CASCADE HARDWOOD, INC.
P.O BOX 269 • 158 RIBELIN RD, CHEHALIS, WA 98532
PHONE: (360) 748-0178 • (800) 851-9484 • FAX (360) 748-1062

Bob
Randy
Rose
Vannessa
Natalia
Scott SC
Tim
Jennifer
Jackie
Carole CMN
Jer S.
Jer B.
David
Virginia
Mary
File

June 17, 1998

Carole Newvine
SWAPCA
1308 NE 134th Street
Vancouver, WA 98685-2747

Re: Order of Approval SWAPCA 97-2051R1

Dear Carole:

Enclosed is a copy of the Source Evaluation Report for our 3 new Coe lumber dry kilns. This is to comply with Order of approval 97-2051R1.

If you have any questions or concerns, please call.

Sincerely,

Gordon Chaffee

Gordon Chaffee

RECEIVED
JUN 22 1998
SOUTHWEST AIR POLLUTION
CONTROL AUTHORITY

HORIZON ENGINEERING LLC

13585 N.E. Whitaker Way • Portland, OR 97230
Phone (503)255-5050 • Fax (503)255-0505
horizone@teleport.com

Project No. 990

AIR CONTAMINANT EVALUATION TEST REPORT

CASCADE HARDWOODS COMPANY
Dry Kiln VOC Emission Factors

April 30-May 10, 1998

Prepared for

Cascade Hardwoods Company
158 Ribelin Rd.
Chehalis, WA 98532

By

David R. Broderick
&
David R. Rossman P.E.

DAVID R. ROSSMAN
STATE OF WASHINGTON
6/7/98
31501
REGISTERED PROFESSIONAL ENGINEER
EXPIRES 1/20/99

Introduction

Between April 30 and May 10, 1998, three samples of Cascade Hardwoods' lumber were dried in Horizon Engineering's laboratory dry kiln. Two samples of alder and one of maple were dried for about three days each. Volatile organic compounds (measured as total gaseous organic compounds, TGOC) were continuously measured in the test kiln using the Dettinger/Horizon Method. The laboratory test was done instead of a source test due to the expense and uncertainties involved in source testing an actual dry kiln.

Gordon Chaffee of Cascade Hardwoods arranged for the work and prepared the lumber samples. Horizon Engineering personnel David Broderick did the testing and Michael Wallace assisted in 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 3 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		Alder	Alder	Maple
Dates		4/30-5/3	5/7-5/10	5/4-5/7
Sample Size	bd ft (dry)	6.0	5.4	7.7
Initial Weight	lb	29	25	33.5
Weight Loss	lb	14.2	15.8	12.1
Test Time	hr	34	36	36
Avg VOC (dry)	ppmvC	25	32	26
Max VOC (wet)	ppmvC	21	27	22
Emission Factor				
@ 0% Moisture	lbC/Mbdft	0.24	0.27	0.20
@ 10% Moisture	lbC/Mbdft	0.085	0.11	0.098

Fig. 1

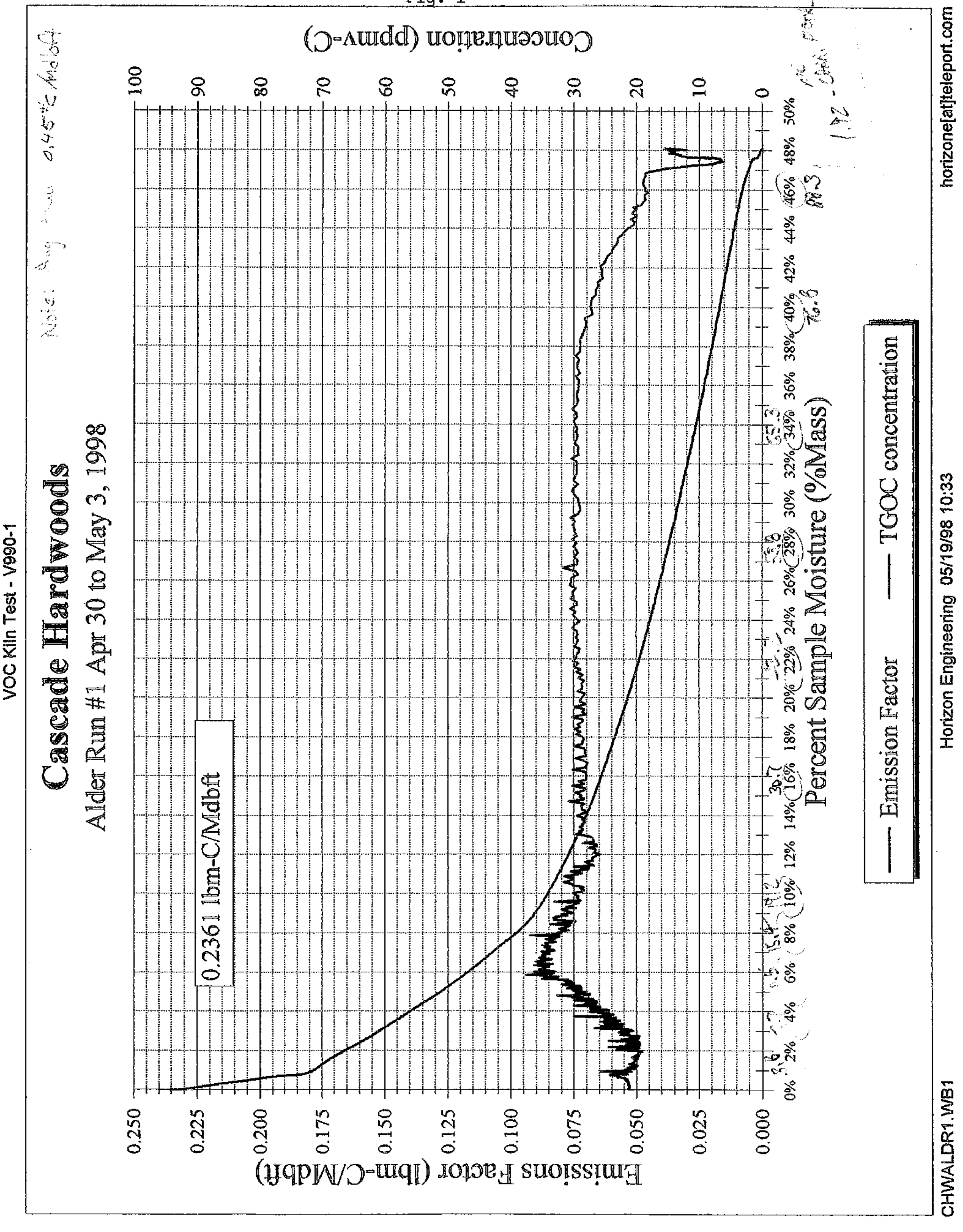

VOC Kiln Test - V990-1
Cascade Hardwoods
Alder Run #1 Apr 30 to May 3, 1998
0.2361 lbm-C/Mdbft
Concentration (ppmv-C)
0
10
20
30
40
50
60
70
80
90
100
Emissions Factor (lbm-C/Mdbft)
0.000
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
0.225
0.250
Percent Sample Moisture (%Mass)
0%
2%
4%
6%
8%
10%
12%
14%
16%
18%
20%
22%
24%
26%
28%
30%
32%
34%
36%
38%
40%
42%
44%
46%
48%
50%
Emission Factor
TGOC concentration
horizone[at]teleport.com
Horizon Engineering 05/19/98 10:33
CHWALDR1.WB1

