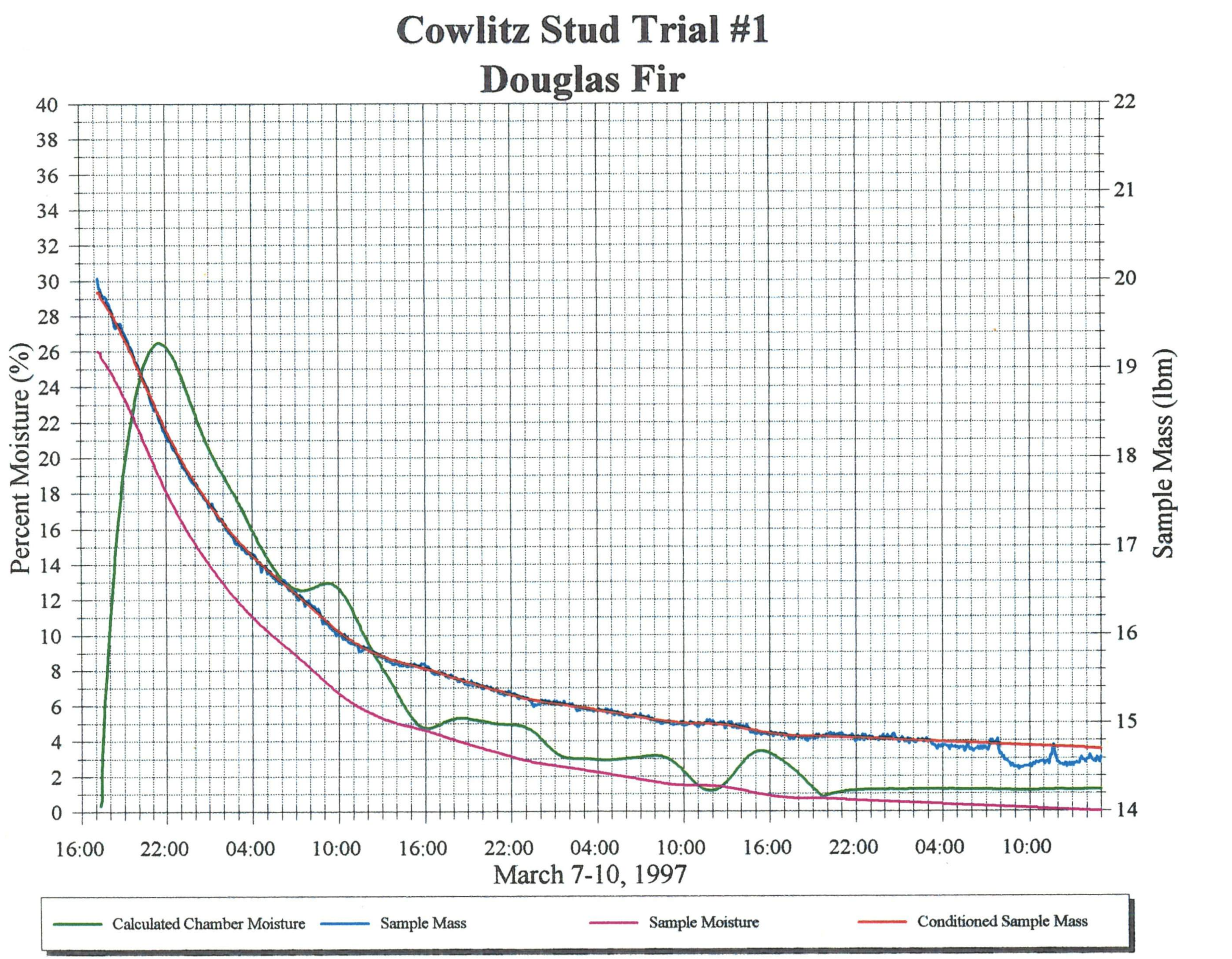
	JUM # 2	actual	start bias	end bias
	span CH_4	952	953.2	947.6
C_3H_8	mid 601.2	600.2	578	582.2
	mid CH_4	90.5	92.5	91.1
	zero N_2	0.0	0.0	-1.2
	time & date		1552 3/7	1404 3/10

LOAD CELL	actual	start check	end check
high	94.70	49.4	49.4
zero	0.0	-0.2	-0.1
time & date		15:45 3/7/97	1400 3/10

	Meter Reading	Time	Date	Load Weight
(17:10)	299.525	16:10	3/7	20.2
(17:25)	309.195	16:25	3/7	19.7
14:49	261.500	13:49	3/9/97	14.79
19:02	352.100	1802	3/9	14.71
10:38	676.341	938	3/10	14.38
14:59	766.679	1359	3/10	14.46


Cowlitz Stud Trial #1
Douglas Fir
Concentration (ppmv-CH4)
500
450
400
350
300
250
200
150
100
50
0
16:00
22:00
04:00
10:00
16:00
22:00
04:00
10:00
16:00
22:00
04:00
10:00
March 7-10, 1997
Concentration Raw Data (Wet)
Corrected Concentration (Dry)


Cowlitz Stud Trial #1
Douglas Fir
Percent Moisture
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Temperature & Relative Humidity
220
200
180
160
140
120
100
80
60
40
20
0
16:00
22:00
04:00
10:00
16:00
22:00
04:00
10:00
16:00
22:00
March 7-10, 1997
% moisture inlet air
% relative humidity inlet air
Inlet air temp
Chamber temp


Cowlitz Stud Trial #1
Douglas Fir
Percent Moisture (%)
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Sample Mass (lbm)
22
21
20
19
18
17
16
15
14
16:00
22:00
04:00
10:00
16:00
22:00
04:00
10:00
16:00
22:00
04:00
10:00
March 7-10, 1997
Calculated Chamber Moisture
Sample Mass
Sample Moisture
Conditioned Sample Mass

Client: Cowlitz Studs
Species: Hemlock
Run: 4
Start Time: 14:25
Start Date: 3/10/97
Y of meter: 0.983

