



**NORTHWEST  
HARDWOODS**

A Weyerhaeuser Company

120 INDUSTRIAL WAY  
LONGVIEW, WA 98632

Source Test  
FILE 11/26  
-WS

Thursday, 15 November, 2001

Mr. Wes Safford  
Southwest Clean Air Agency  
1308 N.E. 134<sup>th</sup> St.  
Vancouver, Wa. 98685-2747

Dear Mr. Safford,

In closed is the VOC Emissions testing, that was completed by Michael R. Milota at the Department of Forest Products Oregon State University Corvallis, Or. VOC Testing was completed November 2, 2001.

Should you require any other material or information, please feel free to contact me at any time

Sincerely

Kim Newbury  
Northwest Hardwoods-Longview  
Safety/Environmental Coordinator

Bob \_\_\_\_\_  
Randy \_\_\_\_\_  
Paul \_\_\_\_\_  
Wess \_\_\_\_\_  
Clint \_\_\_\_\_  
Natalia \_\_\_\_\_  
Vannessa \_\_\_\_\_  
John \_\_\_\_\_  
Jackie \_\_\_\_\_  
Jerry \_\_\_\_\_  
David \_\_\_\_\_  
Laurie \_\_\_\_\_  
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Leo \_\_\_\_\_  
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# **VOC Emissions from Red Alder Lumber**

**Report to**

**Northwest Hardwoods  
120 Industrial Way  
Longview, WA 98632**

**Report by**

**Michael R. Milota  
Department of Forest Products  
Oregon State University  
Corvallis, OR 97331**

**November 2, 2001**

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## VOC Emissions from Red Alder Lumber

### I. Results Summary

One charge, 77.3 board feet, of 4/4 red alder lumber was dried in a small-scale kiln at Oregon State University. The kiln dry- and wet-bulb temperatures were controlled to the schedule provided by Northwest Hardwoods. The dry-bulb temperature started at 160°F (71.1°C) and ended at 180°F (82.2°C). The air velocity was 500 feet per minute (2.5 m/s). The kiln was indirectly heated with steam. There was no humidification. Regulating the amount of air entering the kiln controlled venting. A JUM 3-200 total hydrocarbon analyzer was used to measure organic emissions following EPA Method 25A. It has been demonstrated through past studies that this small-scale kiln and this method give results similar to a large-scale kiln.

The wood was at 6.5% moisture content when drying was stopped at 101.6 hours. The mill dries to 8% moisture content. A total hydrocarbon release of 0.58 lb/mbf was measured up to the time when the wood reached 8% moisture content at 93 hours and 14 minutes. This value is reported "as carbon."

The peak hydrocarbon concentration, 118 ppm (wet gas basis, averaged over a three-hour sampling interval), occurred between hours 3 and 6 of the schedule. This was simultaneous with the peak rate of hydrocarbon release, 0.02 lb/mbf/hr. By the end of the schedule the release rate was one-tenth this much and the concentration was 30 to 40 ppm.

### II. Lumber Source and Handling

Two charges of lumber were delivered to Oregon State University on October 16, 2001, one to be dried and one as a backup. Each was wrapped in plastic at the mill to prevent predrying and loss of organic compounds. The packages as received are shown in Figure 1.

Mill personnel reported that the lumber was sawn on October 11, placed in their green yard, then sampled on October 14. It was further reported that lumber selected was 60% from 10' logs and 40% from 8' logs to match the normal lumber mix for the mill. All pieces were trimmed to 4' prior to shipping. The width of the pieces varied from 4" wide to 15-1/4" wide prior to drying.

The charge to be dried was only stored at OSU for two hours prior to the start of drying. It was left wrapped during this period. The back up charge was placed in a refrigerator. The backup charge was not used.