Fig. 2

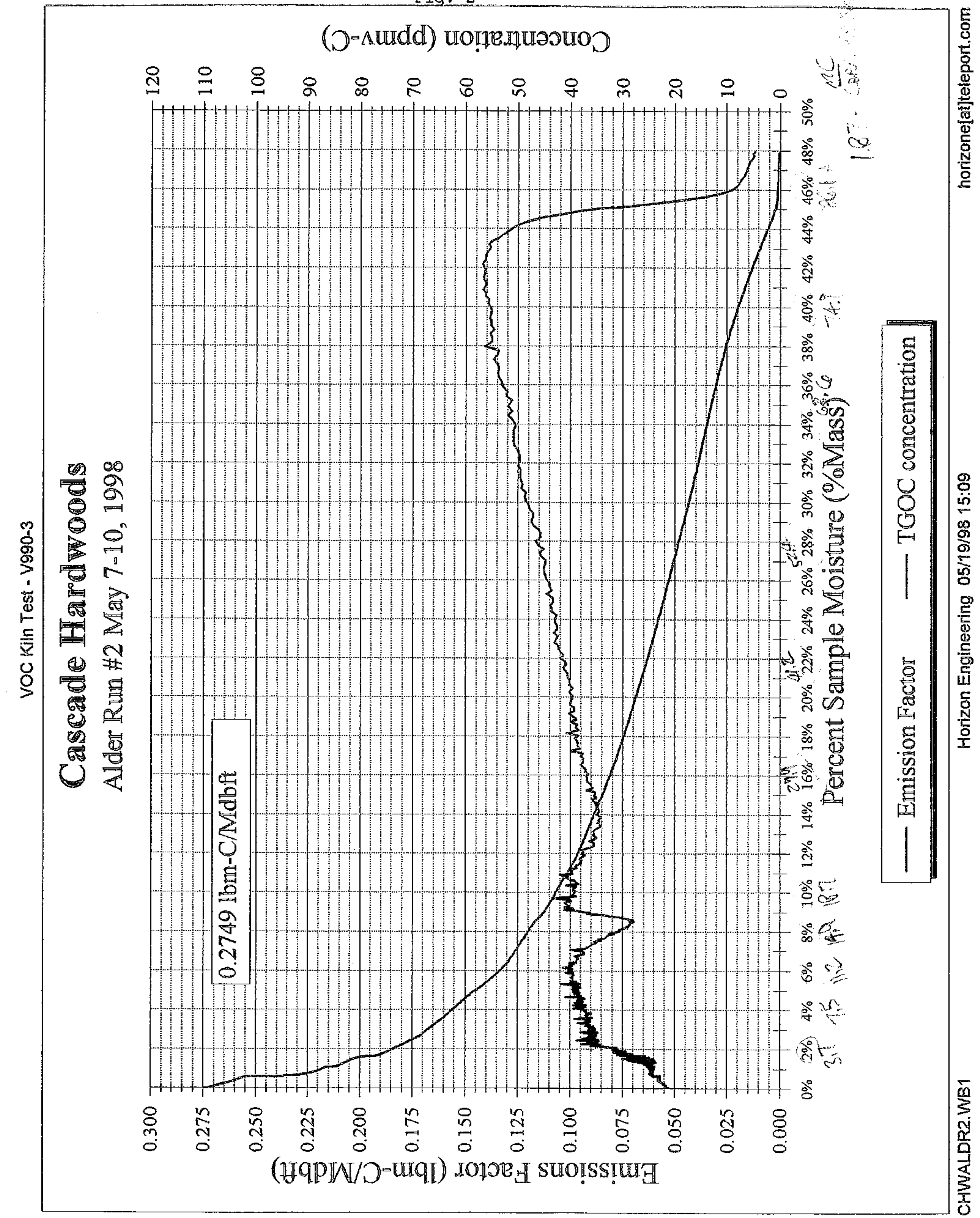
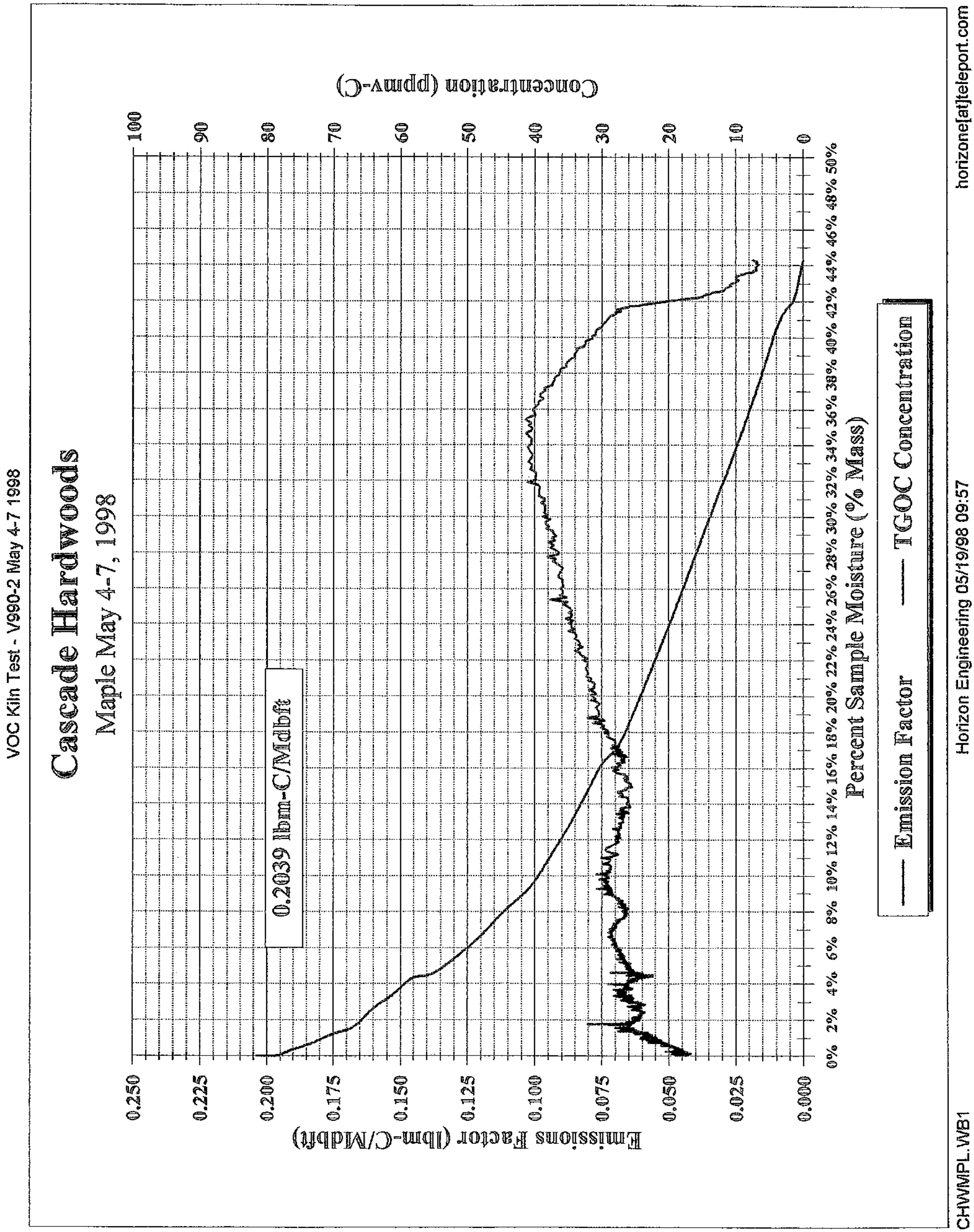

VOC Kiln Test - V990-3
Cascade Hardwoods
Alder Run #2 May 7-10, 1998
0.2749 lbm-C/Mdbft
Emissions Factor (lbm-C/Mdbft)
Concentration (ppmv-C)
Percent Sample Moisture (%Mass)
Emission Factor
TGOC concentration
0.300 0.275 0.250 0.225 0.200 0.175 0.150 0.125 0.100 0.075 0.050 0.025 0.000
120 110 100 90 80 70 60 50 40 30 20 10 0
0% 2% 4% 6% 8% 10% 12% 14% 16% 18% 20% 22% 24% 26% 28% 30% 32% 34% 36% 38% 40% 42% 44% 46% 48% 50%
Horizon Engineering 05/19/98 15:09
horizone[at]teleport.com
CHWALDR2.WB1

Fig. 3


VOC Kiln Test - V990-2 May 4-7 1998
Cascade Hardwoods
Maple May 4-7, 1998
0.2039 lbm-C/Mdbft
Concentration (ppmv-C)
100 90 80 70 60 50 40 30 20 10 0
Emissions Factor (lbm-C/Mdbft)
0.250 0.225 0.200 0.175 0.150 0.125 0.100 0.075 0.050 0.025 0.000
0% 2% 4% 6% 8% 10% 12% 14% 16% 18% 20% 22% 24% 26% 28% 30% 32% 34% 36% 38% 40% 42% 44% 46% 48% 50%
Percent Sample Moisture (% Mass)
Emission Factor
TGOC Concentration
Horizon Engineering 05/19/98 09:57
horizone[at]teleport.com
CHWMPL.WB1

Purpose for the Laboratory Test Method

Cascade Hardwoods has 16 dry kilns to dry cut lumber. Testing the actual kilns would be difficult, costly, and there would be many uncertainties when using the standard EPA Method 25A on a dry kiln. The following conditions make dry kiln testing difficult:

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 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 TGOC 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 in the test method found in the Appendix. A Grieve 27-ft^3 industrial convection oven was used to dry the wood. A Rice

Lake Weighing Systems 0-100 lb load cell is used to continuously monitor 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 TGOC concentrations at oven conditions. Gas sample for the analyzer was taken from a fixed sampling probe in the oven. Data was recorded every five minutes by a Rustrak Ranger II data logging system. Graphic printouts of the data logger information are in the Appendix.

Calibrations Zero, span, calibration error (linearity) and bias checks were made on the TGOC 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 calibrations were done 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 TGOC 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 a best-fit method was used to derive a smooth (conditioned) curve for the weight loss.

Board Volume The sample boards were measured individually; the measurements are in the Appendix. The board foot amount of the sample was based on a board foot being 144 cubic inches of wood.

Discussion

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

APPENDIX

Nomenclature

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

Calibration Information

- Gas Meter
- Standard meter
- Thermocouples
- Drift Correction

Test Method

NOMENCLATURE

Nomenclature

Constants	Value	Units	Definition	Ref
Pstd(1)	29.92129	inHg	Standard Pressure	CRC
Pstd(2)	2116.22	lbf / ft^2		CRC
Tstd	527.67	°R	Standard Temperature	CRC
R	1545.33	ft lbf / lbmol °R	Ideal Gas Constant	CRC
MWatm	28.965	lbm / lbmole	Atmospheric (20.946 %O2, 0.033% CO2, Balance N2+Ar)	
MWc	12.011	lbm / lbmole	Carbon	CRC
MWco	28.010	lbm / lbmole	Carbon Monoxide	CRC
MWco2	44.010	lbm / lbmole	Carbon Dioxide	CRC
MWh2o	18.015	lbm / lbmole	Water	CRC
MWno2	46.006	lbm / lbmole	Nitrogen Dioxide	CRC
MWo2	31.999	lbm / lbmole	Oxygen	CRC
MWso2	64.063	lbm / lbmole	Sulfur Dioxide	CRC
MWn2+ar	28.154	lbm / lbmole (Balance with 98.82% N2 & 1.18% Ar)	Emission balance	
C1	385.3211	ft^3 / lbmol	Ideal Gas Constant @ Standard Conditions	
C2	816.5455	inHg in^2/ °R ft^2	Isokentics units correction constant	
Kp	5129.4	ft / min { (inHg lbm/mole) / (°R inH2O) } ^½	Pitot tube constant	Ref 2.5.1

