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SOURCE EVALUATION TEST REPORT

NORTHWEST HARDWOODS
Dry Kiln VOC Emission Factors

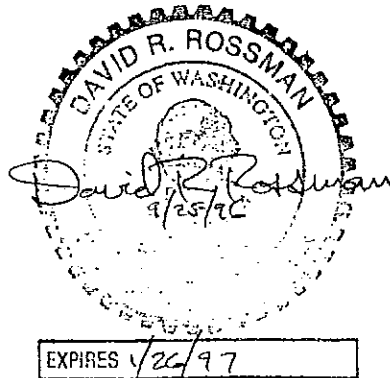
August 1-4, 1996

Prepared for

Northwest Hardwoods
3000 Galvin Road
Centralia, WA 98531

By

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



RECEIVED
OCT 15 1996
SOUTHWEST AIR POLLUTION
CONTROL AUTHORITY

Introduction

On August 1-4, 1996 a sample of Northwest Hardwood's Alder lumber was dried in Horizon Engineering's laboratory dryer. 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.

Testing was done by David Broderick of Horizon Engineering. Greg Griffith, of Northwest Hardwoods, arranged for the work. A copy of the proposed test method has been included in the Appendix.

Summary of Results

Table 1 summarizes the results of the testing. Figure 1 plots the calculated emission factor for the range of percentage H₂O (wet basis) of the wood sample.

Detailed results and sampling parameters are included in the Appendix.

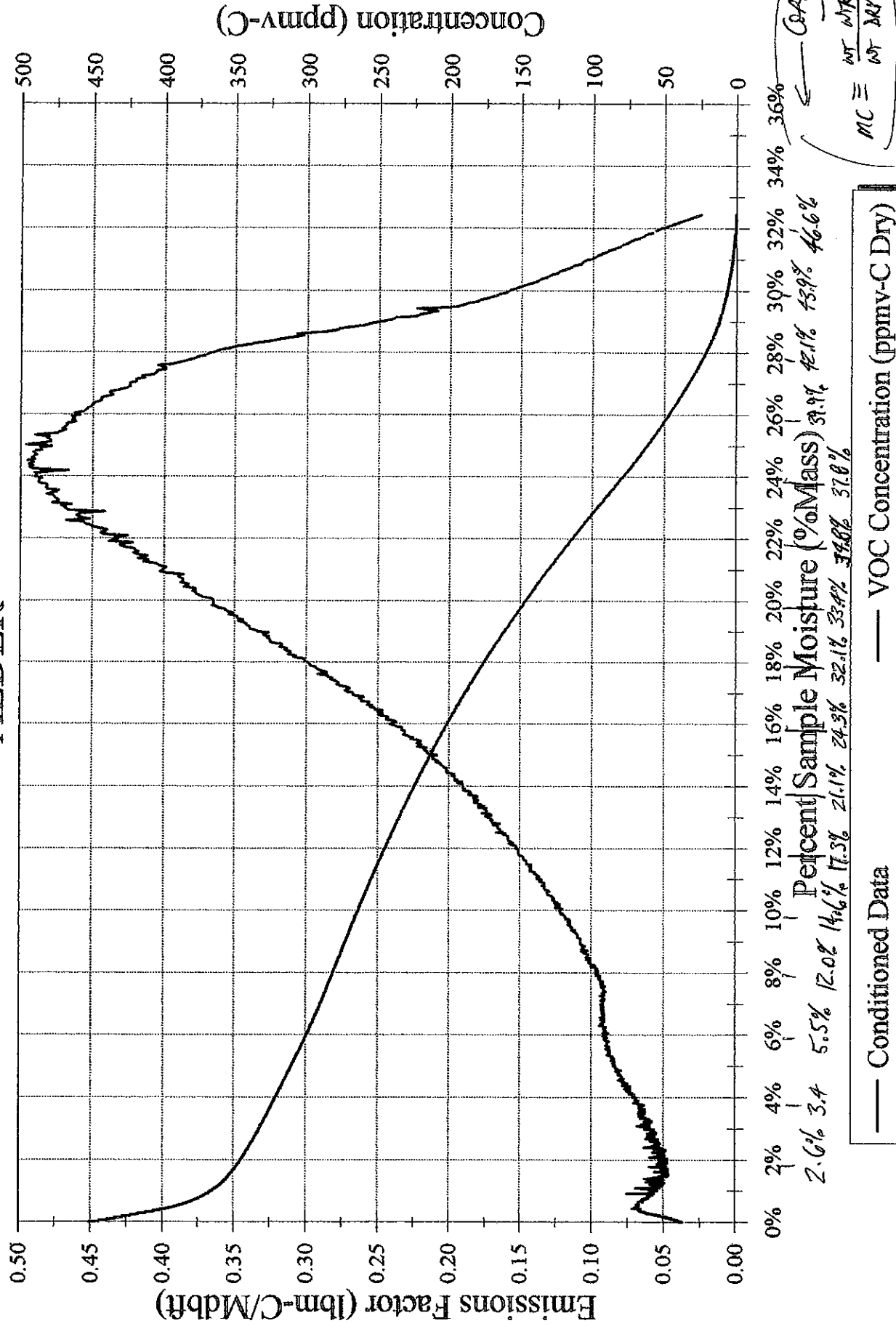
Table 1
Summary of Results

Results	Units	
Species		Alder
Sample size	bd ft	11.2
Initial weight	lb	44
Weight loss	lb	14.5 (4.42)
Test time	hr	72
Avg oven temp	°F	190
Avg inlet temp	°F	79
Avg Flow rate	dscf/min	0.33
Avg VOC	ppmvC	78

use 6% H₂O $\frac{0.3 \text{ lb VOC}}{\text{M Btu}}$
 5.3 lbs of VOC/yr
 1000 6.0 tons.