Pbar	30.1	30.0	30.00	30.1		
Date	3/10	3/11	3/12	3/13		

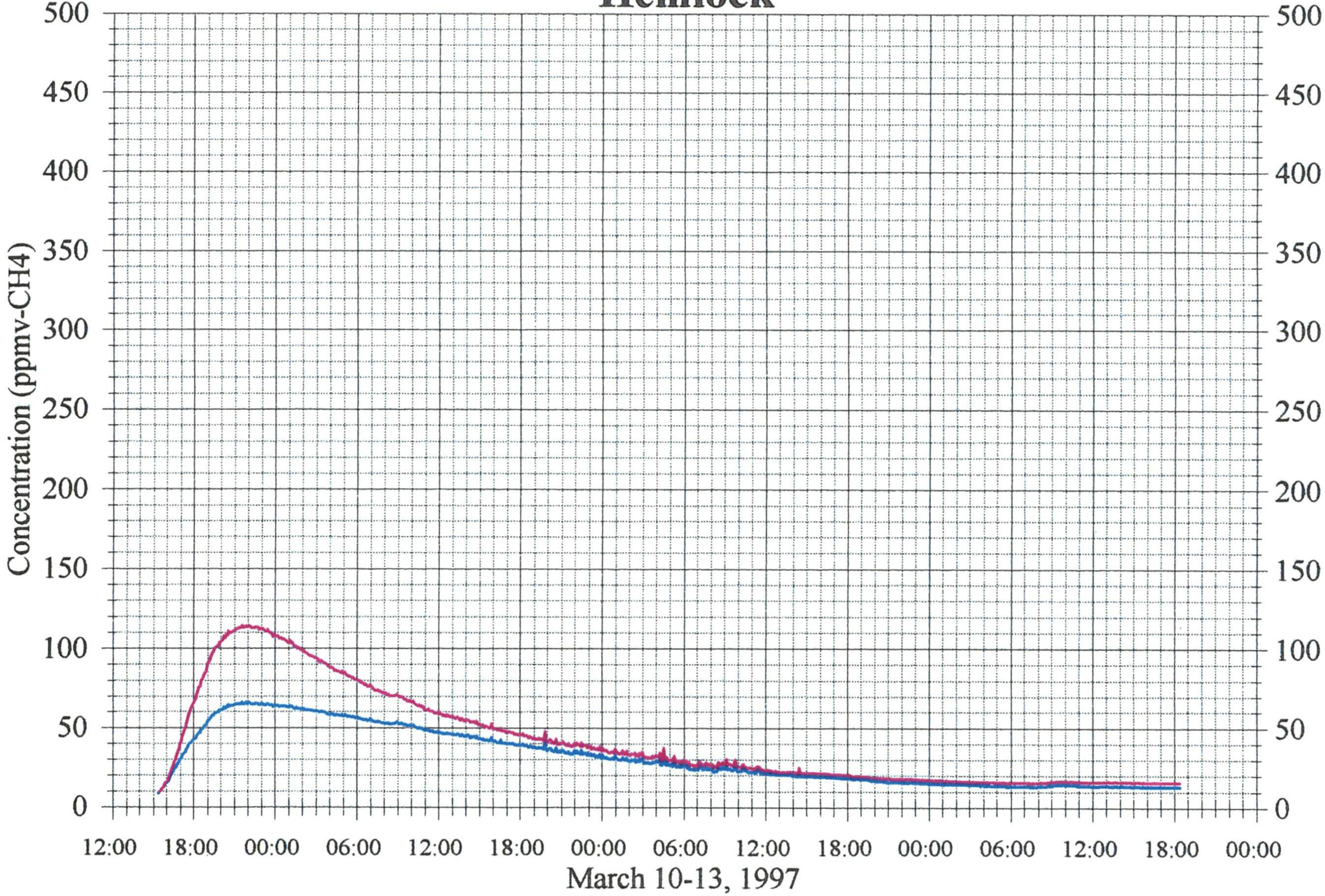
# of boards: 8
dim of boards:
dim of total load:
Bdft (note if dry or wet):

JUM #	actual	start bias	end bias
span CH_4	952	954.9	952.0
mid C_3H_8	601.2	582.2	579.4
mid CH_4	90.5	91.1	91.3
zero N_2	0.0	-1.7	-2.5
time & date		3/10/97 14:15	3/13/97 17:30

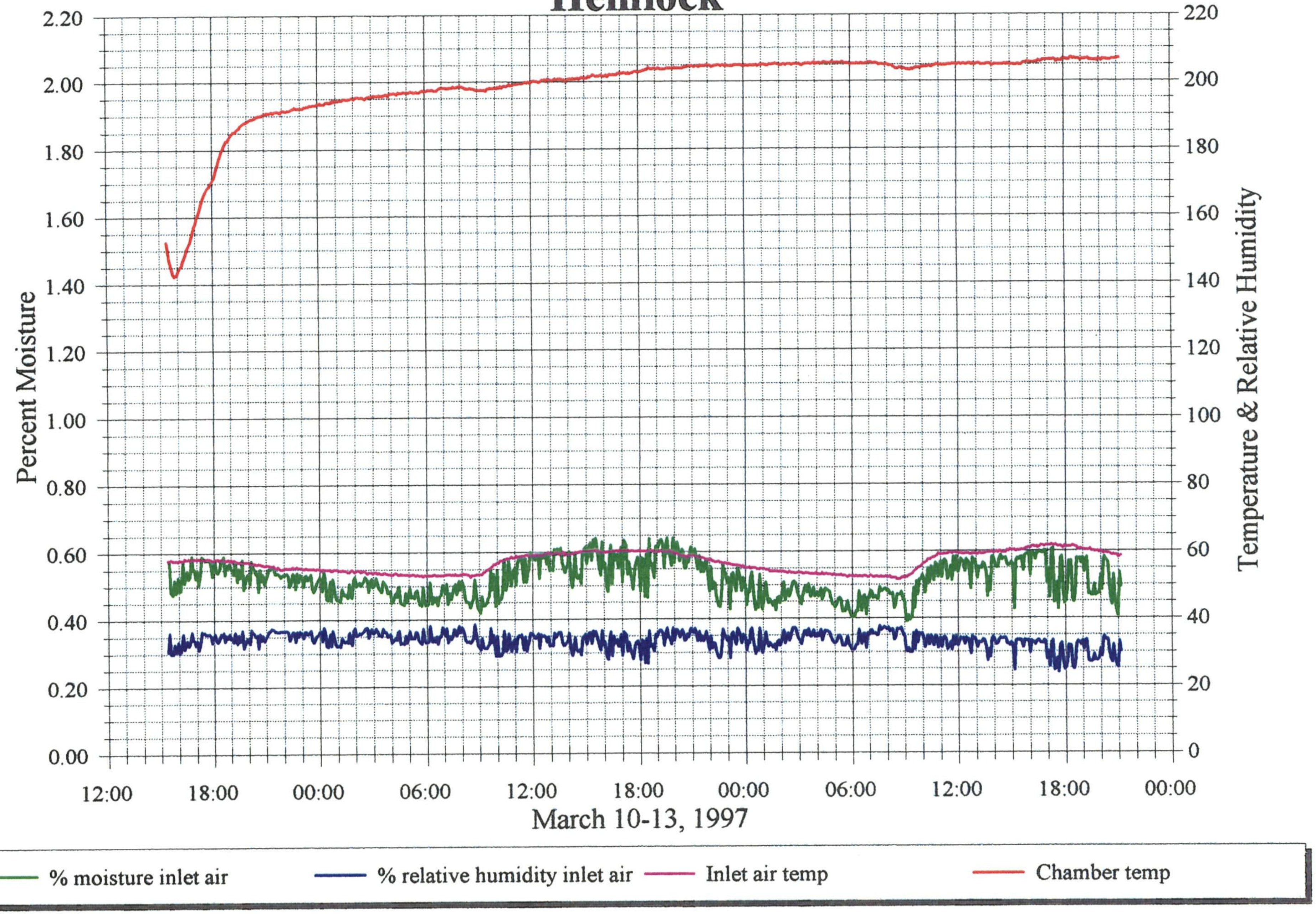
LOAD CELL	actual	start check	end check
high	47.70	49.48	49.43
zero	0.0	-0.05	-0.15
time & date		14:17 3/10	1725 3/13