Symbol	Units	Definition	Calculating Equation or Source of Data	EPA
As	in^2	Area, Stack		
An	in^2	Area, Nozzle		
Bws	%	Moisture, % Stack gas	[100 Vw(std) / [Vw(std)+Vm(std)]]	Eq. 5-3
C	ppmv-C	Carbon (General Reporting Basis for Organics)		
C1	ft3/lbmol	Gas Constant @ Standard Conditions	[R Tstd / Pstd(2)]	
C2	inHg in^2/ °R ft^2		[14,400 Pstd / Tstd]	
Cd	lbm-GAS / MMdscf	Mass of gas per unit volume	[Cgas MWgas / C1]	
cg	gr/dscf	Grain Loading, Actual	[15.432 mn / Vm(std) 1,000]	Eq. 5-6
cg @ X%CO2	gr/dscf	Grain Loading Corrected to X% Carbon Dioxide	[X% / CO2%]	
cg @ X%O2	gr/dscf	Grain Loading Corrected to X% Oxygen	[(20.946-X%) / (20.946-O2%)]	
Cgas	ppmv, %	Gas Concentration, (Corrected)		
Cgas @ X%CO2	ppmv	Gas Concentration Correction to X% Carbon Dioxide	[X% / CO2%]	
Cgas @ X%O2	ppmv	Gas Concentration Correction to X% Oxygen	[(20.946-X%) / (20.946-O2%)]	
CO	ppmv	Carbon Monoxide		
Co	ft	Outer Circumference of Circular Stack		
Ci	ft	Inner Circumference of Circular Stack		
CO2	%	Carbon Dioxide		
Cp		Pitot tube coefficient		
Ct	lb/hr	Particulate Mass Emissions	[60 cg Qsd/ 7,000]	
dH	in H2O	Pressure differential across orifice		
Dn	in	Diameter, Nozzle		
dp^½		Average square root of velocity pressure		
Ds	in	Diameter, Stack		
E	lb / MMBtu	Pollutant Emission Rate	Cgas Fd MWgas (20.946 / (20.946-O2%)) / (1,000,000 C1)	
Fd	dscf / MMBtu	F Factor for Various Fuels		Table 19-1
I	%	Percent Isokinetic	[C2 Ts(abs) Vm(std) / (vs Ps mfg An Ø)]	Eq. 5-8*
Md	lbm / lbmole	Molecular weight, Dry Stack Gas	[(1-%O2-%CO2)(MWn2+ar)+(%O2 MWo2)+(%CO2 MWco2)	Eq. 3-1*
mfg		Mole fraction of dry stack gas	[1-Bws/100]	
Mgas	lbm/hr	Gaseous Mass Emisisons	[60 Cgas(ppmv) MW Pstd(2) Qsd / 1,000,000 R Tstd]	
mn	mg	Particulate lab sample weight		
Ms	lbm / lbmole	Molecular weight, Wet Stack	[Md mfg +MWh2o (1-mfg)]	Eq. 2-5
MW	lbm / lbmole	Molecular Weight		
NO2	ppmv-NO2	Nitrogen Dioxide (General Reporting Basis for NOx)		
NOx	ppmv-NO2	Nitrogen Oxides (Reported as NO2)		
O2	%	Oxygen		
OPC	%	Opacity		
Pbar	in Hg	Pressure, Barometric		
Pg	in H2O	Pressure, Static Stack		
Po	in Hg	Pressure, Absolute across Orifice	[Pbar+dH/13.5955]	
Ps	in Hg	Pressure, Absolute Stack	[Pbar+Pg/13.5955]	Eq. 2-6*
Qa	acf/min	Volumetric Flowrate, Actual	[As vs / 144]	
Qsd	dscf/min	Volumetric Flowrate, Dry Standard	{ Qa Tstd mfg Ps] / [Pstd(1) Ts(abs)]	Eq 2-10*
Rf	MMBtu/hr		[1,000,000 Mgas (20.946-O2)]/ [Cd Fd 20.946]	
SO2	ppmv-SO2	Sulfur Dioxide		
t	in	Wall thickness of a stack or duct		
TGOC	ppmv-C	Total Gaseous Organic Concentration (Reported as C)		
Tm	°F	Temperature, Dry gas meter		
Tm(abs)	°R	Temperature, Absolute Dry Meter	[Tm + 459.67]	
Ts	°F	Temperature, Stack gas		
Ts(abs)	°R	Temperature, Absolute Stack gas	[Ts + 459.67]	
Vlc	ml	Volume of condensed water		
Vm	dcf	Volume, Gas sample		
Vm(std)	dscf	Volume, Dry standard gas sample	[Y Vm Tstd Po]/ [Pstd(1) Tm(abs)]	Eq. 5-1
vs	fpm	Velocity, Stack gas	Kp Cp dp^½ [Ts(abs) / (Ps Ms)]^ ½	Eq. 2-9*
Vw(std)	scf	Volume, Water Vapor	0.04707 Vlc	Eq. 5-2
Y		Dry gas meter calibration factor		Fig. 5.6
Ø	min	Time, Total sample		

* Based on equation.

TEST DATA

Client: CHW
Species: Alder
Run: 3
Start Time: 15:10
Start Date: 5-7-98
Y of meter: .98300

Pbar	30.12	29.92				
Date	5-7	5-11				

# of boards: 8 DRY 1 1/8 x L x6
dim of boards: 8 @ 1 1/4 x 14 1/2 x 6 1/2 (wet)
dim of total load:
Bdft (note if dry or wet): DRY = 5.391 bdft

L = 14 1/4
14 1/2
14 3/8
15
14 1/8
14 1/8
14 1/2
14 1/8

JUM #	actual	start bias	end bias
span	87.6	89.2	85.55
mid	51.2	51.43	50.48
mid	17.5	17.22	16.13
zero	0.0	-0.03	-1.19
time & date		1505 5-7	730 5-11

LOAD CELL	actual	start check	end check
high	24.45 +0	35.39	35.39
zero	0	-0.05	-0.11
time & date		1505 5-7	730 5-11

Meter Reading	Time	Date	Load Weight
598.120	1515	5-7	25.10 *
982.000	830 830	5-8	16.48 *
1118.406	2:40pm	5-8	15.08 *
2089.150	1108	5-10	12.96 *
155.910	1415	5-10	12.95
190.125	1548	5-10	12.94 *
529.200	7-30	5-11	12.96

598.120
982.000
1118.406 296
2089.15 970
2155.91 867
2190.125 886
2529.200 1685

296

Client: Cascade Hard Woods
Species: Maple
Run: 2
Start Time: 8:59
Start Date: 5-4-98
Y of meter:
0.98300

Pbar	30.0	30.12				
Date	5-7	5-7				

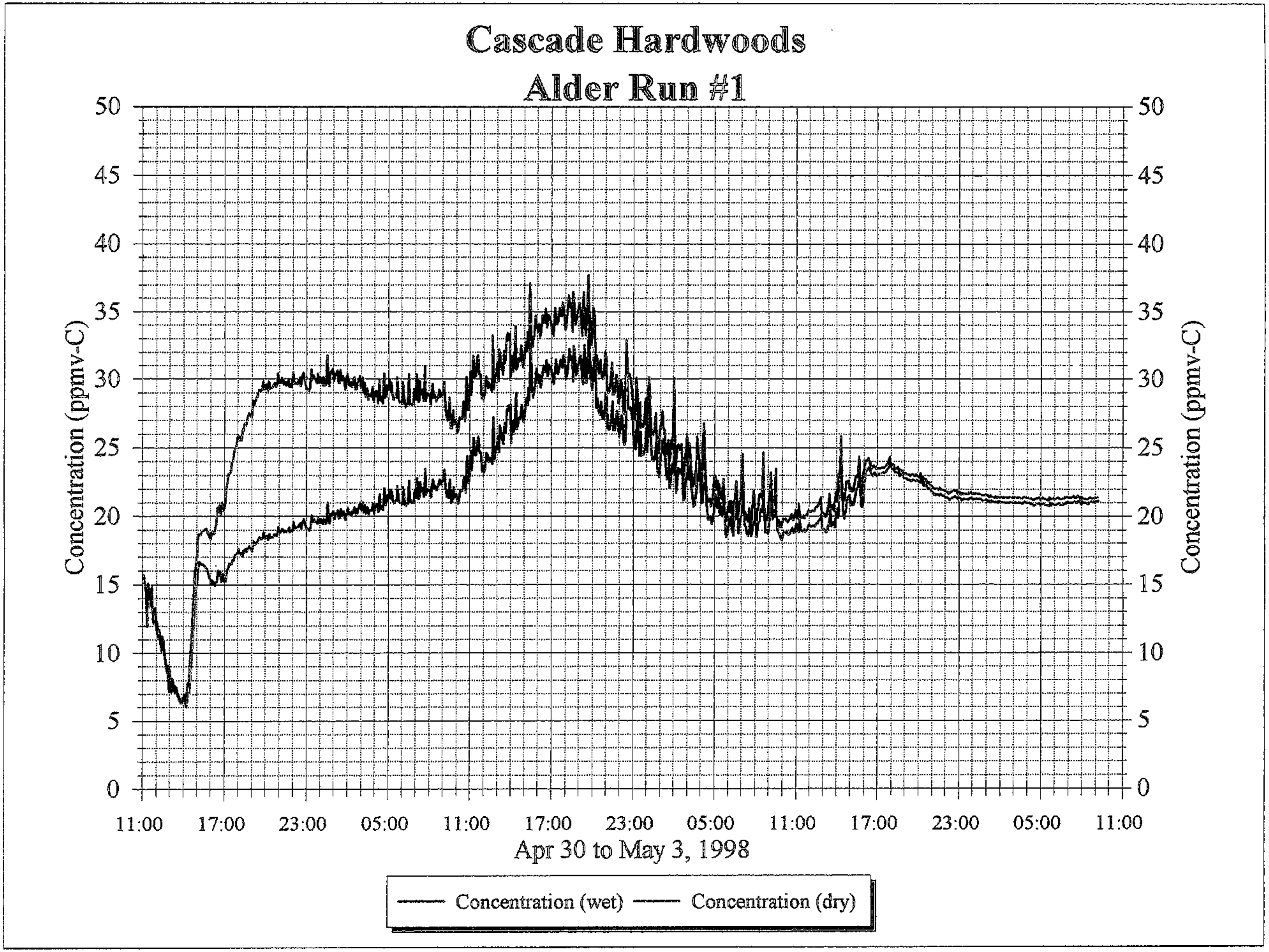
# of boards: 11
dim of boards: 5 5/8 x 12 1/4 x 1 1/2
dim of total load:
Bdft (note if dry or wet): Dry 7.741