→ FINAL MASS WEIGHT
 ≈ 29.580 lb

Northwest Hardwood Trial #1 ALDER



Description of the Source

Northwest Hardwoods uses dry kilns to dry cut lumber. 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 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.

The method applied to the test kiln employs EPA Method 25A in a controlled environment 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.

Sampling Methods

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 VOC analyzer with heated sample line is used to measure VOC concentrations. Data was recorded every two 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.

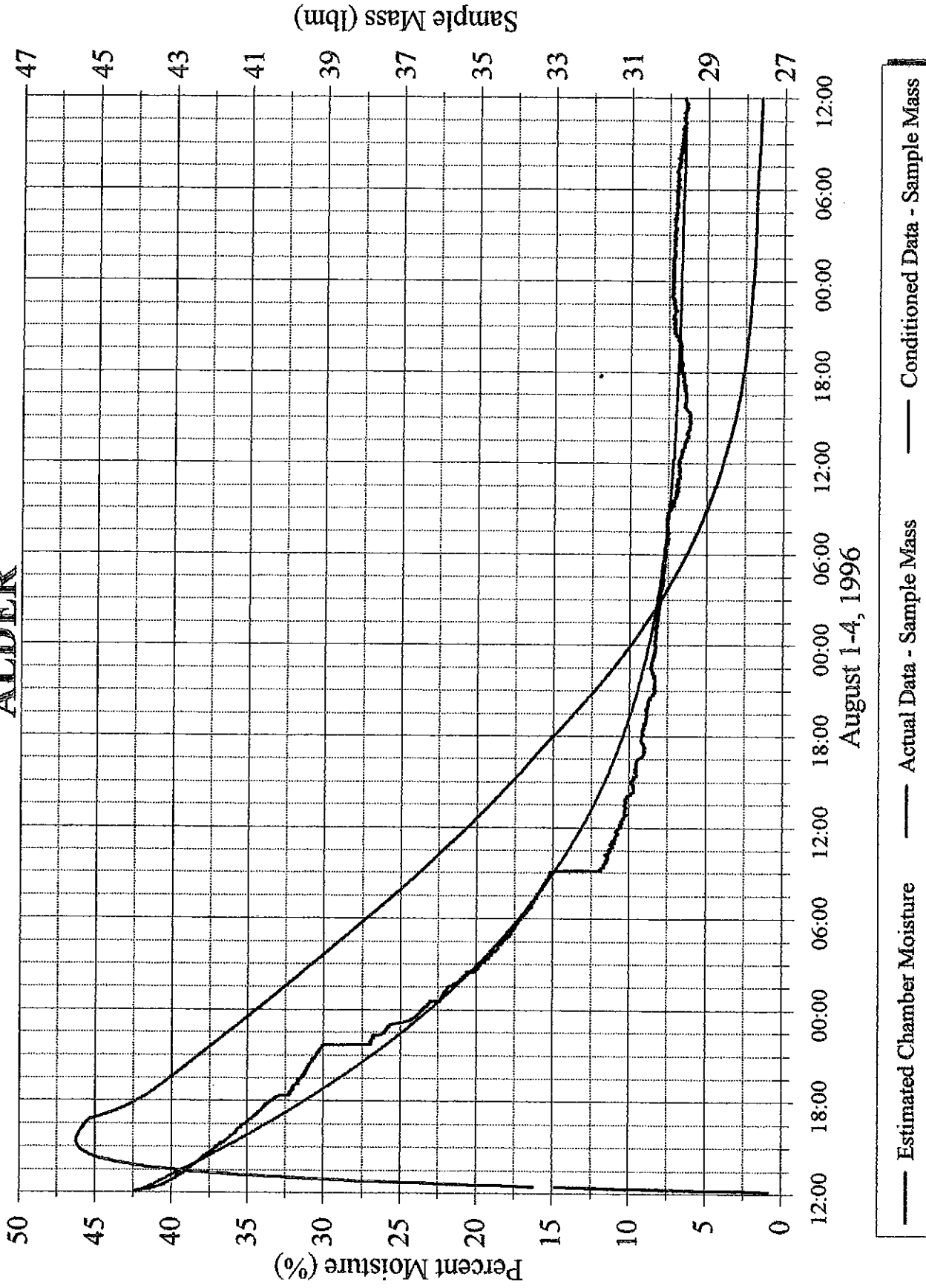
Calibrations Zero, span, calibration error (linearity) and bias checks were made on the VOC monitor at the beginning and end of the test.