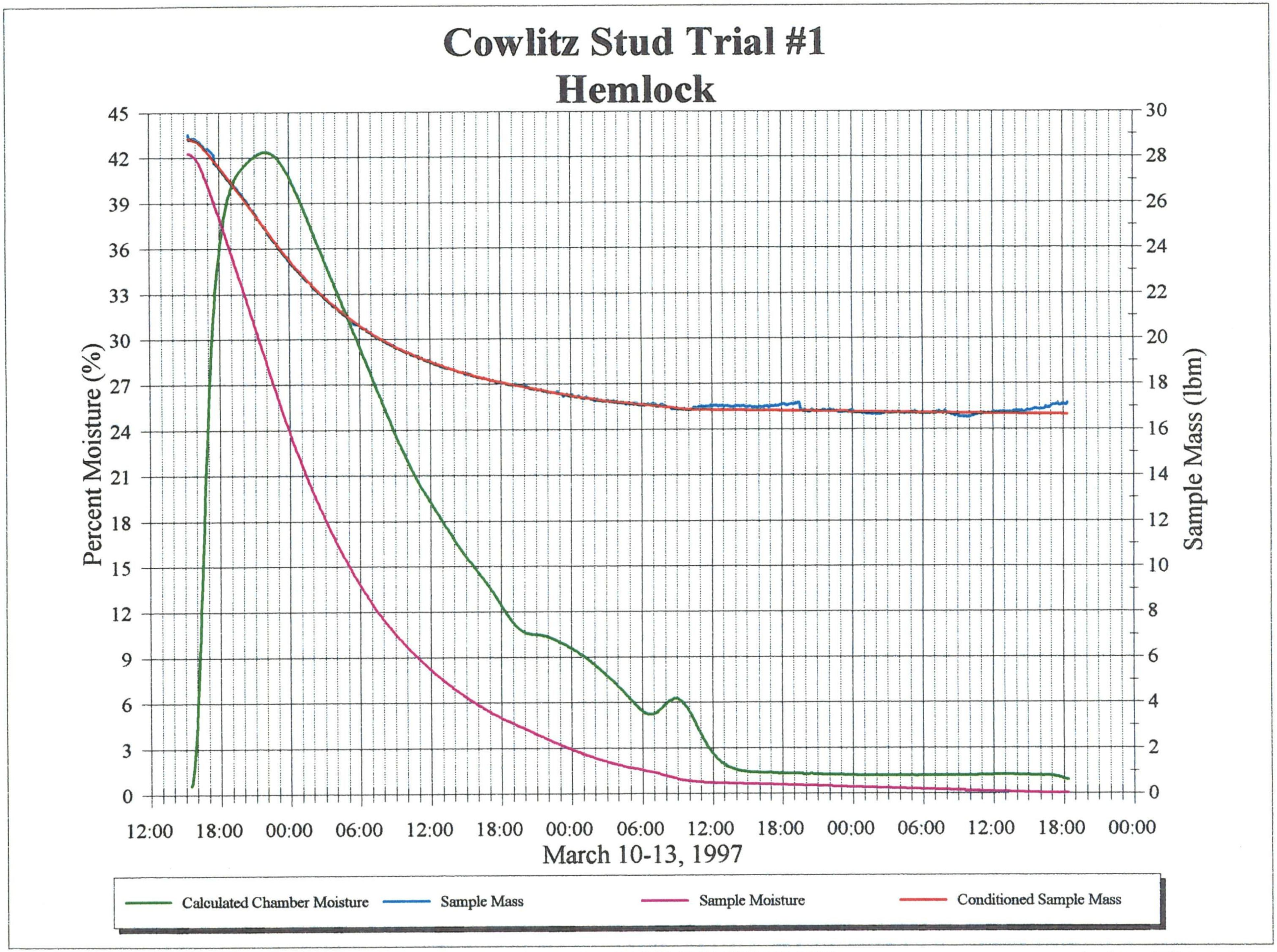
Meter Reading	Time	Date	Load Weight
774.531	1422	3/10	29.0
832.205	17:12	3/10	27.32
130.150	745	3/11	19.60
528.004	17 34	3/11	17.88
611.902	0745	3/12	16.72
746.304	14:30	3/12	16.79
794.303	16:55	3/12	16.89
94.775	8:02	3/13	802 16.42
278.495	17 20	3/13	16.87