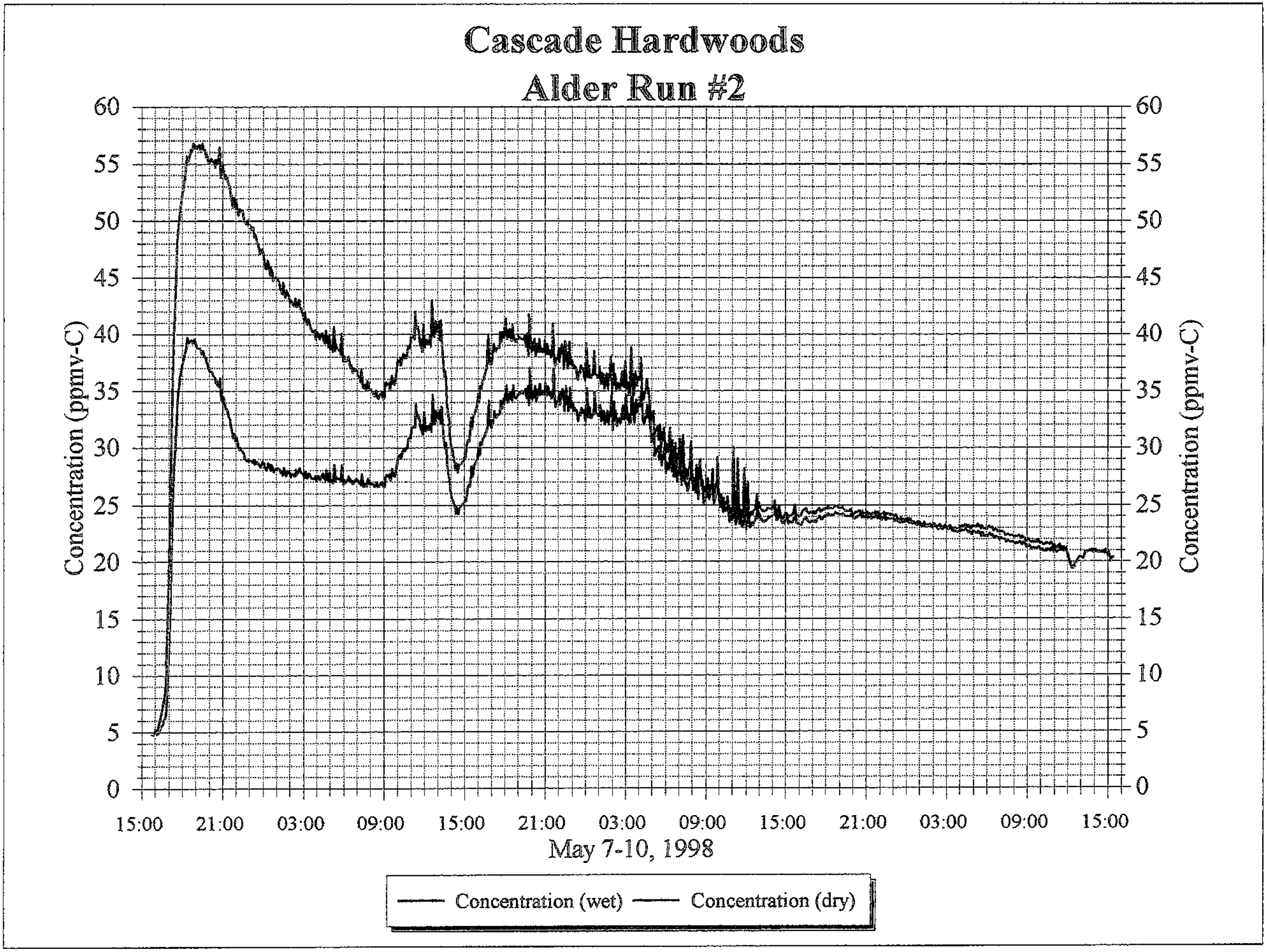
JUM #	actual	start bias	end bias
span	87.6	88.3	79.90
mid	51.2	51.01	46.1
mid	17.5	16.9	15.5
zero	0.0	−0.01	0.12
time & date		8:50 5-4	1450 5-7

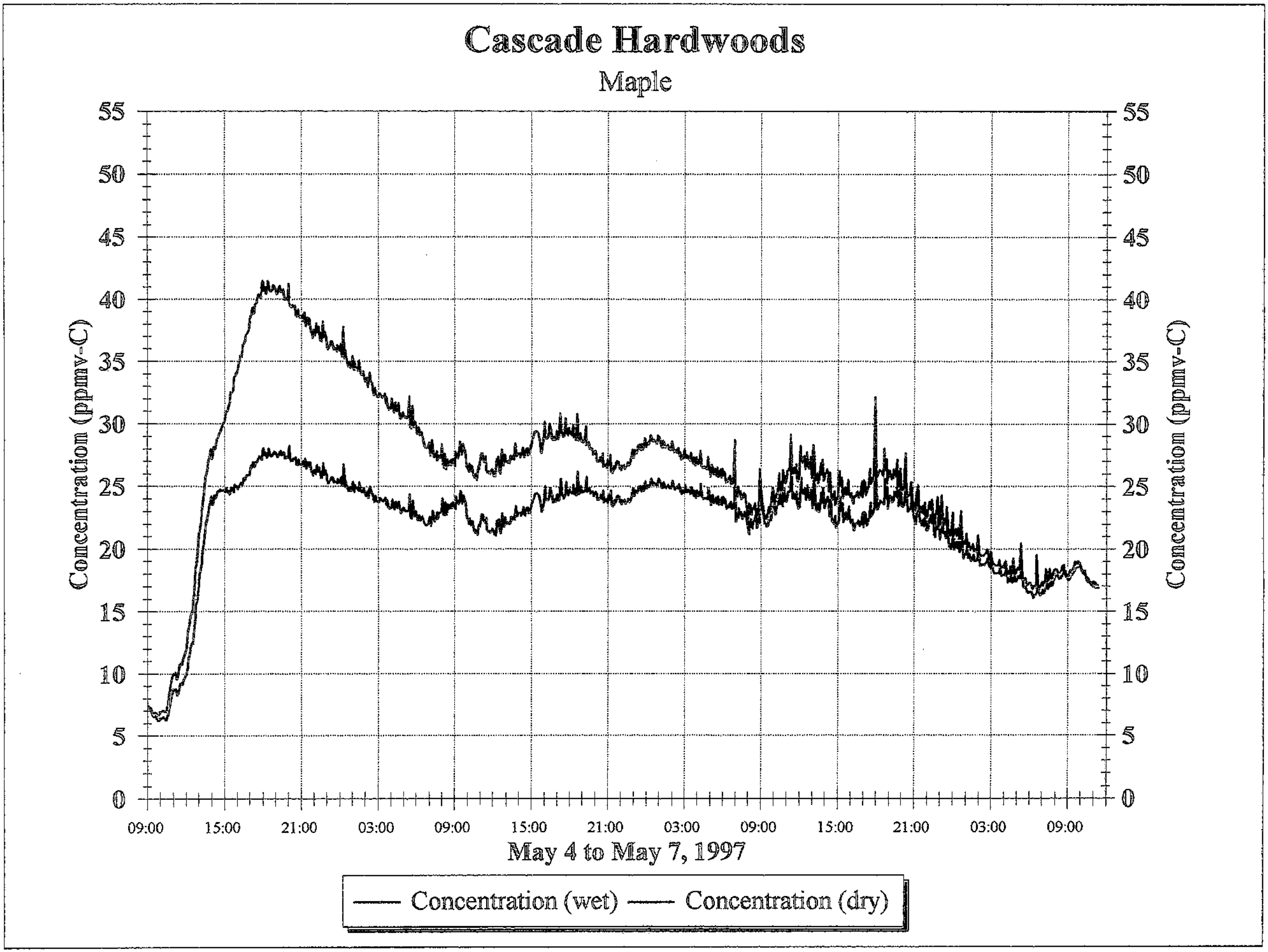
Propane

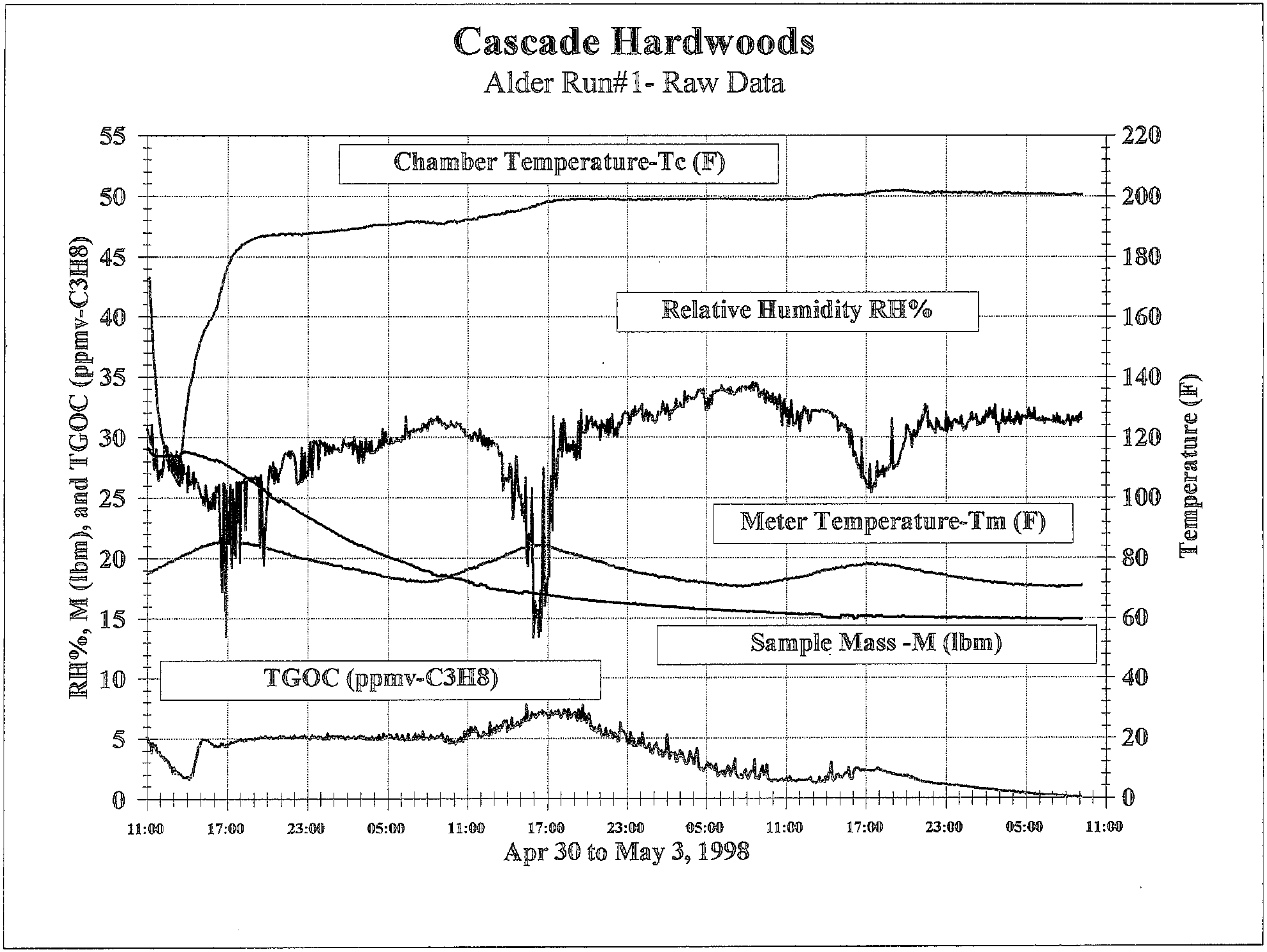
LOAD CELL	actual	start check	end check
high	24.45+10	35.73	35.14
zero	0	−.16	−.22
time & date		845 5-4	1450 5-7