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 The air in-flow rate and the total air flow data for the entire cycle were calculated from the dry gas meter readings, in cubic feet. The air in-flow corrected to a dry standard (dscf) is the same as the out-flow dscf. 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 water introduced 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 curve for the weight loss. Figure 2 shows the actual weight loss and the curve derived using Newton's method. Kiln moisture is also graphed.

Northwest Hardwood Trial #1 ALDER



Discussion

The final moisture content of the actual kiln dried lumber should be used to enter the plot of Figure 1. Annual emissions of VOC (as carbon) can be calculated based on production of dried Alder.

APPENDIX

Nomenclature

Data

VOC Concentration Plot

Temperature/Humidity Plot

Inlet Flow Plot

Calibration Information

Meter Box

Standard meter

Thermocouples

Drift Correction

Test Method

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 %O ₂ , 0.033% CO ₂ , Balance N ₂ +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% N ₂ & 1.18% Ar)	Emission balance	
C1	385.3211	ft ³ / lbmol	Ideal Gas Constant @ Standard Conditions	
C2	816.5455	inHg in ³ / °R ft ³	Isokenitics units correction constant	
Kp	5129.4	ft / min [(inHg lbm/mole) / (°R inH ₂ O)] ^1/2	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	ft ³ /lbmol	Gas Constant @ Standard Conditions	[R Tstd / Pstd(2)]	
C2	inHg in ³ / °R ft ³		[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%CO ₂	gr/dscf	Grain Loading Corrected to X% Carbon Dioxide	[X% / CO ₂ %]	
cg @ X%O ₂	gr/dscf	Grain Loading Corrected to X% Oxygen	[(20.946-X%) / (20.946-O ₂ %)]	
Cgas	ppmv, %	Gas Concentration, (Corrected)		
Cgas @ X%CO ₂	ppmv	Gas Concentration Correction to X% Carbon Dioxide	[X% / CO ₂ %]	
Cgas @ X%O ₂	ppmv	Gas Concentration Correction to X% Oxygen	[(20.946-X%) / (20.946-O ₂ %)]	
CO	ppmv	Carbon Monoxide		
Co	ft	Outer Circumference of Circular Stack		
Ci	ft	Inner Circumference of Circular Stack		
CO ₂	%	Carbon Dioxide		
Cp		Pitot tube coefficient		
Ct	lb/hr	Particulate Mass Emissions	[60 cg Qsd / 7,000]	
dH	in H ₂ O	Pressure differential across orifice		
Dn	in	Diameter, Nozzle		
dp ^{1/2}		Average square root of velocity pressure		
Ds	in	Diameter, Stack		
E	lb / MMBtu	Pollutant Emission Rate	Cgas Fd MWgas (20.946 / (20.946-O ₂ %)) / (1,000,000 C1)	Table 19-1
Fd	dscf / MMBtu	F Factor for Various Fuels		
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-%O ₂ -%CO ₂)(MWn2+ar)+(%O ₂ MWo2)+(%CO ₂ MWco2)]	Eq. 3-1*
mfg		Mole fraction of dry stack gas	[1-Bws/100]	
Mgas	lbm/hr	Gaseous Mass Emissions	[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		
NO ₂	ppmv-NO ₂	Nitrogen Dioxide (General Reporting Basis for NO _x)		
NO _x	ppmv-NO ₂	Nitrogen Oxides (Reported as NO ₂)		
O ₂	%	Oxygen		
OPC	%	Opacity		
Pbar	in Hg	Pressure, Barometric		
Pg	in H ₂ O	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*
RI	MMBtu/hr		[1,000,000 Mgas (20.946-O ₂)] / [Cd Fd 20.946]	
SO ₂	ppmv-SO ₂	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	dscf	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 ^{1/2} [Ts(abs) / (Ps Ms)] ^ 1/2	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.

Hardwood Trial

Summary table with columns: Date, Time, Value, VOC, RH, etc. for various dates and times.

Main data table with columns: Date, Time, Value, VOC, RH, etc. for a series of measurements from 01-Aug to 16-Aug.

Handwritten notes on the right side of the page, including '24 500' and '20 24 500'.

Northwood Hardwood Allard August 1-4, 1996	Yr P=12119 25/2991 Initial DL=51.9 kPa	Spec 20	Unit mm	St n	3rd 19 mm	DBH 138	Chamber 36	Core n	NDDP x -7.03 y -32.50 z -29.10	(Y) A -0.349E B 0.00919 C -0.0011 D 0.00000	A -0.349E B 0.00919 C -0.0011 D 0.00000	A -0.349E B 0.00919 C -0.0011 D 0.00000	A -0.349E B 0.00919 C -0.0011 D 0.00000	A -0.349E B 0.00919 C -0.0011 D 0.00000
--------------------------------------------------	-------------------------------------------------	------------	------------	---------	--------------	------------	---------------	-----------	--------------------------------------------------	---------------------------------------------------------------------	--------------------------------------------------------------	--------------------------------------------------------------	--------------------------------------------------------------	--------------------------------------------------------------

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Date	Time	Value F	Value T	Value VDC	Value RH	Value % RH	Value mm	Calculated Wind Mph	Calculated Wind km/h	Wind Dir	Wind Speed Mph	Wind Speed km/h	Wind Dir	Wind Speed Mph	Wind Speed km/h	Wind Dir	Wind Speed Mph	Wind Speed km/h	Wind Dir	Wind Speed Mph	Wind Speed km/h	Wind Dir	Wind Speed Mph	Wind Speed km/h	Wind Dir	Wind Speed Mph	Wind Speed km/h	
01-Aug	07:10:00	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250
01-Aug	07:15:00	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250	17.250

Northwest Hardwood August 14, 1996

Table with 10 columns: V, S, G, S, S, D, C, C, C, D. Values include 1.0110, 25.9283, 101.39, etc.