**FIGURE 1.** Picture of lumber as received.

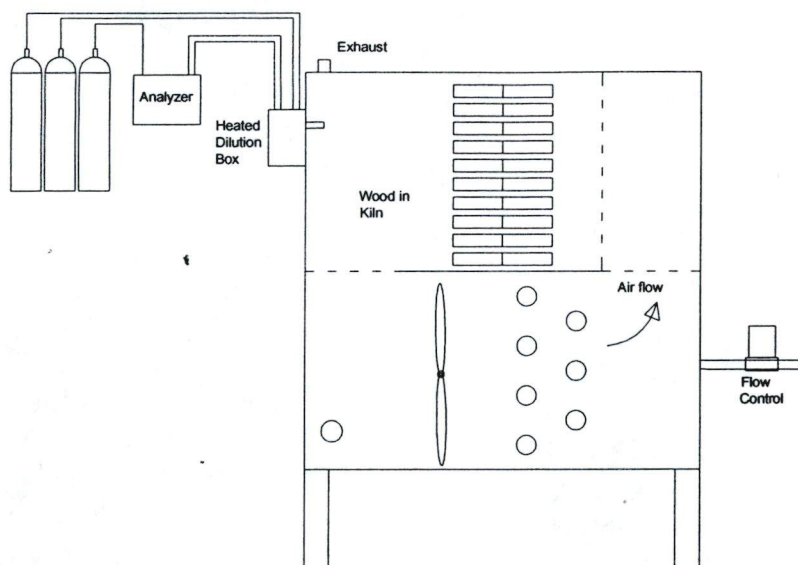
### **III. Kiln Description and Operation**

A schematic of the kiln is shown in Figure 2 and a picture of the loaded kiln in Figure 3. The kiln box is approximately 4' by 4' by 4'. It is indirectly heated by steam.

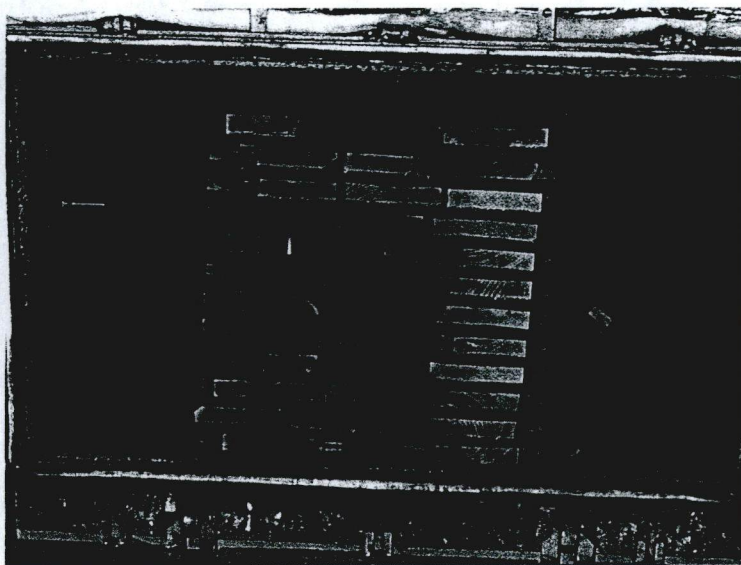
Four dry-bulb thermocouples and two wet-bulb thermocouples are located on the entering-air side of the load. The dry-bulb thermocouples are spaced in a grid. The two wet-bulb thermocouples are under a single sock at the center of the entering-air side of the load.

#### **Humidity**

A 200 L/min MKS mass flow meter controlled and measured the amount of air entering the kiln. It was factory calibrated and checked using a bubble meter. The amount of air entering the kiln is based on the wet-bulb temperature - if it is above setpoint, the airflow is increased and if it is below setpoint the airflow is decreased. This is exactly analogous to venting for a commercial kiln. A minimum of 10 L/min entered the kiln at all times, more than removed by the analyzer (< 2.5 L/min). Putting air into the kiln at a rate of 100 L/min causes the pressure in the kiln to be 60 to 130 Pa above ambient, depending on location in the kiln (high-pressure or low-pressure side). Thus, any fugitive leakage should be out of the kiln. The steam spray line is disabled, so no water vapor is added to the kiln atmosphere.