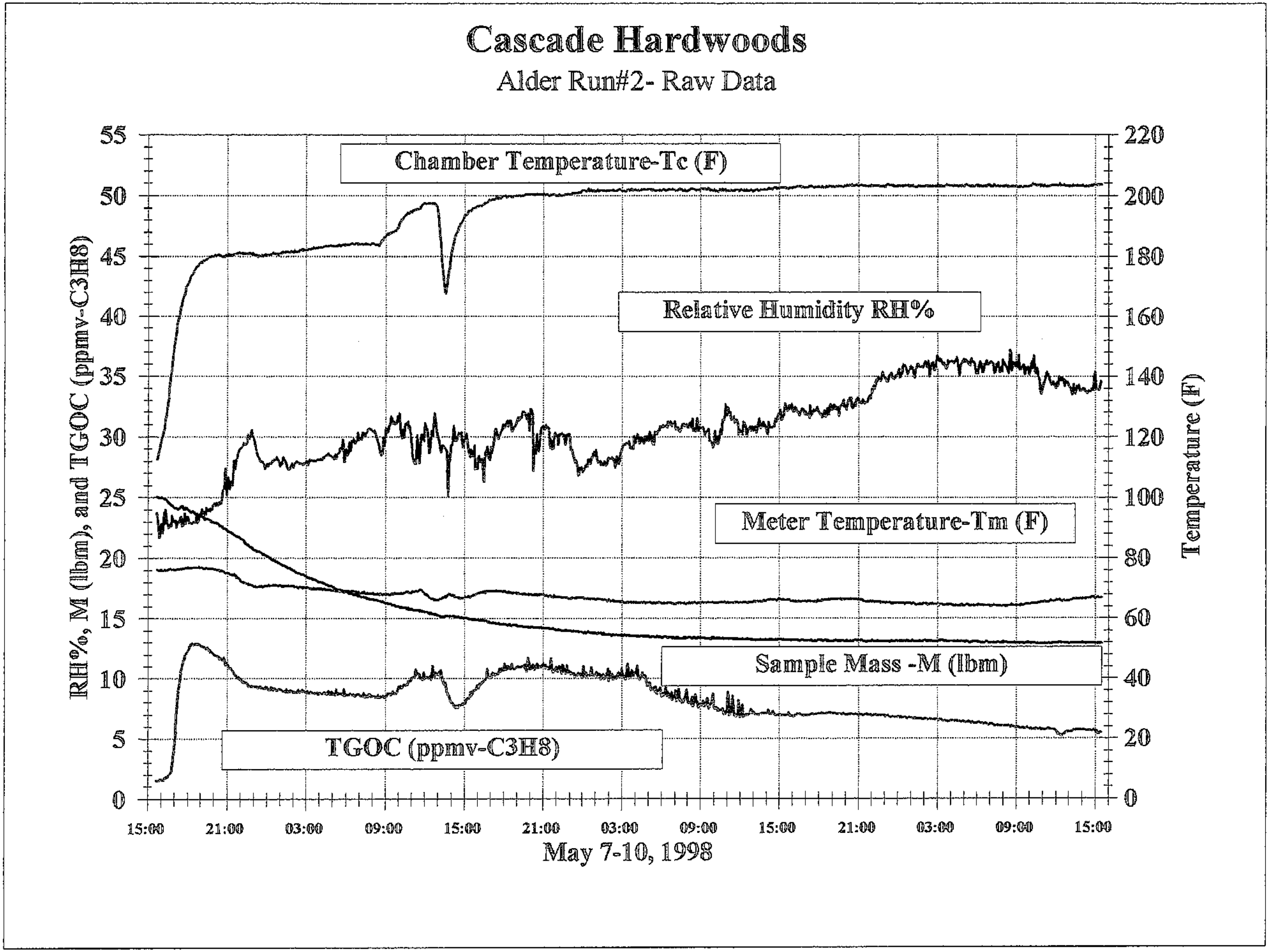
	Meter Reading	Time	Date	Load Weight
13	495.850	859	5-4	33.53
90	668.195	1524	5-4	31.78
278	1092.000	706	5-5	23.94
326	1199.980	1107	5-5	23.14
400	1366.005	1717	5-5	21.58
453	1484.721	2140	5-5	20.91
564	1732.700	0657	5-6	19.69
	1981.670	1614	5-6	1896
708	2054.450	1855	5-6	18.64
853	2328.400	0700	5-7	18.04
	2503.340	1140	5-7	17.73
	2580.000	1430	5-7	17.73


Cascade Hardwoods
Alder Run #1
Concentration (ppmv-C)
50
45
40
35
30
25
20
15
10
5
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
Apr 30 to May 3, 1998
Concentration (wet)
Concentration (dry)


Cascade Hardwoods
Alder Run #2
Concentration (ppmv-C)
60
55
50
45
40
35
30
25
20
15
10
5
0
15:00
21:00
03:00
09:00
15:00
21:00
03:00
09:00
15:00
21:00
03:00
09:00
15:00
May 7-10, 1998
Concentration (wet)
Concentration (dry)


Cascade Hardwoods
Maple
Concentration (ppmv-C)
55
50
45
40
35
30
25
20
15
10
5
0
09:00
15:00
21:00
03:00
09:00
15:00
21:00
03:00
09:00
15:00
21:00
03:00
09:00
May 4 to May 7, 1997
Concentration (wet)
Concentration (dry)


Cascade Hardwoods
Alder Run#1- Raw Data
Chamber Temperature-Tc (F)
Relative Humidity RH%
Meter Temperature-Tm (F)
Sample Mass -M (lbm)
TGOC (ppmv-C3H8)
RH%, M (lbm), and TGOC (ppmv-C3H8)
Temperature (F)
55 50 45 40 35 30 25 20 15 10 5 0
220 200 180 160 140 120 100 80 60 40 20 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
Apr 30 to May 3, 1998


Cascade Hardwoods
Alder Run#2- Raw Data
Chamber Temperature-Tc (F)
Relative Humidity RH%
Meter Temperature-Tm (F)
Sample Mass -M (lbm)
TGOC (ppmv-C3H8)
RH%, M (lbm), and TGOC (ppmv-C3H8)
Temperature (F)
0
5
10
15
20
25
30
35
40
45
50
55
0
20
40
60
80
100
120
140
160
180
200
220
15:00
21:00
03:00
09:00
15:00
21:00
03:00
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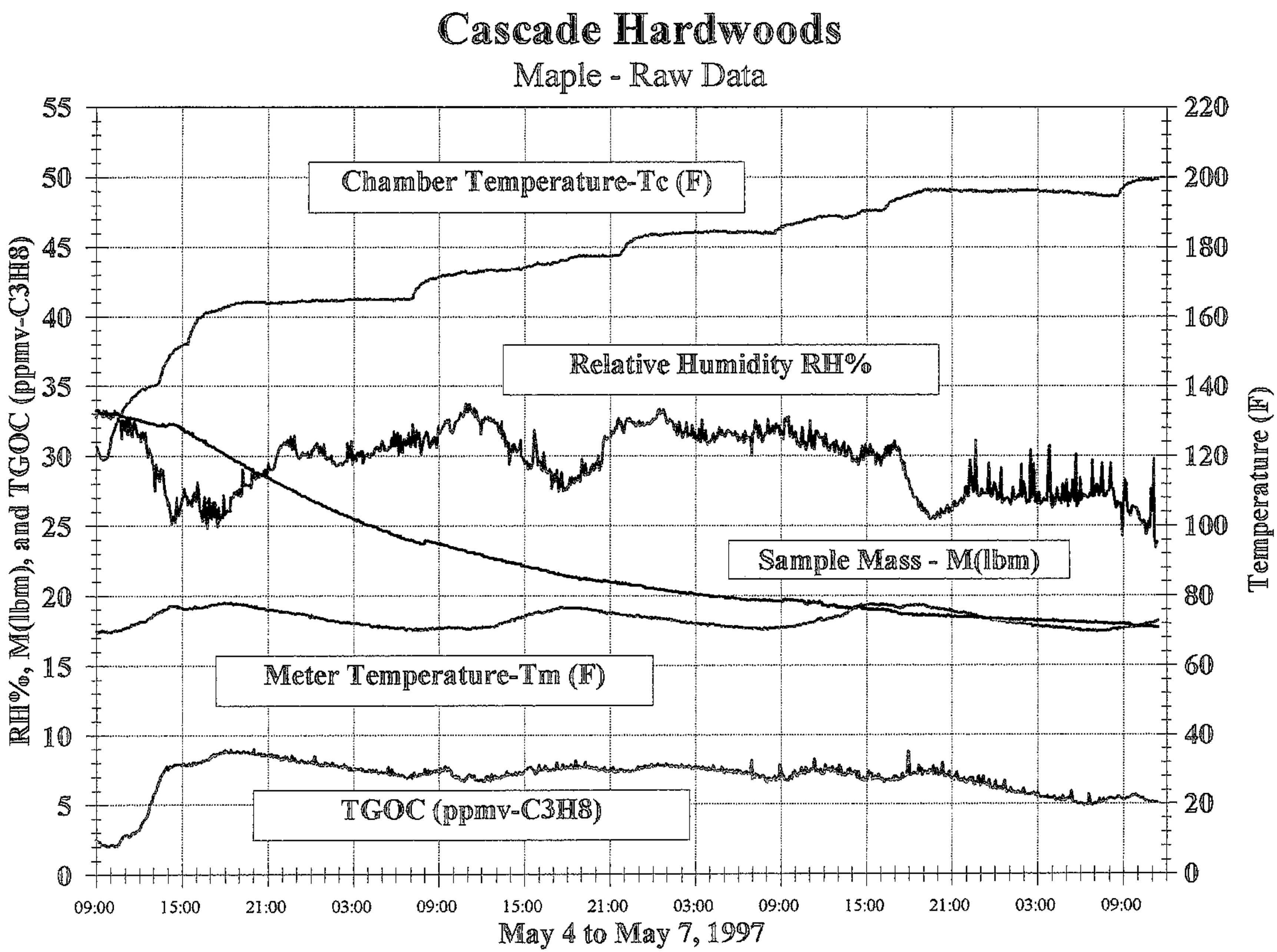
09:00
15:00
May 7-10, 1998