Main data table with 29 columns (1-29) and 100 rows. Columns include Date, Time, Value Tr, Value Tm, Value VOC, Value RH, Value Bm, etc. Rows contain detailed trial data for various dates and times.

Main data table with columns for Date, Time, Value, etc. It contains a large grid of numerical data points.

Hardwood Trial

Table with columns for Date, Time, Value, Volume, etc. and rows for various dates from 01-Aug to 30-Aug. Includes a detailed header with units and abbreviations.

Northwest Newco
Altitude
August 1-1, 1996

Table with columns: V, W, X, Y, Z, etc. and values for various parameters.

Main data table with columns: Date, Time, Values, Calculated, and various measurements (e.g., Wood Moisture, Wet Volume, etc.)

Northwest Hardwood										Hardwood Trial 1										NOORP																			
August 14, 1996										Date										Date																			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
Area	Time	Value	Value	Value	Value	Value	Value	Value	Value	Area	Time	Value	Value	Value	Value	Value	Value	Value	Value	Area	Time	Value	Value	Value	Value	Value	Value	Value	Area	Time	Value	Value	Value	Value	Value	Value	Value	Value	
AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	AVG	
01-Aug-09:14:00	09:14:00	100.43	79.51	16.51	16.51	16.51	16.51	16.51	16.51	01-Aug-09:14:00	09:14:00	100.43	79.51	16.51	16.51	16.51	16.51	16.51	16.51	01-Aug-09:14:00	09:14:00	100.43	79.51	16.51	16.51	16.51	16.51	16.51	16.51	01-Aug-09:14:00	09:14:00	100.43	79.51	16.51	16.51	16.51	16.51	16.51	16.51

Northwest Hardwood
Alden
August 1-4, 1996

Table with columns: Date, Time, Value, etc. Summary statistics for the trial.

Main data table with columns: Date, Time, Value, etc. Contains detailed trial data for various dates and times.

Hardwood Trial

Northwest Hardwood August 1-4, 1996

Main data table with columns for Date, Time, Value, etc. It contains a large grid of numerical data points.

Nonhardwood Hardwood
Alder
August 1-4, 1996

Summary table with columns: P=, L=, S=, D=, W=, T=, C=, A=, B=, C=, D=, E=, F=, G=, H=, I=, J=, K=, L=, M=, N=, O=, P=, Q=, R=, S=, T=, U=, V=, W=, X=, Y=, Z=

Main data table with columns: Date, Time, Value, etc. Rows include measurements for Alder and Hardwood across various dates and times.

Table with 29 columns: Date, Time, Value F, Value T, Value W, Value V, Value P, Value R, Value S, Value M, Value L, Value H, Value A, Value B, Value C, Value D, Value E, Value F, Value G, Value H, Value I, Value J, Value K, Value L, Value M, Value N, Value O, Value P, Value Q, Value R. Includes headers for Species, Diameter, Length, Volume, Weight, Moisture, etc.