**FIGURE 2.** Schematic of kiln and sampling system.



**FIGURE 3.** Picture of lumber in kiln (after drying).



## Temperature

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

## Schedules

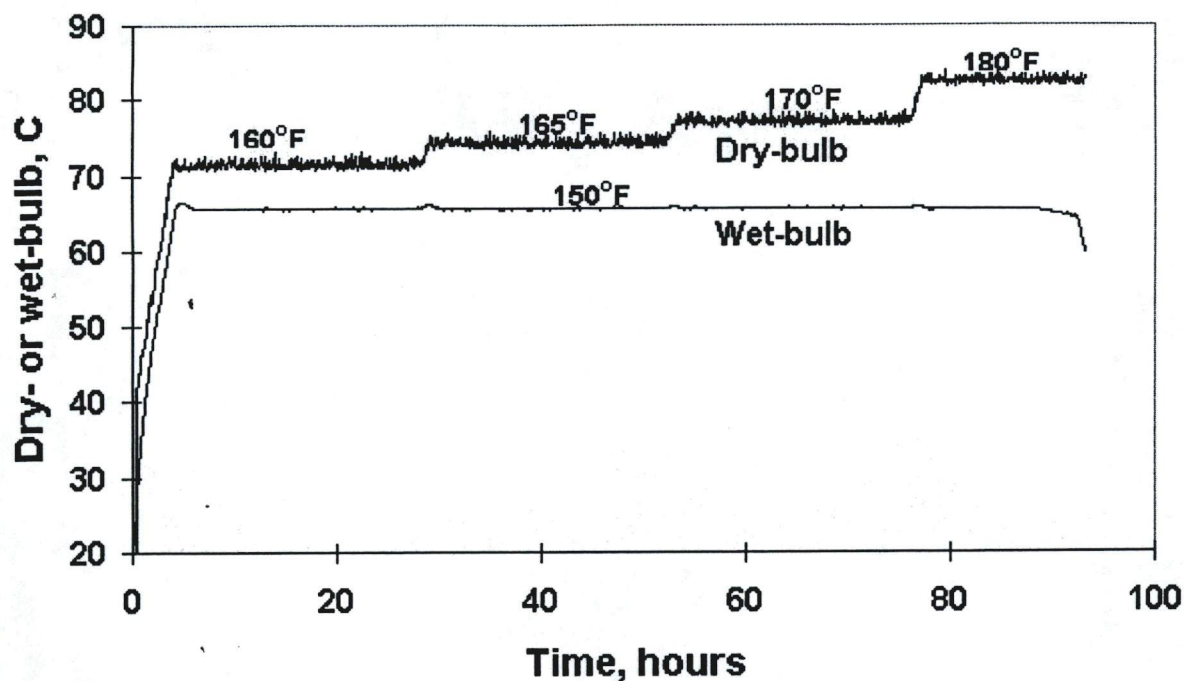
The drying schedule supplied by the mill is shown in Table 1. The actual dry- and wet-bulb temperatures used are similar to the schedule. These are presented in Figure 2. For the actual drying, a one-hour ramp time was used where the schedule in Table 1 indicates a zero ramp time. This was done so better temperature and humidity control could be maintained.

## Charge Sequence

The kiln was made ready and 2" were trimmed from each end of each board to give 44" samples. These were then weighed, placed in the kiln, and dried according to the schedule provided. Sampling for hydrocarbon was done as described in section IV. At the end of drying the wood was weighed, oven dried, and reweighed so initial and final moisture contents could be determined by ASTM D4442.

**TABLE 1.** Drying schedule.

Step time, hours	Ramp time, hours	Dry-bulb, °F	Wet-bulb, °F
28	4	160	150
24	0	165	150
24	0	170	150
16	0	180	150
12	0	180	140
12	0	180	130



**FIGURE 4.** Dry- and wet-bulb temperatures during the drying cycle.

#### IV. Sampling Systems and Methodologies

Figures 5a and 5b show the hydrocarbon sampling system. The fuel gas was hydrogen. The span gas was EPA Protocol 1527 ppm propane in air, the mid-gas was certified 881 ppm propane. The zero gas was Grade 5 air. Detailed sampling procedures are in Appendix 1 and a summary is presented below.