Cowlitz Stud Trial #1
Hemlock



Cowlitz Stud Trial #1
Hemlock





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Standard Dry Gas Meter

Flow Rate CFH	Prof
21	O. 99.7
	C. 99.8
36	O. 99.7
	C. 99.6
41	O. 99.6
	C. 99.6
60	O. 99.7
	C. 99.5
75	O. 99.5
	C. 99.6

Tested 12/21/95
By Greg Beck

File fs022796
Method EPA #5.3.2 & 5.6
Location Horizon Shop
Meter Box ID FS-A 685998
Meter ID None
Calibrated jdf

Pb= 30.02 (in Hg)
Ta= 60 (oF)
Date 2/14/97

	Old 9-23-96	New 02-14-97	Change (+/-)
Y=	0.98537	0.99578	1.06%

FS-A 685998 / FS-A 685998 / FS-A 685998 / FS-A 685998	VAC (inH20)	dH (inH2O)	Standard Meter (ft3)	Net (ft3)	Field Meter (ft3)	Net (ft3)	Standard Tw (oF)	Meter Tw (oR)	Field Tdi (oF)	Meter Tdo (oF)	To (oR)	Tm (oR)	Time t (min)	Y	Allowable Tolerance Y 0.020
Initial	N/A	N/A	0.0050	5.9950	892.6050	6.0170	61.0	521.2	61.2	61.2	521.4	521.4	23.133	0.99673	0.001
Final			6.0000		898.6220		61.4		61.6	61.6					
Initial	N/A	N/A	0.0000	6.0000	899.0040	6.0390	61.8	522.1	62.0	62.0	522.0	522.0	10.367	0.99335	0.002
Final			6.0000		905.0430		62.4		62.0	62.0					
Initial	N/A	N/A	0.0000	6.0000	905.0430	6.0130	62.6	522.8	62.2	62.2	522.5	522.5	11.433	0.99727	0.001
Final			6.0000		911.0560		63.0		62.8	62.8					
														0.99578	0.002

File
Method EPA #5.3.2 & 5.6
Location Horizon Shop
Meter Box ID FS-D 2713329
Meter ID None
Calibrated jdf

Pb= 30.20 (in Hg)
Ta= 60 (oF)
Date 02/14/97

	Old 09-23-96	New 02-14-97	Change (+/-)
Y=	0.99517	0.98300	-1.22%

FS-D 2713329 / FS-D 2713329 / FS-D 2713329 / FS-D 2713329	VAC. (inH20)	dH (inH2O)	Standard Meter (ft3)	Net (ft3)	Field Meter (ft3)	Net (ft3)	Standard Tw (oF)	Meter Tw (oR)	Field Tdi (oF)	Meter Tdo (oF)	To (oR)	Tm (oR)	Time t (min)	Y	Allowable Tolerance Y 0.020
Initial	N/A	N/A	0.0000	6.0250	6.6120	6.1730	63.8	524.1	62.6	62.6	522.2	522.2	12.033	0.97249	0.011
Final			6.0250		12.7850		64.4		61.8	61.8					
Initial	N/A	N/A	0.0250	5.9760	12.7850	5.9740	64.4	524.7	61.8	61.8	521.7	521.7	11.467	0.99462	0.012
Final			6.0010		18.7590		65.0		61.6	61.6					
Initial	N/A	N/A	0.0010	6.0000	18.5590	6.0710	65.0	525.3	61.8	61.8	521.9	521.9	13.917	0.98191	0.001
Final			6.0010		24.6300		65.6		62.0	62.0					
														0.98300	0.008

File fs022796
Method EPA #5.3.2 & 5.6
Location Horizon Shop
Meter Box ID FS-E 2713328
Meter ID None
Calibrated jdf

Pb= 30.20 (in Hg)
Ta= 60 (oF)
Date 02/14/97

	Old 09-23-96	New 02-14-97	Change (+/-)
Y=	1.00818	0.99878	-0.93%

FS-E 2713328 / FS-E 2713328 / FS-E 2713328 / FS-E 2713328	VAC (inH20)	dH (inH2O)	Standard Meter (ft3)	Net (ft3)	Field Meter (ft3)	Net (ft3)	Standard Tw (oF)	Meter Tw (oR)	Field Tdi (oF)	Meter Tdo (oF)	To (oR)	Tm (oR)	Time t (min)	Y	Allowable Tolerance Y 0.020
Initial	N/A	N/A	0.0010	5.9990	293.7780	5.9200	64.8	524.7	62.6	62.6	522.3	522.3	10.333	1.00871	0.010
Final			6.0000		299.6980		64.6		62.0	62.0					
Initial	N/A	N/A	0.0000	6.0250	299.6980	6.0620	65.2	525.3	62.2	62.2	522.1	522.1	12.167	0.98784	0.011
Final			6.0250		305.7600		65.4		62.0	62.0					
Initial	N/A	N/A	0.0250	5.9750	305.7600	5.9330	65.4	525.8	62.0	62.0	522.0	522.0	15.000	0.99980	0.001
Final			6.0000		311.6930		66.2		62.0	62.0					
														0.99878	0.007

Thermocouple Calibration

Date:	21-Aug-96	Deviation	@60 F	7.8	Pb=	29.95 in Hg	DRB
Next Calibration:	17-Feb-97	Limit	@212 F	10.1	Ta=	80.0 oF	960820tc
			@375 F	12.5			