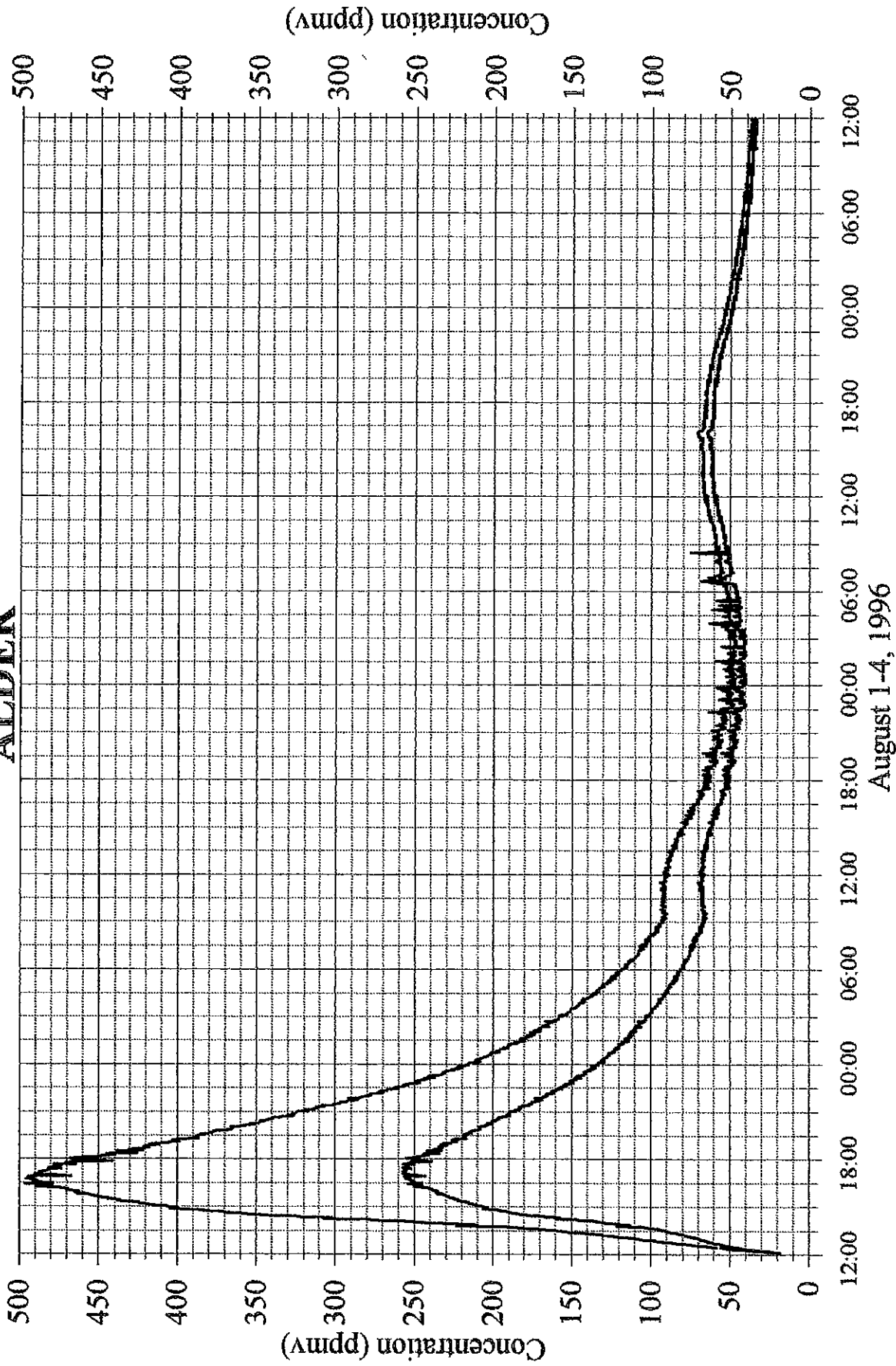
Northwest Hardwood
Allier
August 14, 1996

Summary table with columns: Yr, P, W, S, D, C, M, N, O, A, B, C, U, D. Values include 13119, 29.292, 101.3, 11.18, etc.

Main data table with columns: Date, Time, Value, etc. Rows contain detailed measurements for various dates and times, including values like 0.91300, 0.91300, 0.91300, etc.