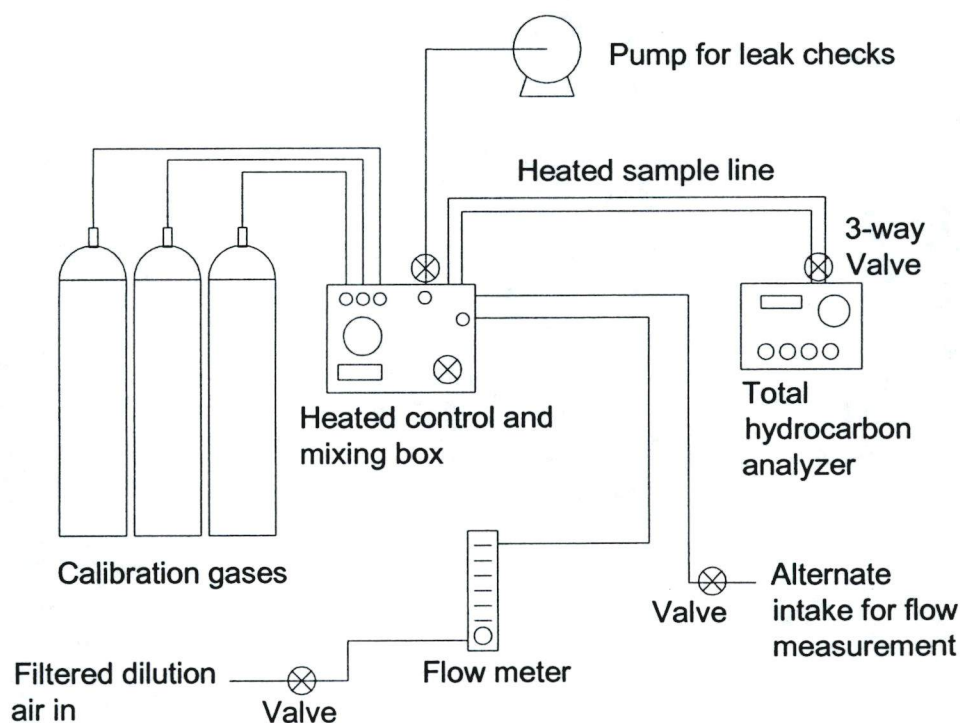
The THC sample was drawn from the kiln directly into a dilution/filter box mounted on the side of the kiln. The box was heated to 126°C. It is assumed that the gas in the kiln is well-mixed and that the composition in the kiln near the exhaust is the same at the composition of the exhaust. The sample line from the box to the analyzer was heated to 146°C. The valve at the back of the analyzer was heated to 154°C.

Leak checks were conducted before and after the charge was dried. Valves are closed and all components from just behind the probe tip to the valve at the back of the analyzer are placed under a 20 inHg vacuum. Less than one inHg pressure change during two minutes is acceptable and this was easily met for both tests. Note that the system does not operate under significant pressure or vacuum when it is in operation.

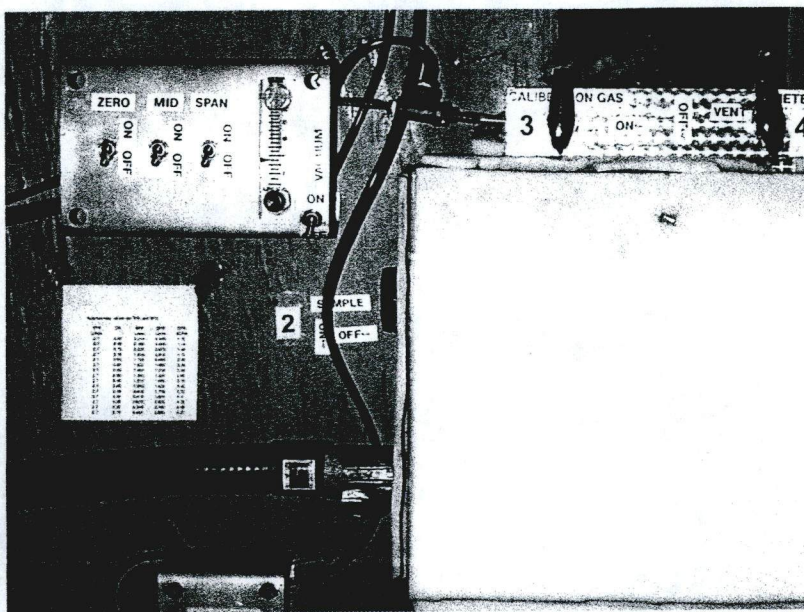


Total flow and sample flow to the analyzer were checked using an NIST-traceable flow meter. This was done at the beginning and end of each sampling interval. The meter was attached to the system near the probe tip within the heated box. The valves were repositioned so that the sample came from the meter rather than the kiln. Readings made with the dilution gas off and on indicated the dilution ratio used to lower the gas moisture content to the detector. The flow readings were verified by observing the change in the analyzer reading for span gas before and after the dilution gas was turned on. The dilution ratio calculated based on the analyzer readings was generally within 2% of that determined by the flow meter.

Calibration of the zero and span of the detector was done at the beginning of each run (about every three hours). The calibration gas was introduced by setting the valves so the calibration gas entered the system near the probe tip at ambient pressure. The calibration was checked at the end of each run with no adjustments made to the zero or span during the run. The span drift was always less than two percent of full scale for a run and generally less than one percent. The zero did not drift during the four days of sampling.