Cascade Hardwoods
Maple - Raw Data
Chamber Temperature-Tc (F)
Relative Humidity RH%
Sample Mass - M(lbm)
Meter Temperature-Tm (F)
TGOC (ppmv-C3H8)
RH%, M(lbm), and TGOC (ppmv-C3H8)
Temperature (F)
0
5
10
15
20
25
30
35
40
45
50
55
0
20
40
60
80
100
120
140
160
180
200
220
09:00
15:00
21:00
03:00
09:00
15:00
21:00
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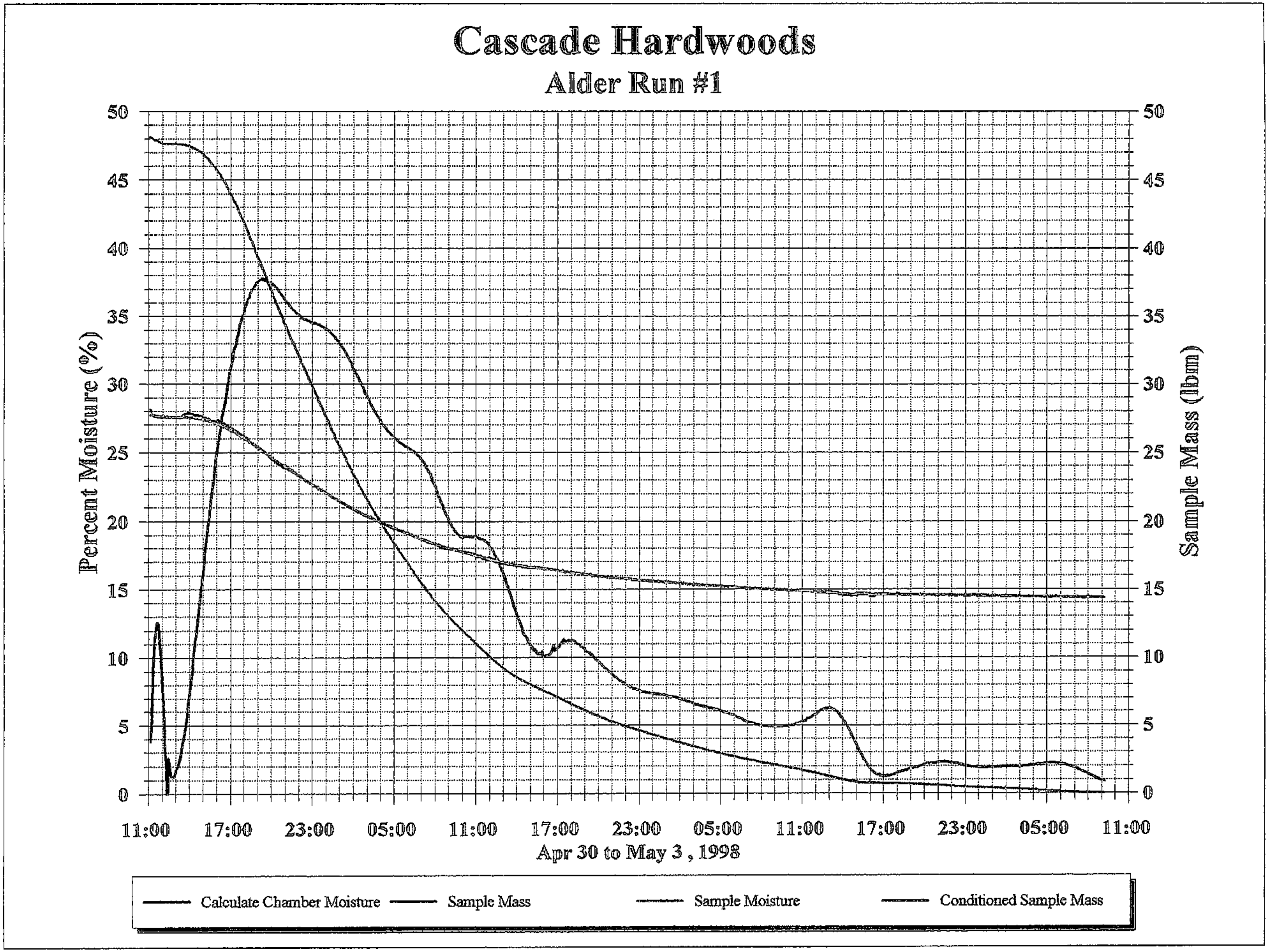
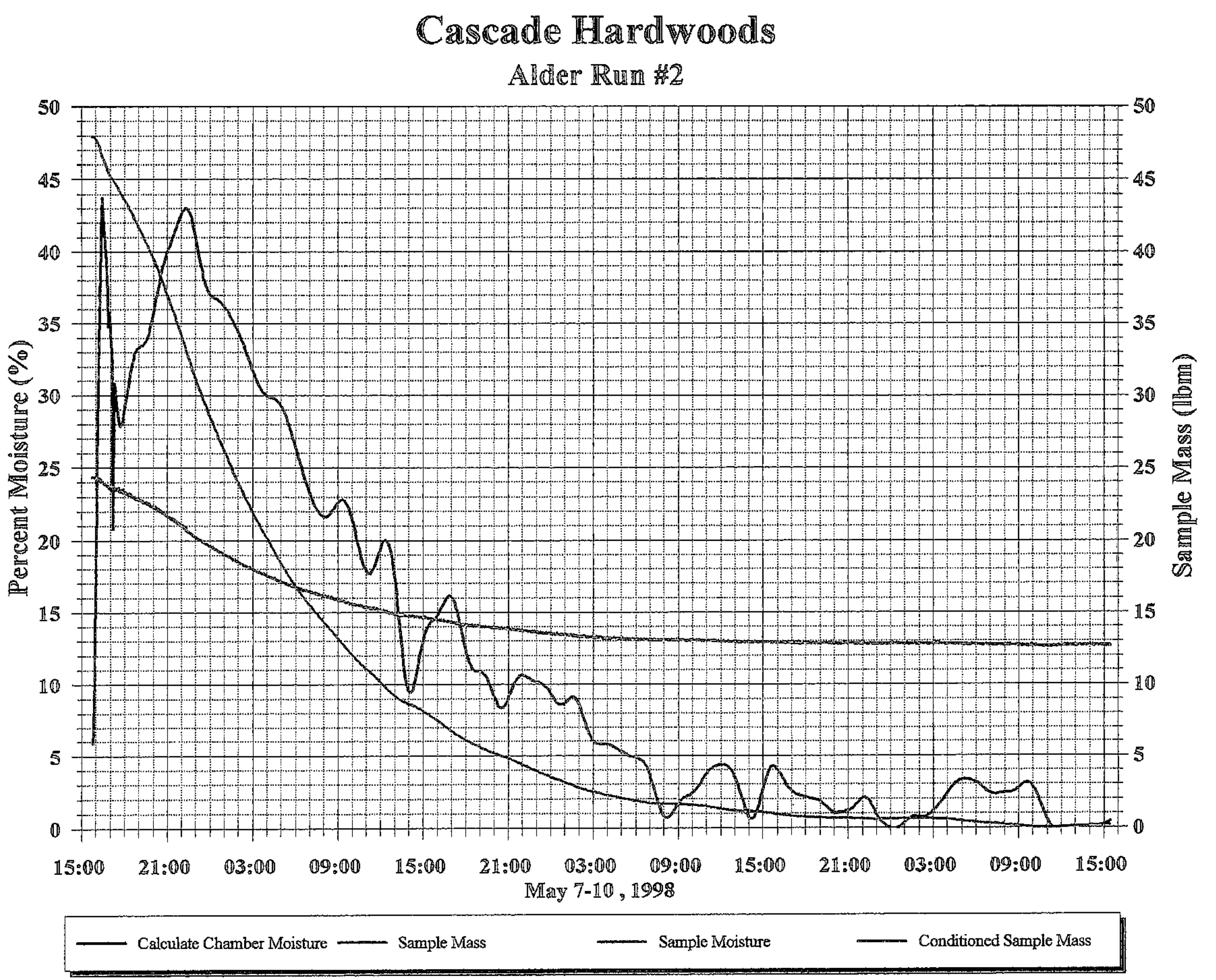
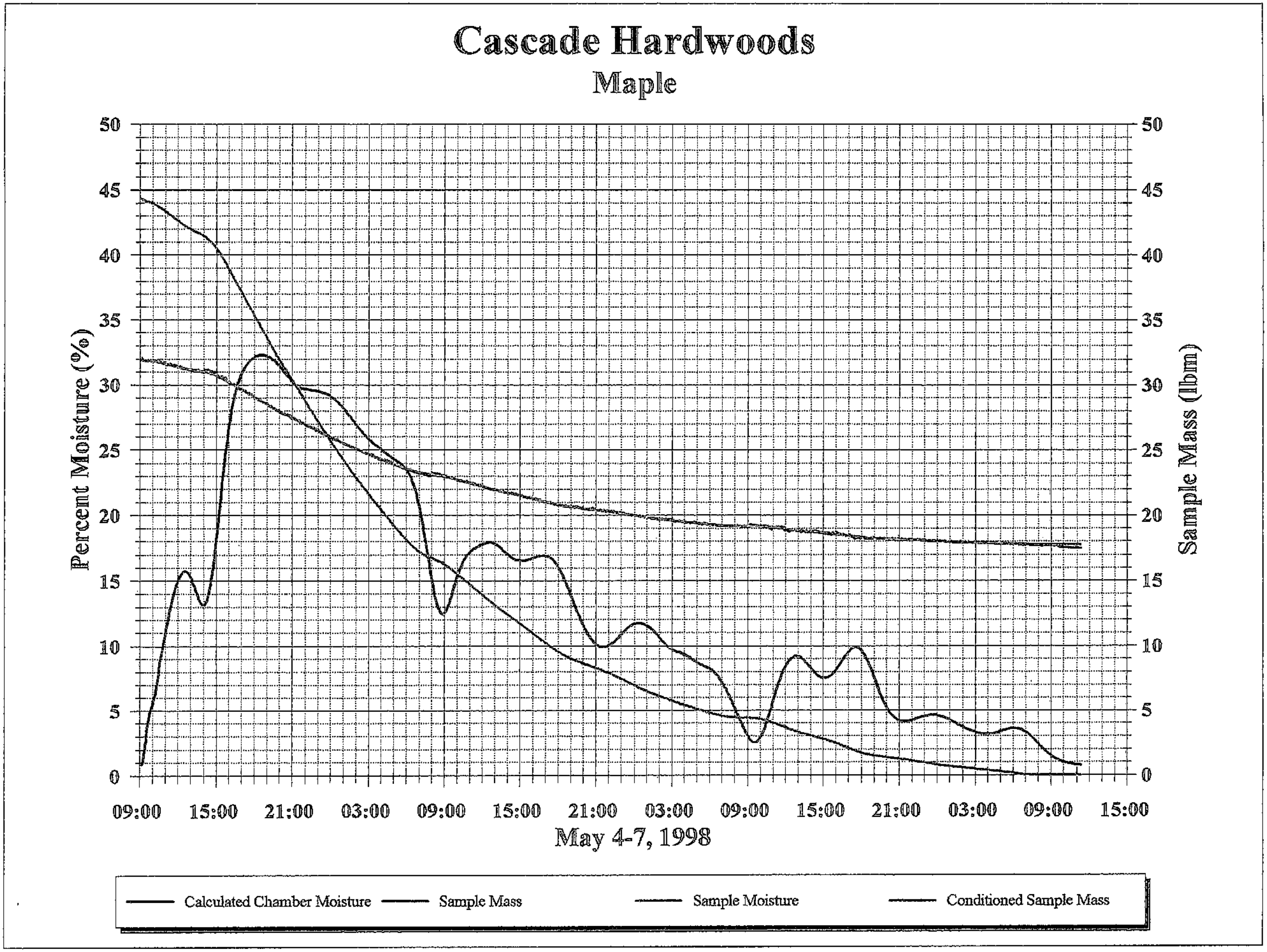
03:00
09:00
May 4 to May 7, 1997