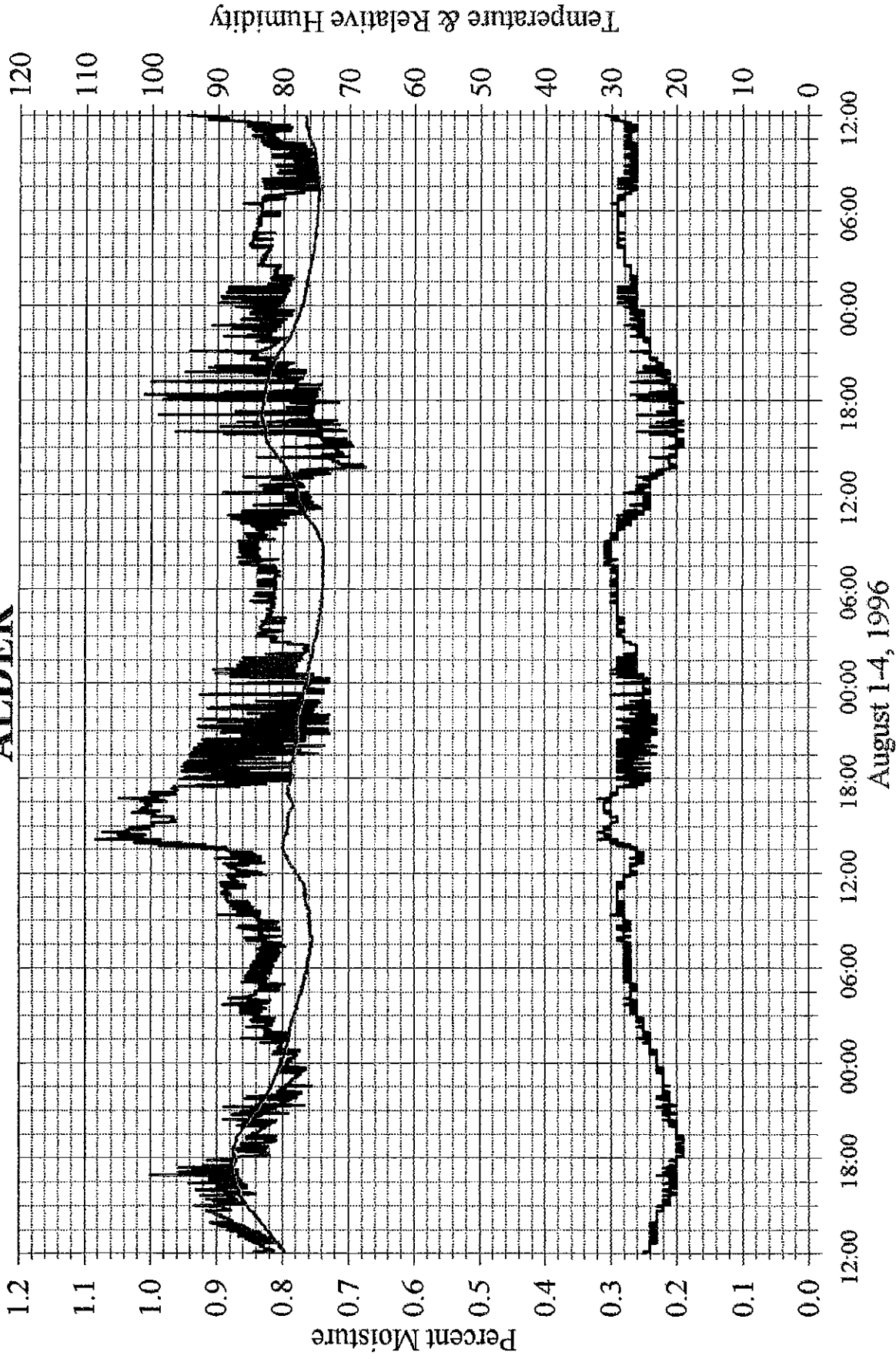
Northwest hardwood Trial #1

ALDER



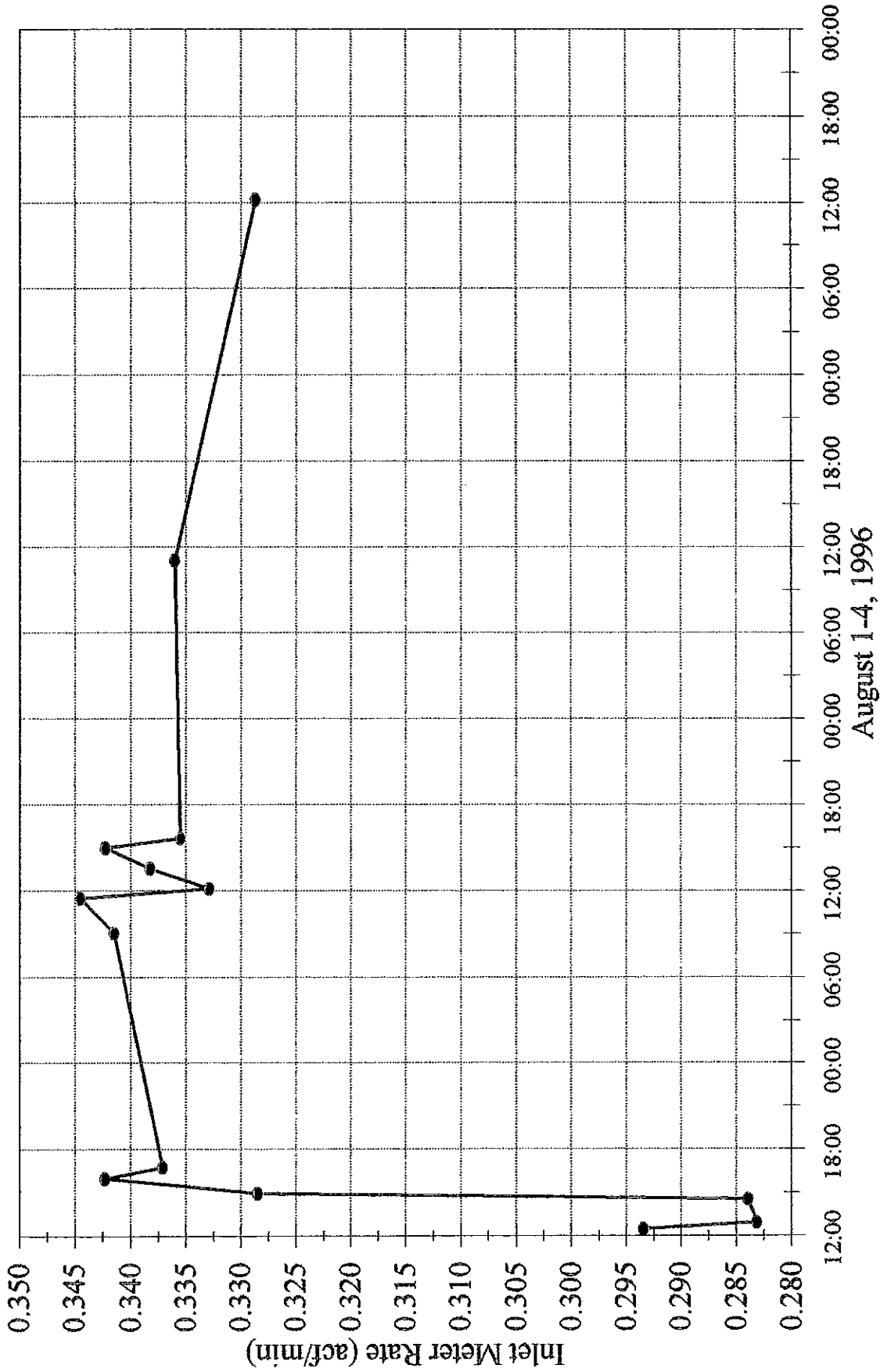
Northwest hardwood Trial #1

ALDER



Northwest Hardwood Trial #1

Alder



—●— Meter Readings

Free Standing Meter Calibrations

File	is022796															
Method	EPA #5.3.2 & 5.6															
Location	Horizon Shop															
Meter Box ID	FS-A 685998						Pb=	29.95 (in Hg)			Old	2-26-96	New	9-23-96	Change	(+/-)
Meter ID	None						Ta=	61.6 (oF)			Y=	0.98842	0.98537	-0.31%		
calibrated	jdf						Date	2/26/96								
FS-A 685998	VAC	dH	Standard	Net	Field	Net	Standard	Meter	Field	Meter	To	Tm	Time	Y	Allowable	
FS-A 685998	(inH2O)	(inH2O)	Meter	(ft)	Meter	(ft)	Tw	Tw	Tdi	Tdo	(oR)	(oR)	t		Tolerance	
FS-A 685998			(ft)		(ft)		(oF)	(oR)	(oF)	(oF)			(min)	Y	Y	
FS-A 685998															0.020	
Initial	N/A	N/A	0.1500	5.8500	861.1880	5.9410	71.0	531.0	71.0	71.0	531.0	531.0	11.283	0.98468	0.001	
Final			6.0000		867.1290		71.0		71.0	71.0						
Initial	N/A	N/A	0.0500	6.9500	867.1720	7.0430	71.0	531.5	71.0	71.0	531.5	531.5	29.683	0.98680	0.001	
Final			7.0000		874.2150		72.0		72.0	72.0						
Initial	N/A	N/A	1.0000	5.0000	874.2150	5.0780	72.0	532.0	72.0	72.0	532.0	532.0	18.367	0.98464	0.001	
Final			6.0000		879.2930		72.0		72.0	72.0						
														0.98537	0.001	

File	is022796															
Method	EPA #5.3.2 & 5.6															
Location	Horizon Shop															
Meter Box ID	FS-D 2713329						Pb=	30.01 (in Hg)			Old	2-27-96	New	9-23-96	Change	(+/-)
Meter ID	None						Ta=	66 (oF)			Y=	1.01885	0.99517	-2.32%		
calibrated	drb						Date	9/23/96								
FS-D 2713329	VAC	dH	Standard	Net	Field	Net	Standard	Meter	Field	Meter	To	Tm	Time	Y	Allowable	