	Probe/ID	Ambient Standard, F	Measured, F	Difference F	Boiling, Water Standard, F	Measured, F	Difference F	Boiling, Oil Standard, F	Measured, F	Difference F	Average Difference F
Probe	3-1	38.0	38.6	-0.6	212.4	212.4	0.0	340.8	338.8	2.0	0.47
Probe	3-2	38.0	38.0	0.0	211.6	213.4	-1.8	333.8	332.4	1.4	-0.13
Probe	3-3	37.0	37.8	-0.8	211.6	212.2	-0.6	334.8	332.6	2.2	0.27
Probe	3-4	39.0	39.4	-0.4	211.8	212.2	-0.4	336.2	334.8	1.4	0.20
Probe	4-1	38.0	37.8	0.2	211.2	210.6	0.6	343.8	341.6	2.2	1.00
Probe	4-2	39.0	38.6	0.4	212.2	211.6	0.6	326.4	322.8	3.6	1.53
Probe	4-3	39.0	38.4	0.6	211.4	212.8	-1.4	334.2	331.4	2.8	0.67
Probe	4-4	38.0	37.8	0.2	211.6	212.6	-1.0	335.0	331.6	3.4	0.87
Probe	4-5	38.0	38.6	-0.6	211.6	212	-0.4	347.8	345.6	2.2	0.40
Probe	4-6	38.0	38.8	-0.8	211.6	213.8	-2.2	350.8	348.2	2.6	-0.13
Probe	4-7	37.0	38.4	-1.4	211.4	211.8	-0.4	337.2	341.2	-4.0	-1.93
Probe	5-2	39.0	38.6	0.4	211.8	213.4	-1.6	330.8	330.4	0.4	-0.27
Probe	5-3	38.0	39.4	-1.4	211.8	213.2	-1.4	330.2	328.8	1.4	-0.47
Probe	5-4	38.0	38.0	0.0	212	211.8	0.2	329.2	327.0	2.2	0.80
Probe	5-5	37.0	38.0	-1.0	211.8	212.2	-0.4	328.0	327.8	0.2	-0.40
Probe	5-6	38.0	38.4	-0.4	212	212.8	-0.8	324.4	323.0	1.4	0.07
Probe	5-7	39.0	38.8	0.2	212	213	-1.0	326.2	324.2	2.0	0.40
Probe	5-8	37.0	37.6	-0.6	212	212.8	-0.8	328.0	328.0	0.0	-0.47
Probe	5-9	37.0	39.6	-2.6	211.4	212.8	-1.4	330.4	327.8	2.6	-0.47
Probe	7-1	38.0	38.4	-0.4	212	210	2.0	329.0	326.6	2.4	1.33
Probe	7-2	37.0	37.6	-0.6	211.8	212.8	-1.0	330.6	328.8	1.8	0.07
Probe	7-3	38.5	39.2	-0.7	212.2	211	1.2	327.6	327.6	0.0	0.17
Probe	10-1	39.0	38.8	0.2	212	211	1.0	325.4	324.2	1.2	0.80
Probe	10-2	37.0	38.4	-1.4	212	211.4	0.6	328.0	326.6	1.4	0.20
Probe	10-3	39.0	40.4	-1.4	211.8	211.2	0.6	328.2	326.2	2.0	0.40
Free Standing Pitot	11-S	76.2	78.6	-2.4	196.4	201.2	-4.8	367.4	366.2	1.2	-2.00
	10-S	39.0	38.6	0.4	212	212.6	-0.6	327.0	326.8	0.2	-0.00
	F1	39.0	38.4	0.6	212	212	0.0	341.8	342.2	-0.4	0.07
	F3	39.0	38.4	0.6	212	213.6	-1.6	328.8	327.8	1.0	0.00
	F4	38.0	37.8	0.2	212.6	211	1.6	340.2	338.6	1.6	1.13
	F5	62.8	62.6	0.2	198.2	199	-0.8	368.4	367.8	0.6	-0.00
	F23	37.0	37.0	0.0	212	213	-1.0	341.4	343.6	-2.2	-1.07
	F40	39.0	38.2	0.8	212	212.8	-0.8	355.4	355.6	-0.2	-0.07
	F51	38.0	37.8	0.2	213	213	0.0	330.4	330.2	0.2	0.13
	F83	38.0	38.6	-0.6	212.2	213	-0.8	338.2	338.0	0.2	-0.40
	F84	38.0	38.2	-0.2	210.8	213.6	-2.8	355.6	351.4	4.2	0.40
	F85	38.0	37.6	0.4	212	212.4	-0.4	355.4	352.2	3.2	1.07
	B1	36.0	34.6	1.4	212	213.4	-1.4	367.0	371.2	-4.2	-1.40
	B2	36.0	36.0	0.0	212	210.6	1.4	371.0	366.8	4.2	1.87
	B3	81.0	78.2	2.8	211.8	216.4	-4.6	402.8	401.2	1.6	-0.07
	B4	36.0	36.8	-0.8	212	209.6	2.4	367.0	364.2	2.8	1.47
	B5	81.0	78.8	2.2	212	209.4	2.6	388.6	379.6	9.0	4.60
	B6	36.0	37.2	-1.2	212	211.4	0.6	367.0	369.6	-2.6	-1.07
	B7	37.0	37.6	-0.6	211.6	208.4	3.2	389.6	396.0	-6.4	-1.27
	B8	38.0	34.6	3.4	212	214.6	-2.6	366.8	375.4	-8.6	-2.60
	B9	36.0	35.0	1.0	212	212.8	-0.8	370.0	369.6	0.4	0.20
	B10	38.0	40.2	-2.2	212	209.6	2.4	369.4	370.8	-1.4	-0.40
	B11	38.0	39.8	-1.8	212	208.6	3.4	369.4	362.2	7.2	2.93
	B12	40.8	41.0	-0.2	212	213.2	-1.2	369.0	370.2	-1.2	-0.87
	B13	37.0	33.6	3.4	212	212.6	-0.6	371.4	374.2	-2.8	-0.00
	B14	36.0	36.4	-0.4	212	212.8	-0.8	371.4	371.6	-0.2	-0.47
	B15	38.0	37.0	1.0	212	212.6	-0.6	371.4	370.6	0.8	0.40
AVERAGE		40.7	40.8	-0.1	211.3	211.7	-0.4	347.7	346.8	0.9	0.2
				-0.02%			-0.05%			0.11%	
Hivol Dial Gauges											
9169		62.2	67	-4.8			0.0			0.0	-4.80
9142		62.4	64	-1.6	212.2	211	1.2			0.0	-0.20
D-5		61.6	60	1.6			0.0			0.0	1.60
D-2		61.6	60	1.6	211.6	210	1.6	365.8	360.0	5.8	3.00
D-7		61.4	58	3.4			0.0			0.0	3.40
D-9		61.6	60	1.6	211.6	210	1.6	365.0	362.0	3.0	2.07
D-12		64.4	70	-5.6	212.4	200	12.4			0.0	3.40
D-13		64.6	70	-5.4	212.8	212	0.8			0.0	-2.30
D-14		61.4	58	3.4			0.0			0.0	3.40

Standard Used Fluke 5895570

DRIFT CORRECTION DOCUMENTATION

EPA Drift Equations:

Method 3a : Oxygen and Carbon Dioxide

$$Cgas = \frac{(Cma - Coa) * (C - Cm)}{(Cm - Co)} + Cma \qquad \text{(Eq. 3a-1)}$$

Method 6c : Sulfur Dioxide

$$Cgas = \frac{Cma * (C - Co)}{(Cm - Co)} \qquad \text{(Eq. 6c-1)}$$

; Coa = 0

Method 7e : Nitrogen Oxides

Section 8, Method 7e; " Follow Section 8 of Method 6C (Eq. 6c-1)."