**FIGURE 5A.** Schematic of heated filter box with air dilution system, heated sample line, and analyzer. Sample enters heated box from back of drawing (box is attached to kiln).



**FIGURE 5B.** Photo of VOC sampling system showing heated sample box (with white insulation), toggle valves and flow meter for calibration gases (upper left), on/off valve for calibration gas (3 at upper center right), heated sample line to analyzer (green tube, lower left), valve for sample (2 at center), toggle valve to vacuum pump (near calibration gas valves), and vent/flowmeter valve (4 at upper right).

## V Data Reduction and Treatment

The "FlowCalc" page in the files "RA1, Kiln.XLS" in Appendix 2 show the calculations for each 3-minute interval during the charge. Column A is a reading number. Columns B and C are the clock and charge times, respectively. Columns D and E are the average dry- and wet-bulb temperatures. Column F is the vapor pressure at the wet-bulb temperature. The absolute humidity is shown in column G and the molal humidity in column H.

### Flow calculations

The volumetric dry gas flow rate in column I (file "RA1, Kiln.XLS" in Appendix 2) is the flowmeter reading adjusted for the meter calibrations and the molar humidity of the entering gas. This is in standard (at 0°C) liters per minute. In column J this has been converted to a mass flow rate in kg/min and in column K is the same information is expressed as a molal flow rate.



## Moisture calculations

The water removal rate in g/min (column L) (file "RA1, Kiln.XLS" in Appendix 2) is calculated from the humidity and the gas flow rate and the total water (column M) is an integration of column L over time.

The moisture content of the wood at each interval in the event (column N) was determined by reducing the MC of the wood based on the amount of water leaving the kiln during the previous 3-minute interval.

## Total hydrocarbon calculations

The original total hydrocarbon analyzer reading is shown in column O (file "RA1, Kiln.XLS" in Appendix 2). In column P this has been corrected to compensate for the range setting switch on the analyzer. Also in column P, the THA data between sampling runs has been adjusted to the average of the data during the 15-minute periods before and after the down time. The dilution THA (column Q) is the corrected THA reading divided by the dilution ratio (from column Y). In column R we have the opportunity to compensate for the effect of moisture on the JUM detector. This was not done so column R equals column Q. Finally in column S, the hydrocarbon concentration is converted to a dry gas basis concentration.

In column T the hydrocarbon flow rate in g/min as carbon is calculated in a manner analogous to the water flow rate using the dry gas flow rate and the hydrocarbon concentration. Column U is the integral of column T over time, the cumulative hydrocarbon release up to that point in the schedule. Column V is the cumulative unit emissions, that is, column U divided by the oven-dry weight of the wood in the kiln.

Column X indicates the hydrocarbon sampling run and column Y is the dilution ratio during that run. The next two columns, Z and AA, are the cumulative dry gas and water during the kiln cycle. These are used obtain the average gas moisture contents. The corrected wood moisture content, as discussed in section VI, is shown in column AC. The kiln air and analyzer air moisture contents are shown in columns AD and AE.

At the end (bottom) of the FlowCalc spreadsheet are summaries by run of the flow data for the total hydrocarbon run intervals.

The other pages in the files "RA1, Kiln.XLS" are graphs of the data in the FlowCalc page. Moisture content and board weight data are in the files named "RA1, Board.XLS." A file extension ".prn" indicates raw data as collected.



## VI. Sampling Results

The hydrocarbon emissions are summarized graphically here. All emission data is presented in detail in Appendix 2.

Figure 6 shows total hydrocarbon concentration and vent rate versus time. These are presented together because they tend to change in opposite directions. That is, for a given rate of emission release, the concentration could be high with a low vent rate, or the concentration low with a high vent rate. Note that the vent rate increases and the concentration decreases when the schedule changes occur at 28, 52, 76, and 92 hours.

Figure 7 shows the cumulative hydrocarbon emissions and the rate of emissions versus time. The cumulative emissions (in grams) is the emissions up to any point in time in the schedule. The rate of emissions (in grams per minute) is how much is coming out per unit time. The small spikes at 8, 52, 76, and 92 hours are times when the venting increases due to a schedule change, either a higher temperature or greater wet-bulb depression.

Figure 8 shows the wood moisture content versus time. The measured moisture content is obtained by doing a mass balance on the gas steams, then subtracting the water leaving the kiln from the initial moisture content of the wood. The mass balance was within 2 moisture content percentage points of the moisture loss that actually occurred based on the change in board weight. The estimated moisture content should most accurately represent the MC-time relationship because the initial and final moisture contents match the oven-dry test.