Cascade Hardwoods
Alder Run #1
Percent Moisture (%)
Sample Mass (lbm)
50
45
40
35
30
25
20
15
10
5
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
Apr 30 to May 3 , 1998
Calculate Chamber Moisture
Sample Mass
Sample Moisture
Conditioned Sample Mass


Cascade Hardwoods
Alder Run #2
Percent Moisture (%)
Sample Mass (lbm)
0
5
10
15
20
25
30
35
40
45
50
15:00
21:00
03:00
09:00
15:00
21:00
03:00
09:00
15:00
21:00
03:00
09:00
15:00
May 7-10 , 1998
Calculate Chamber Moisture
Sample Mass
Sample Moisture
Conditioned Sample Mass


Cascade Hardwoods
Maple
Percent Moisture (%)
Sample Mass (lbm)
0
5
10
15
20
25
30
35
40
45
50
09:00
15:00
21:00
03:00
09:00
15:00
21:00
03:00
09:00
15:00
21:00
03:00
09:00
15:00
May 4-7, 1998
Calculated Chamber Moisture
Sample Mass
Sample Moisture
Conditioned Sample Mass

Alder Run 1

w x h	l	volume	
7.125	14.375	102.4219	
7.125	18.125	129.1406	
7.125	17.625	125.5781	
7.125	17.625	125.5781	
7.125	18.25	130.0313	
7.125	17.5	124.6875	
7.125	17.1875	122.4609	
		859.8984	total volume
		5.971517	dry bdft

Alder Run 3

w x h	l	volume	
6.75	14.25	96.1875	
6.75	14.5	97.875	
6.75	14.375	97.03125	
6.75	15	101.25	
6.75	14.125	95.34375	
6.75	14.125	95.34375	
6.75	14.5	97.875	
6.75	14.125	95.34375	
		776.25	total volume
		5.390625	dry bdft

Maple Run 2

w x h	l	volume	
7.6875	13.5	103.7813	
7.6875	13.125	100.8984	
7.6875	13.625	104.7422	
7.6875	13.625	104.7422	
7.6875	13.5	103.7813	
7.6875	13.5	103.7813	
7.6875	12.75	98.01563	
7.6875	12.75	98.01563	
7.6875	12.5	96.09375	
7.6875	12.875	98.97656	
7.6875	13.25	101.8594	
		1114.688	total volume
		7.740885	dry bdft

CALIBRATION INFORMATION

File	fs022796				
Method	EPA #5.3.2 & 5.6				
Location	Horizon Shop				
Meter Box ID	FS-A 685998	Pb=	30.02 (in Hg)		
Meter ID	None	Ta=	60 (oF)		
Calibrated	jdf	Date 2/14/97			

	Old	New	Change
	9-23-96	02-14-97	(+/-)
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	Pb=	30.20 (in Hg)		
Meter ID	None	Ta=	60 (oF)		
calibrated	jdf	Date	02/14/97		

	Old	New	Change
	09-23-96	02-14-97	(+/-)
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	Pb=	30.20 (in Hg)		
Meter ID	None	Ta=	60 (oF)		
calibrated	jdf	Date	02/14/97		

	Old	New	Change
	09-23-96	02-14-97	(+/-)
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

Tualatin Meter Shop
NEW METER INCOMING TEST REPORT DATA
(Non-Temperature Compensating Meters)

Annual Standard Meter
Calibration
Singer AC-175

Cal by Northwest Nat. Gas

Meter Size, Type AC 175 P.O. Number ____ Report By A Beck Date 3/27/98

	Meter Number	Prover No.	Proof Open	Proof Check	Open Minus Check	Diff INWC	Proper Config?	Paint? Assy?	No Leaks? Threads? Other?	ACCEPT?	REJECT?
1.		175	99.9	99.9							
2.		100	99.7	99.9							
3.		90	99.8	99.8							
4.		50	99.8	99.7							
5.		30	99.7	99.8							
6.											
7.											
8.											
9.											
10.											
11.											
12.											
13.											
14.											
15.											
16.											
17.											
18.											
19.											
20.											

Totals This Page: Accepted ____ Rejected ____ Tested ____

Page ____ of ____

Revised 8/1/97
F-8738NS

Thermocouple Calibration

Date:	24-Mar-98	Deviation	@60 F	7.8	Allowable Diff.		Pb=	29.88 in Hg		JDF	
Next Calibration:	20-Sep-98	Limit	@212 F	10.1	Allowable Diff.		Ta=	70.0 oF		980324tc	
			@325 F	11.8	Allowable Diff.						