FS-D 2713329	(inH2O)	(inH2O)	Meter	(ft)	Meter	(ft)	Tw	Tw	Tdi	Tdo	(oR)	(oR)	t		Tolerance	
FS-D 2713329			(ft)		(ft)		(oF)	(oR)	(oF)	(oF)			(min)	Y	Y	
FS-D 2713329															0.020	
Initial	N/A	N/A	0.0000	6.0000	229.3080	6.0180	67.0	527.0	65.0	65.0	525.5	525.5	17.100	0.99417	0.001	
Final			6.0000		235.3260		67.0		66.0	66.0						
Initial	N/A	N/A	0.0000	6.0000	235.3260	5.9990	69.0	529.0	66.0	66.0	527.0	527.0	9.350	0.99639	0.001	
Final			6.0000		241.3250		69.0		68.0	68.0						
Initial	N/A	N/A	0.0000	6.0000	247.3545	6.0475	70.0	530.0	71.0	71.0	531.5	531.5	11.600	0.99495	0.000	
Final			6.0000		253.4020		70.0		72.0	72.0						
														0.99517	0.001	

File	is022796															
Method	EPA #5.3.2 & 5.6															
Location	Horizon Shop															
Meter Box ID	FS-E 2713328						Pb=	30.01 (in Hg)			Old	2-27-96	New	9-23-96	Change	(+/-)
Meter ID	None						Ta=	68 (oF)			Y=	1.00347	1.00818	0.47%		
calibrated	drb						Date	9/23/96								
FS-E 2713328	VAC	dH	Standard	Net	Field	Net	Standard	Meter	Field	Meter	To	Tm	Time	Y	Allowable	
FS-E 2713328	(inH2O)	(inH2O)	Meter	(ft)	Meter	(ft)	Tw	Tw	Tdi	Tdo	(oR)	(oR)	t		Tolerance	
FS-E 2713328			(ft)		(ft)		(oF)	(oR)	(oF)	(oF)			(min)	Y	Y	
FS-E 2713328															0.020	
Initial	N/A	N/A	0.0500	5.9500	257.3570	5.9190	72.0	531.5	69.0	69.0	530.0	530.0	12.100	1.00240	0.006	
Final			6.0000		263.2760		71.0		71.0	71.0						
Initial	N/A	N/A	0.0000	6.0000	263.2760	5.9670	71.0	531.0	71.0	71.0	532.0	532.0	11.717	1.00742	0.001	
Final			6.0000		269.2430		71.0		73.0	73.0						
Initial	N/A	N/A	0.0000	6.0000	269.2430	5.9520	71.0	531.0	74.0	74.0	534.5	534.5	12.000	1.01471	0.007	
Final			6.0000		275.1950		71.0		75.0	75.0						
														1.00818	0.004	