Figure 9 shows the cumulative hydrocarbon emissions versus moisture content. The emissions for drying to any moisture content can be read from this graph. If, for example, a mill wanted to dry to 19% instead of 8%, the total hydrocarbon emissions would be 0.51 lb/mbf. The relationship between moisture content and emissions is very linear after the initial part of the schedule. Note that the spikes do not appear on this graph because both the emissions rate and the drying rate are affected by schedule changes.

Table 2 shows the VOC results by run for the charge. This has been truncated to 93:14 hours:minutes. The interval time periods shown in the table include the times between sampling and mass calculations are adjusted to account for these. The interval time periods sum to the drying time to eight percent moisture content. Sampling occurred for 96% of the total drying time as it took 5 to 10 minutes to check and calibrate the analyzer and set up dilution between three-hour sampling periods.

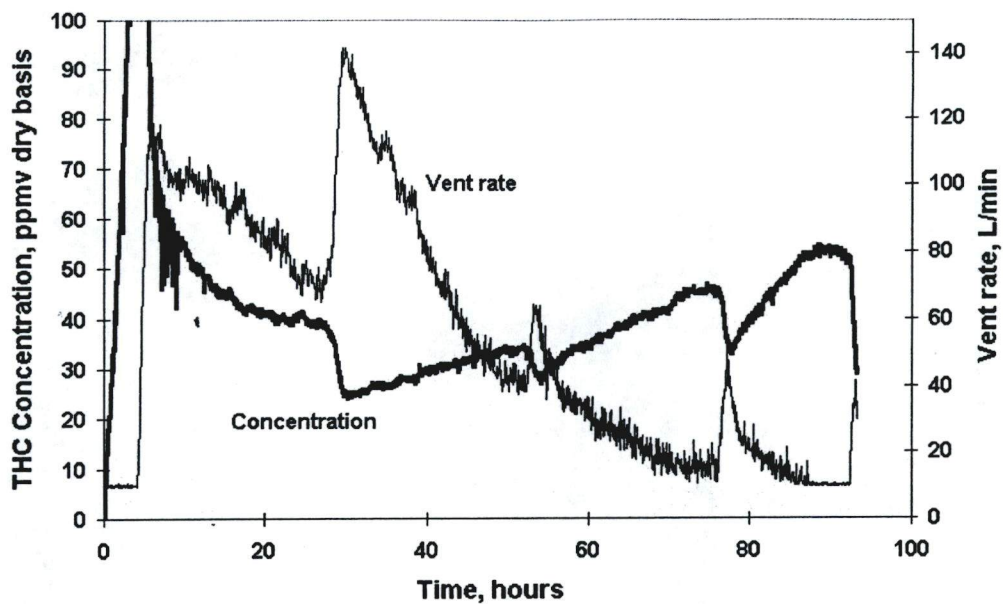


FIGURE 6. Hydrocarbon concentration and vent rate versus time.

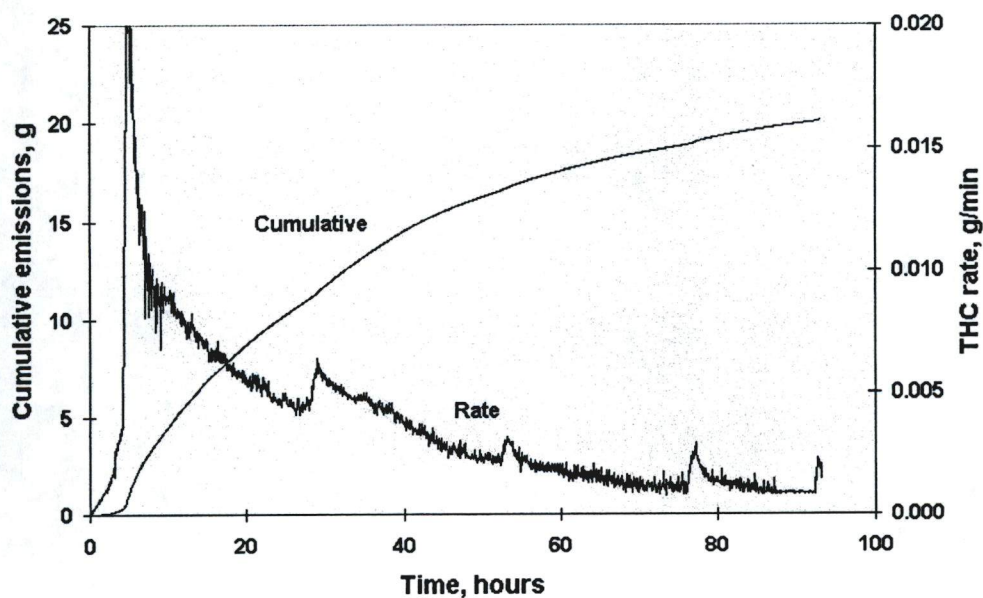


FIGURE 7. Cumulative emissions and rate of emissions versus time.