Method 10 : Carbon Monoxide

The EPA does not currently address Gas Filter Correlation Instruments therefore there are no current standards.

Method 25a : Total Gaseous Organic Concentration (TGOC)

This method does not mention correcting for drift although there are established limits.

Horizon Engineering Drift Correction Equations:

$$Cgas = \frac{(Cid - Zx) * (Cma - Coa)}{(Sx - Zx)}$$

$$Sx = \frac{(Cmf - Cmi) * (Tx - Tci)}{(Tcf - Tci)} + Cmi$$

$$Zx = \frac{(Cof - Coi) * (Tx - Tci)}{(Tcf - Tci)} + Coi$$

$$Tx = \frac{(Tte - Tts)}{2} + Tts$$

EPA	Definition	Horizon Engineering
Cgas	Effluent gas concentration, dry basis	Cgas
Cma	Actual upscale calibration gas concentration	Cma
Coa	Actual zero/low calibration gas concentration	Coa
Cm	Average of initial and final system upscale calibration bias responses	
	Initial system upscale calibration bias response	Cmi
	Final system upscale calibration bias response	Cmf
Co	Average of initial and final system zero/low calibration bias responses	
	Initial system zero/low calibration bias response	Coi
	Final system zero/low calibration bias response	Cof
C	Average gas concentration indicated by gas analyzer, dry basis	Cid
	Starting test time	Tts
	Ending test time	Tte
	Initial system bias calibration response time	Tci
	Final system bias calibration response time	Tcf
	Mid-point of test time or gas sampling interval to be analyzed	Tx
	Approximate upscale response at mid-point test time	Sx
	Approximate zero/low response at mid-point test time	Zx

Notes of Exception:

1] TGOC is first recorded on a wet basis then corrected to a dry basis.

2] The TGOC instruments used have some historic data on instrument response to different hydrocarbons. For Propane the response is 1 to 1 molecule while Methane is 1.037 to 1 molecule. We correct for the instruments "over response" to the methane.

Test Method for Determination of Dry Kiln VOC Emissions

April 5, 1996

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1.0 INTRODUCTION

Lumber dry kilns have been identified by the EPA and other environmental agencies as a source of Volatile Organic Compounds (VOCs). The green lumber contains VOCs, which are emitted during the drying process. In order to measure the emissions from dry kilns, it is recommended to apply a test method incorporating EPA Method 25A. However, it is not practical to use the standard EPA Method 25A for dry kilns, because of the following conditions:

a.) Lumber drying can take over 100 hours to process one load.

b.) Most dry kilns have multiple vents and often have significant leakage around the loading doors.

c.) The venting process is periodic. The vents open to release moisture and VOCs in an irregular pattern.

The multiple vent configuration of most dry kilns and the periodic venting makes it difficult to measure the exhaust flow rate. The leakage from doors and other gaps is not measurable and therefore will produce inaccurate results. In addition, tests would need to be repeated for every species of wood the plant dries.

This method applies EPA Method 25A in a controlled environment, where a sample of the lumber is dried in a laboratory dryer and the VOC emissions are measured. The measured quantity of emissions can then be applied to determine accurate emission factors for the actual process by mathematical methods.