		Ambient			Boiling, Water			Boiling, Oil			Average
	Probe/ID	Standard, F	Measured, F	Difference F	Standard, F	Measured, F	Difference F	Standard, F	Measured, F	Difference F	Difference F
Probe	3-1	33.2	33.0	0.2	211.4	211.4	0.0	357.8	358.4	-0.6	-0.13
Probe	3-2	33.2	33.4	-0.2	212.6	213.6	-1.0	352.8	356.8	-4.0	-1.73
Probe	3-3	34.8	34.8	0.0	210.6	212.6	-2.0	336.4	333.8	2.6	0.20
Probe	wc3-4	33.4	34.6	-1.2	212.2	214.2	-2.0	319.0	316.8	2.2	-0.33
Probe	3-5	33.2	33.4	-0.2	212.8	212.6	0.2	353.8	365.0	-11.2	-3.73
Probe	3-6	34.2	36.0	-1.8	211.6	213.8	-2.2	329.0	334.0	-5.0	-3.00
Probe	3-7	33.2	33.0	0.2	212.8	214	-1.2	358.6	356.8	1.8	0.27
Probe	3-8	33.2	33.6	-0.4	212.8	211.8	1.0	358.2	361.4	-3.2	-0.87
Probe	4-1	35.0	34.6	0.4	211.8	215	-3.2	346.6	346.8	-0.2	-1.00
Probe	4-2	34.6	33.0	1.6	211.2	208.2	3.0	332.4	328.4	4.0	2.87
Probe	4-3	35.4	36.2	-0.8	210.8	211.8	-1.0	332.8	336.0	-3.2	-1.67
Probe	4-4	34.4	33.2	1.2	210.6	211.6	-1.0	340.8	340.8	0.0	0.07
Probe	4-5	34.2	34.6	-0.4	210	212.2	-2.2	338.2	340.0	-1.8	-1.47
Probe	4-6	34.4	33.8	0.6	210.2	210.2	0.0	334.0	332.6	1.4	0.67
Probe	4-7	35.0	35.0	0.0	210.6	212.2	-1.6	336.4	340.4	-4.0	-1.87
Probe	5-2	33.0	33.8	-0.8	212.4	210	2.4	316.4	309.2	7.2	2.93
Probe	5-3	33.6	33.6	0.0	214.6	210.6	4.0	316.0	310.0	6.0	3.33
Probe	5-4	33.0	32.0	1.0	212.4	210.6	1.8	315.8	311.0	4.8	2.53
Probe	5-5	32.2	33.0	-0.8	211.4	210.4	1.0	314.4	314.0	0.4	0.20
Probe	5-6	33.0	32.6	0.4	213	210.8	2.2	315.4	313.8	1.6	1.40
Probe	5-7	32.4	32.4	0.0	214.4	211.2	3.2	319.6	317.4	2.2	1.80
Probe	5-8	33.0	32.8	0.2	212.4	211	1.4	324.4	321.8	2.6	1.40
Probe	5-9	33.0	32.6	0.4	212	211.2	0.8	317.4	320.0	-2.6	-0.47
Probe	7-1	33.6	32.6	1.0	210.8	210.8	0.0	313.0	315.8	-2.8	-0.60
Probe	7-2	33.6	33.0	0.6	211.8	211	0.8	318.6	318.6	0.0	0.47
Probe	7-3	33.2	33.6	-0.4	213.6	211	2.6	318.4	316.0	2.4	1.53
Probe	7-4	33.6	33.6	0.0	212.8	211.2	1.6	315.0	313.0	2.0	1.20
Probe	7-5	32.8	32.6	0.2	213.6	211.2	2.4	320.4	312.0	8.4	3.67
Probe	7-6	32.8	33.0	-0.2	213.4	211.6	1.8	312.4	311.8	0.6	0.73
Probe	10-1	33.6	33.6	0.0	211.8	211.8	0.0	317.2	315.6	1.6	0.53
Probe	10-2	33.8	33.2	0.6	213.8	211	2.8	315.4	316.2	-0.8	0.87
Probe	10-3	33.2	34.4	-1.2	212.2	212.4	-0.2	315.6	318.4	-2.8	-1.40
Pitot	11-S	34.2	33.6	0.6	212.4	214.2	-1.8	314.8	314.2	0.6	-0.20
Pitot	10-S	33.8	33.4	0.4	212.4	213.8	-1.4	325.2	319.0	6.2	1.73
	F3	36.0	34.6	1.4	210.4	211.8	-1.4	280.8	278.6	2.2	0.73
	F23	34.2	35.8	-1.6	210	212.6	-2.6	274.0	272.0	2.0	-0.73
	F51	34.0	34.2	-0.2	211.4	211.8	-0.4	319.0	320.0	-1.0	-0.53
	F84	35.4	33.8	1.6	211.2	213.6	-2.4	308.2	311.8	-3.6	-1.47
	F85	35.2	33.8	1.4	211.2	213	-1.8	306.8	304.2	2.6	0.73
	F100	34.0	34.0	0.0	212.2	211.8	0.4	318.8	316.6	2.2	0.87
	A1	33.2	32.6	0.6	210.8	211.6	-0.8	370.8	368.8	2.0	0.60
	A2	33.4	34.0	-0.6	212	211	1.0	370.4	367.4	3.0	1.13
	A3	33.2	33.8	-0.6	213	212	1.0	368.0	368.8	-0.8	-0.13
	A4	33.4	33.2	0.2	212.8	212	0.8	366.2	363.4	2.8	1.27
	A5	33.4	33.0	0.4	211.8	212.6	-0.8	364.8	362.8	2.0	0.53
	A6	33.2	33.8	-0.6	212.4	209.8	2.6	364.2	357.0	7.2	3.07
	B3	35.8	35.2	0.6	210.6	203.8	6.8	294.8	295.4	-0.6	2.27
	B7	36.2	35.0	1.2	211.2	201.6	9.6	287.4	290.6	-3.2	2.53
	B8	36.2	34.6	1.6	211.4	210.6	0.8	322.8	325.6	-2.8	-0.13
	B10	35.8	35.2	0.6	211.4	213.4	-2.0	312.8	314.8	-2.0	-1.13
	B11	36.2	35.4	0.8	211.2	208.4	2.8	328.0	328.6	-0.6	1.00
	B13	36.0	33.8	2.2	212	211.4	0.6	316.2	316.4	-0.2	0.87
	B14	35.6	34.3	1.3	211.4	213	-1.6	301.8	304.2	-2.4	-0.90
AVERAGE		34.0	33.8	0.2	211.9	211.4	0.5	326.9	326.5	0.5	0.4
				0.04%			0.07%			0.06%	
Hivol Dial Gauges											
9118		35.4	35	0.4							
D-2					211.6	211	0.6	320.6	326.0	-5.4	
D-5					211.4	210	1.4	322.0	330.0	-8.0	
D-7		35.2	35	0.2	211.4	206	5.4				
D-9					211.2	210	1.2	321.8	328.0	-6.2	
D-10		33.4	36	-2.6	210.6	212	-1.4				
D-14		36.2	32	4.2							

Standard Used Fluke 5895570

HORIZON ENGINEERING LLC
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DRIFT CORRECTION DOCUMENTATION

EPA Drift Equations:

- Method 3A: Oxygen and Carbon Dioxide

$$C_{gas} = \frac{(C_{ma} - C_{oa})(C - C_m) + C_{ma}}{(C_m - C_o)} \qquad \text{(Eq. 3A-1)}$$

- Method 6C: Sulfur Dioxide

$$C_{gas} = \frac{C_{ma}(C - C_o)}{(C_m - C_o)} \quad \text{where } C_{oa} = 0 \qquad \text{(Eq. 6C-1)}$$

- Method 7E: Nitrogen Oxides, Section 8 of Method 7E states: "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:

$$C_{gas} = \frac{(C_{id} - Z_x)(C_{ma} - C_{oa})}{(S_x - Z_x)} \qquad S_x = \frac{C_{mf} - C_{mi})(T_x - T_{ci})}{(T_{cf} - T_{ci})} + C_{mi}$$

$$Z_x = \frac{(C_{of} - C_{oi})(T_x - T_{ci})}{(T_{cf} - T_{ci})} - +C_{oi} \qquad T_x = \frac{(T_{te} - T_{ts})}{2} + T_{ts}$$

EPA	Definition	Horizon
C_{gas}	Effluent gas concentration, dry basis	C_{gas}
C_{ma}	Actual upscale calibration gas concentration	C_{ma}
C_{oa}	Actual zero/low calibration gas concentration	C_{oa}
C_m	Average of initial and final system upscale calibration bias responses	
	Initial system upscale calibration bias response	C_{mi}
	Final system upscale calibration bias response	C_{mf}
C_o	Average of initial and final system zero/low calibration bias responses	
	Initial system zero/low calibration bias response	C_{oi}
	Final system zero/low calibration bias response	C_{of}
C	Average gas concentration indicated by gas analyzer, dry basis	C_{id}
	Starting test time	T_{ts}
	Ending test time	T_{te}
	Initial system bias calibration response time	T_{ci}
	Final system bias calibration response time	T_{cf}
	Mid-point of test time or gas sampling interval to be analyzed	T_x
	Approximate upscale response at mid-point test time	S_x
	Approximate zero/low response at mid-point test time	Z_x

Notes or exceptions:
TGOC is first recorded on a wet basis, then corrected to a dry basis
The TGOC instruments used by Horizon 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 instrument's "over response" to methane.

TEST METHOD

Test Method for Determination of Dry Kiln VOC Emissions

April 5, 1996

Prepared by:

H. DETTINGER
PROJECT MANAGEMENT
202 SW 16th CT Troutdale Oregon 97060 Phone 503 666 8967 Fax 503 666 9356

and

David Broderick
9-July-96

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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.

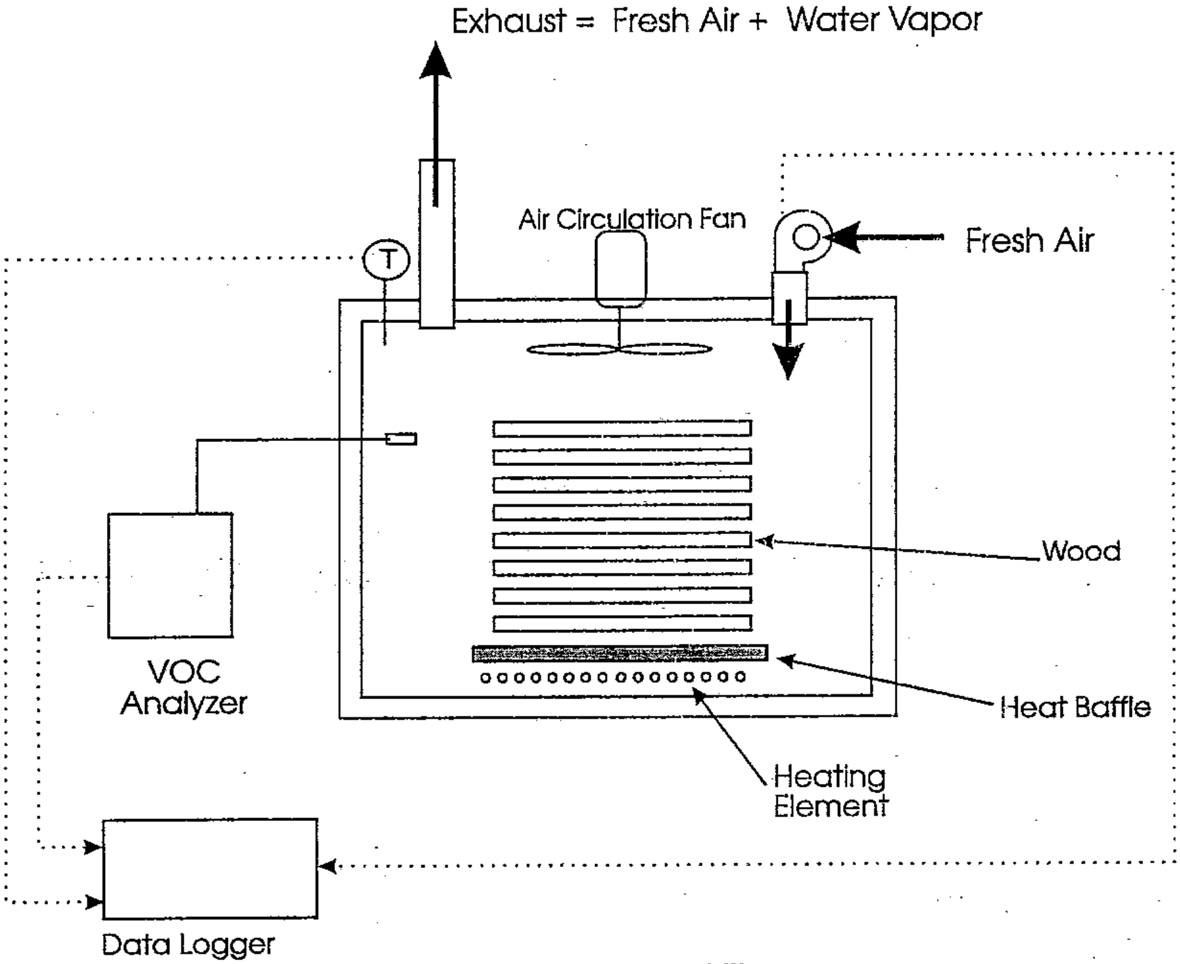
1.1 PRINCIPAL

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.