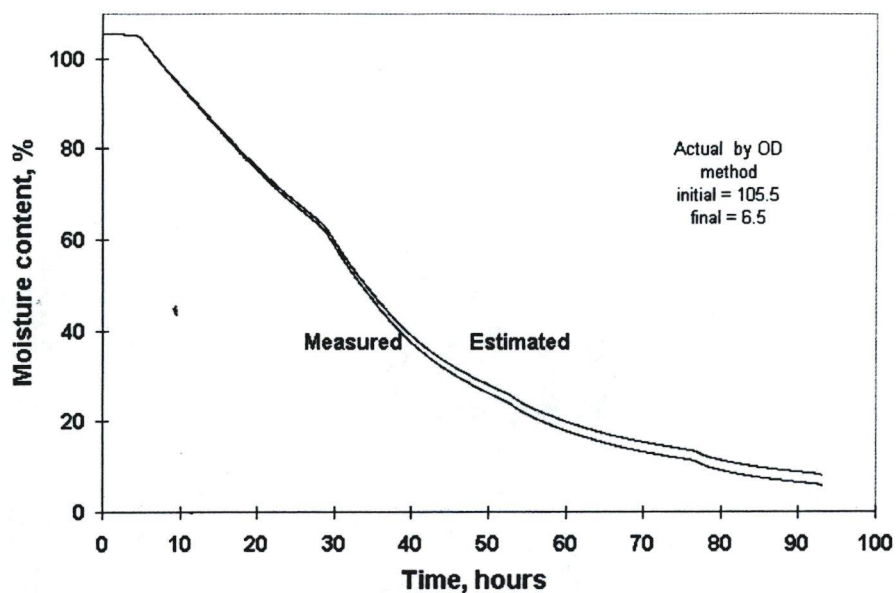


FIGURE 8. Moisture content versus time for the charge.

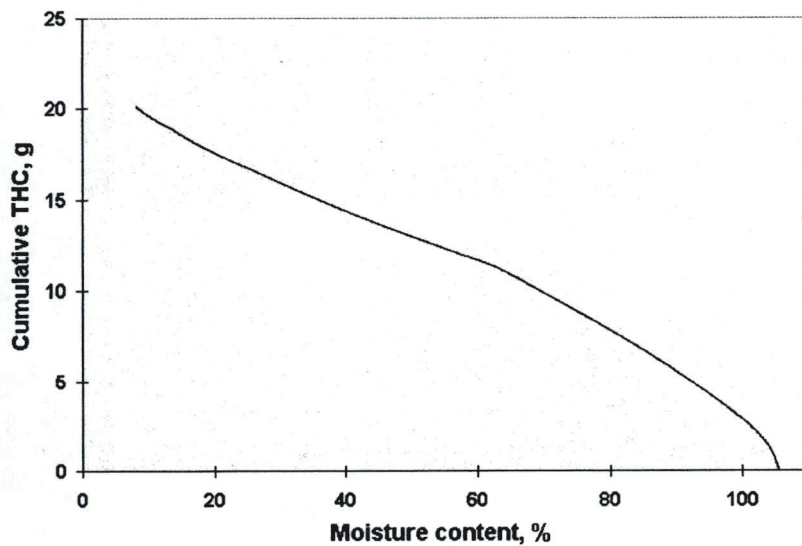


FIGURE 9. Cumulative emissions versus moisture content of the charge.



TABLE 3. Summary of sample runs.