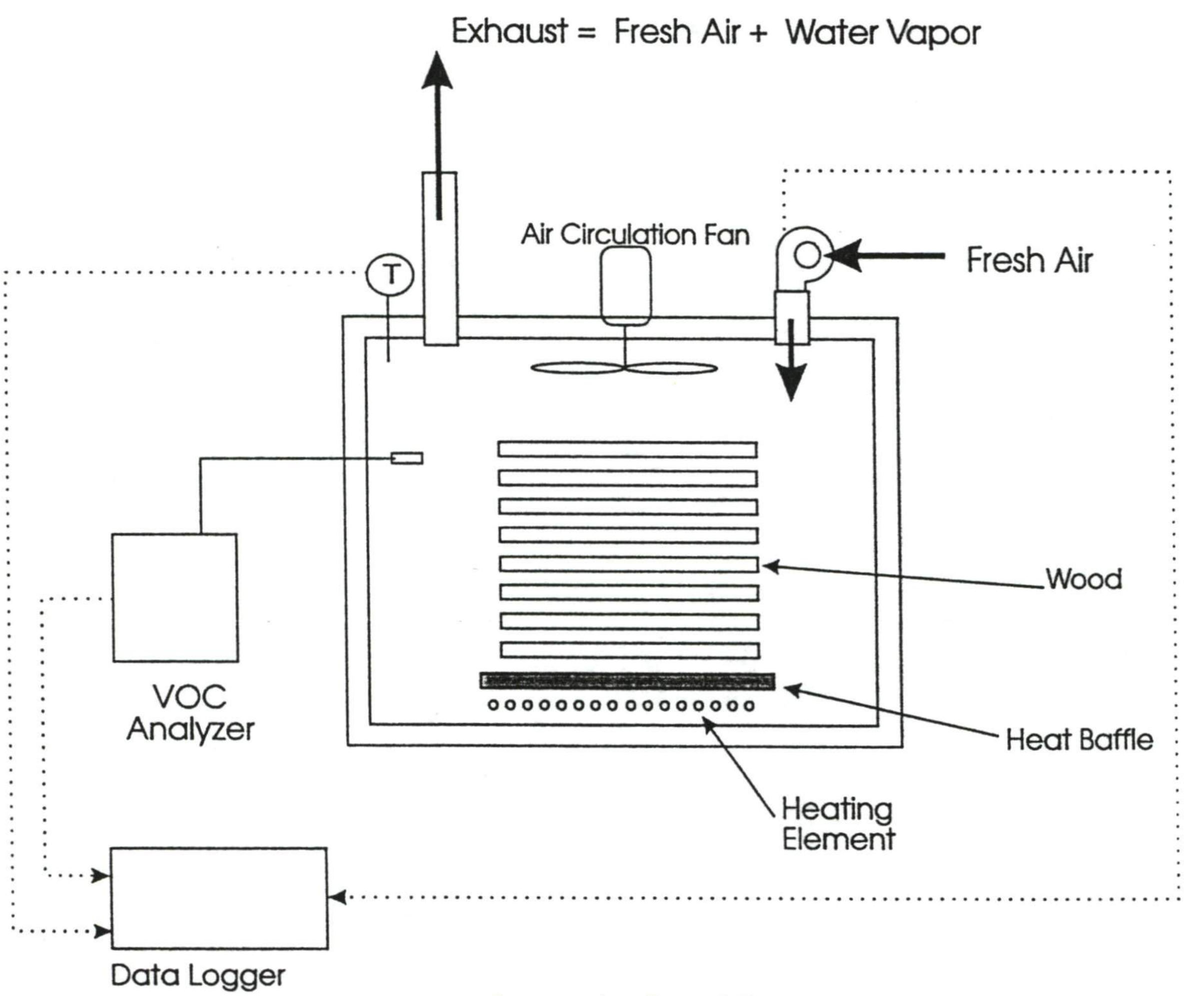
1.1 PRINCIPAL

The method for VOC measurements is based on simulated drying conditions in a laboratory size lumber dry kiln that operates in a controlled environment and can dry approximately 10 to 15 board foot of lumber.

The method is considered to be a worst case analysis, where the highest temperature for a typical drying cycle is applied to the sample at all times. The humidity is not controlled. The maximum temperature is to be that used at the actual kiln site. This is normally about 200°F. This method allows any sample drying time, but normal times of approximately 36 to 48 hours will result in a stable (dry) test load weight. Testing times can be extended if the test load weight is not stable. VOC concentrations from the test kiln are not expected to reach zero near the end of the drying cycle.

The VOC analyzer indicates concentration on a wet basis. To correct the concentration to a dry basis it is not necessary to continuously measure the moisture content of the sample stream even though the moisture varies over the drying cycle. An average moisture content for VOC analyzer correction is calculated at any time based on the dry air volume delivered to the kiln and the amount of moisture evaporated from the sample load. As long as the air flow rate to the kiln is greater than that extracted by the analyzer, moisture and air escaping from the oven through cracks are not a problem.

1.2 SYSTEM SCHEMATIC



Sample Dry Kiln

1.3 APPLICABILITY AND SENSITIVITY OF RESULTS

From the laboratory test results emission factors can be calculated for a typical drying schedule. Separate emission factors can be calculated for each wood species to any percentage dryness.

1.4 TEST KILN APPARATUS

Test Kiln: Industrial drying oven, convection type, with sealed doors and openings, of a size sufficient to hold the test load with adequate air circulation space around the test load. The kiln shall be equipped with the following instrumentation:

Load Cell and Platform: The entire test load shall be sensed by the load cell on a continuous basis. The load cell suspension system shall be designed to minimize binding. The platform should allow the use of non-organic sticker boards to separate the test load boards in a manner similar to actual drying conditions.

Temperature Sensor: A continuous record of the kiln temperature shall be maintained.

VOC Sample Probe: A stainless steel or glass probe to gather sample for the analyzer. The probe outlet should be kept to a minimum length and insulated to prevent condensation before the heated sample line connection.

Air Inlet: To be placed in a location where the air becomes mixed quickly with oven internal air.

Air Outlet: A pressure relief line to allow excess exhaust air to vent. This line should be heated or kept sloped down to prevent accumulation of condensed water vapor that could block the exhaust stream.

Other Test System Equipment Necessary:

Total Hydrocarbon Analyzer System: Heated total hydrocarbon analyzer and sample line, constructed, operated, and calibrated according to EPA Method 25A.

Inlet Air System: A system of providing a constant, measured, hydrocarbon free air to the system. The air should either be dried or have its temperature and humidity measure so that moisture in the stream can be quantified.

Data Logging System: A system to provide a continuous record of the recorded parameters throughout the testing period. Data is to be recorded at intervals no longer than two minutes apart.

2.0 SAMPLE COLLECTION PROCEDURE

Depending on the species and on the location of the board within the log, the VOC content will vary. It is recommended that the collected samples represent a cross section of the log from which the board were cut.

Resin rich soft woods often have localized pitch concentration. These so-called pitch pockets can release significantly more VOC than the average board. Sample boards with pitch pockets should not be selected for the test batch of lumber.

Each species of lumber must be tested separately in order to determine species specific VOC release. Therefore all sample boards for a specific test must be of the same species.

The selected boards must be cut into sample boards between 18" and 24" long (all samples boards should be of approximately the same length).

The board thickness and the width of the boards must represent the average dry kiln load.

The samples must be collected immediately after the log is sawed into boards (within 8 hours).

At least 6 separate boards must be used to compile the sample load.

The composite sample load must be at least 10 board foot based on U.S. Lumber Scale.

Each board must be marked with the date of collection, a batch number and a board number (example - Mar 20/96 - 1/3). This means that the piece came from the first of the six selected boards and is the third piece of the same board. It is best to use pencil for marking. Marking pens may add VOCs to the board.

After the sample board are collected, prepare a data sheet with the following information:

a.) Company Name
Address
Telephone Number

Contact Person

b.) Date of sample preparation.
Responsible person collecting the sample.
Signature of the responsible person.

c.) Species of the lumber.

d.) Total number of pieces shipped and the total board feet in the sample batch.

e.) Dry kiln identification in which this lumber is normally dried.
Identify more than one kiln, if appropriate.

f.) Identify each sample piece as shown in the following example:

Sample #	Nominal Size	Length
1/3	8/4" by 6"	18" (plus or minus 1/8")

g.) Provide the normal drying schedule for this lumber and the maximum drying temperature.

h.) Provide the final moisture content for this lumber.