Standard Dry Gas Meter

Flow Rate CFH	Prof
21	0.99.7 c. 99.8
36	0.99.7 c. 99.6
41	0.99.6 c. 99.6
60	0.99.7 c. 99.5
75	0.99.5 c. 99.6

Tested 12/21/95
By Greg Beck

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			Boiling, Water			Boiling, Oil			Average Difference F
	Standard, F	Measured, F	Difference F	Standard, F	Measured, F	Difference F	Standard, F	Measured, F	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	345.8	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	369.8	0.2	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

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

Method 6c : Sulfur Dioxide

$$C_{gas} = \frac{C_{ma} * (C - C_o)}{(C_m - C_o)} \quad (\text{Eq. 6c-1})$$

; $C_{oa} = 0$

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:

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

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

EPA	Definition	Horizon Engineering
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_{ef}
	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 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.

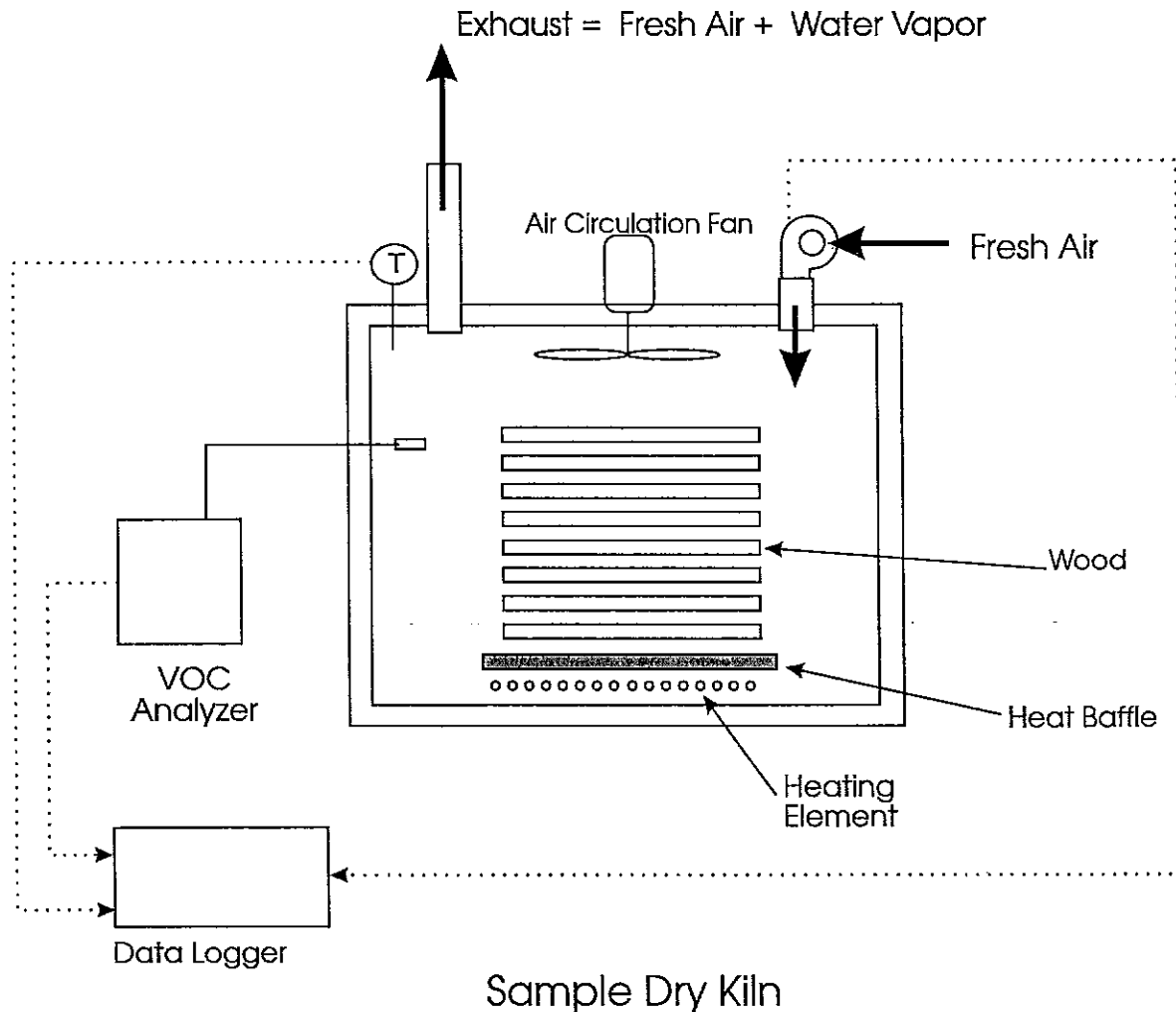
1.1 PRINCIPAL

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



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