Immediately after collecting the samples the entire package of sample boards must be shrink-wrapped or enclosed in a plastic bag and sealed with tape to avoid moisture and VOC loss.

2.1 SAMPLE SHIPPING PROCEDURE

The samples should be packaged in a box to avoid damage of the vapor seal during shipping. To ensure arrival at the laboratory within 48 hours of the date the samples were cut and wrapped, select a carrier that can deliver within the specified time.

2.2 PREPARATION AND SET-UP BEFORE TESTING

The testing laboratory must be prepared to perform the test within 96 hours after the samples were collected. Samples should be refrigerated in the shipping materials until the testing is started.

The VOC analyzer must be calibrated following EPA Method 25A. The load cell must be calibrated with known weights. The oven should be preheated for several hours at a temperature slightly above the anticipated test maximum to avoid condensation.

After the preparation, place the lumber in the sample dry kiln and start the VOC sampling device. After the drying cycle has been started, the sample kiln door must be latched and may not be opened during the entire drying process.

The lumber in the sample dry kiln must be dried to the maximum temperature at which the lumber is normally dried at the plant site. Test kiln temperature may be increased at intervals, however, to avoid very high humidity in the chamber.

The heating system and internal air circulation system for the dry kiln must be operating continuously during the drying process.

2.3 DATA COLLECTION

During the drying cycle the following information shall be collected and recorded.

a.) VOC concentration, in ppmvC, inside the sample dry kiln once every two minutes.

b.) The temperature in the sample dry kiln.

c.) The in-flow of fresh air into the sample dry kiln in scfh. The flow rate shall not be less than 10 scfh and not more than 100 scfh for every 10 board foot of lumber in the sample kiln. The meter temperature and the relative humidity of the in-flow air should be recorded.

d.) The weight of the lumber once every two minutes.

e.) The total drying time in hours and minutes shall be recorded.

2.4 TERMINATING THE DRYING CYCLE

The lumber will be dried until the weight of the wood has become stable to less than +/- 0.25 lb over a 12 hour period. Some variation in weight can be expected due to inlet air humidity changes.

Final calibrations checks should be conducted on the VOC analyzer as outlined in EPA Method 25A. A post check on the weighing system must also be performed.

3.0 DATA EVALUATION THEORY

The air in-flow rate and the total air flow data for the entire cycle will be the summarized meter reading in cubic feet. The air in-flow corrected to a dry standard (dscf) will be the same as the out-flow dscf. This will be the volume used in the pounds of VOC calculation.

The water vapor volume will be calculated from the total water loss of the sample plus the water introduced in the in-flow air. From the total water vapor volume and the total dry air volume a percentage moisture can be calculated for any time during the test cycle.

With the results of VOC concentration in ppmvC (wet basis), the percentage moisture, and the volumetric flow in dscf, the total VOC release in lbC can be calculated for any lumber moisture content.

From the result in lb of VOC for the test sample, an emission factor in lb of VOC per 1000 board feet of lumber can be calculated.

3.1 EQUATIONS TO DETERMINE EXHAUST FLOW

The actual exhaust flow from the sample dry kiln is the sum of the air flow plus the water vapor flow from the evaporated water in the wood. However, this is not used in the emission factor calculation.

a.) Air in-flow in dscf

Vsd = Y Vm T(std) Pb mfg(2) / P(std-1) Tm(abs)

Vm = meter reading volume in actual cft
Y = gas meter correction factor
T(std) = standard temperature, 527.67°R
Tm(abs) = meter temperature in degree Rankin.
Pb = pressure in inch Hg at test site.
P(std-1) = standard pressure, 29.92129 inHg
mfg(2) = mole fraction of dry meter air

b.) Mole fraction of dry meter air

mfg(2) = 1 - Bws(2)/100

Bws(2) = RH Vp / Pb(2)

Bws(2) = precent moisture of in-flow air
RH = relative humidity of in-flow air
Vp = vapor presure of moisture content of in-flow air
Pb(2) = barametric pressure in kPa

c.) Vapor pressure of moisture content of in-flow air

$$Vp = \exp(A + B\,Tm + C/Tm + D/Tm^2)$$

A = 18.6866
B = -0.00243724
C = -4509.47
D = -149541.0
*in this equation Tm is in °C + 273.15

3.2 EQUATION TO DETERMINE EXHAUST MOISTURE

a.) Mole fraction of dry gas

mfg(1) = 1 - Bws(1)/100

Bws = precent moisture of exhaust

b.) Precent moisture

Bws(1) = 100 Vw(std) / Vw(std) + Vm(std)

Vw(std) = volume of water vapor, scf
Vm(std) = volume of dry gas, scf

c.) Volume of water vapor

$$Vw(std) = 0.04707\,W / 0.99823 + Vw(std)_{in} + Vw(std)_{inital}$$

W = weight loss of wood, grams
$Vw(std)_{in}$ = volume of water vapor in the in-flow gas, scf
$Vw(std)_{initial}$ = volume of water vapor in over at start of test

3.3 VOC CONCENTRATION

a.) VOC concentration corrected

VOC(cor) = VOC(dry) corrected for drift per EPA Method 25A

b.) VOC dry calculation

VOC(dry) = VOC(wet) / mfg(1)

VOC(wet) = average from analyzer in ppm
mfg(1) = mole fraction of dry air in oven

3.4 TOTAL SAMPLE VOC IN POUNDS

Mgas = VOC(cor) MW Pstd(2) Vsd / 1000000 R T(std)

VOC(cor) = ppm dry, corrected for drift
MW = molecular weight of carbon, 12.01 lbm / lbmol
Pstd(2) = 2116.22 lbf / ft^2
Vsd = volume of sample (section 3.1)
R = 1545.33 ft lbf / lbmol °R
T(std) = absolute standard temp., 527.67 °R

3.5 VOC EMISSION FACTOR

It is recommended to express the VOC emission factor is in Lbs. of VOC per 1000 board foot of lumber based on U.S. lumber scale. For other lumber scales the numbers must be corrected.

a.) Emission factor in Lbs./1000 BF (U.S.)

EF = Mgas / (BF_{sample}) * 1000 (in Lb / 1000 BF U.S.)

BF = Total board foot of lumber dried in the sample kiln in U.S. lumber scale.