Sample Run	Time	Dry Flow Rate @68	Wet Flow Rate @68	THC wet conc	THC mass as C	THC rate as C	Average		
							Wood MC	Air MC	Anal. MC
	hrs	l/min	l/min	ppmv	lbs/mbf	lb/hr/mbf	%	%	%
1	3.15	10.8	11.8	44.9	0.005	0.001	105.5	8	8
2	3.00	63.5	84.4	117.6	0.059	0.020	104.4	25	15
3	3.15	114.4	151.6	43.9	0.054	0.017	98.6	25	14
4	3.00	109.0	144.5	39.0	0.044	0.015	92.5	25	15
5	3.15	105.1	139.3	34.7	0.039	0.012	86.6	25	15
6	3.20	99.0	131.2	32.1	0.035	0.011	80.8	25	14
7	3.25	90.8	120.3	30.6	0.031	0.010	75.3	25	15
8	3.05	81.4	107.9	30.1	0.026	0.008	70.4	25	15
9	3.45	78.1	103.6	28.9	0.027	0.008	65.9	25	15
10	2.10	135.7	180.3	21.4	0.020	0.010	61.0	25	15
11	2.70	134.4	177.7	19.1	0.024	0.009	55.0	24	14
12	3.70	115.3	152.6	20.3	0.030	0.008	48.0	24	15
13	2.05	101.0	133.6	21.1	0.015	0.007	42.4	24	14
14	4.25	78.9	104.3	22.7	0.026	0.006	37.4	24	15
15	3.05	60.3	79.7	23.7	0.015	0.005	32.9	24	15
16	3.15	49.8	65.8	24.8	0.013	0.004	29.9	24	15
17	2.30	45.4	60.1	25.4	0.009	0.004	27.6	24	15
18	1.90	54.9	72.8	24.1	0.009	0.004	25.8	25	14
19	4.10	46.7	61.8	23.3	0.015	0.004	23.0	24	14
20	4.10	34.3	45.3	26.3	0.013	0.003	20.1	24	15
21	1.20	29.9	39.5	27.8	0.003	0.003	18.6	24	14
22	4.15	25.5	33.7	29.5	0.011	0.003	17.3	24	14
23	3.15	19.9	26.3	31.0	0.007	0.002	15.9	24	15
24	3.10	17.1	22.6	33.5	0.006	0.002	14.8	24	15
25	2.65	16.6	22.0	34.3	0.005	0.002	14.0	24	15
26	1.50	36.9	48.8	29.9	0.005	0.004	13.2	24	15
27	4.15	25.4	33.5	29.0	0.010	0.002	11.6	24	14
28	4.15	15.8	20.8	35.4	0.008	0.002	10.2	24	14
29	1.15	12.1	15.9	39.1	0.002	0.002	9.5	24	14
30	3.70	11.0	14.4	40.2	0.006	0.002	9.0	24	14
31	2.50	18.7	23.7	37.0	0.005	0.002	8.4	21	13

.577

Copies of all field sampling sheets, including dilution system and heated component data, are available at OSU. An example of these is included in Appendix 3. To include all sheets would add approximately 80 pages to this appendix and most data has been transferred to some other part of the report.

## VII Quality Assurance

### Leak checks

Leak checks were performed before on the VOC system and after the charge was dried, both one of were was successful.

### Calibration

Data for the calibration gases are given in Appendix 4. The mid gas was not named because the analyzer was within tolerance without naming. The calibration sheet for the flow meter is also included is also included in Appendix 4 as is the thermocouple calibration check.

## VIII Discussion

There were no anomalies during this charge or unexpected problems that would affect the data.

The value of 0.58 lb/mbf is comparable to values we have measured for Douglas-fir (0.5 to 1 lb/mbf), higher than hemlock or the true firs (non resinous softwoods) (0.25 to 0.5 lb/mbf), and lower than for the pines (1 to 3 lb/mbf). *RED ALDER*

## **Appendix 1. Detailed Sampling Procedures**



## INSTRUCTIONS FOR CHECKS OF EMISSIONS KILN

**Purpose:** Ensure kiln is operating correctly

**Clock time:** Record from computer

**Run time:** Record from computer. Check the box if the computer screen being refreshed and time is advancing.

**Box temperature:** Read from metal electrical box under desk, left controller. The top and bottom numbers should be similar on the box should be similar, about 126 C..

**Valve temperature:** Read from metal electrical box under desk, right controller. The top and bottom numbers should be similar on the box should be similar, about 154 C..

**Dry-bulb temperature:** Read from computer screen. Compare to graph to be sure it's correct. If it's not within a degree or two of the chart, check again in a few minutes. During startup (the first 3 or so hours), it may not be able to track. If it's too high, the heat valve should be closed, too low and the heat valve should be open. If it does not appear to be working correctly, call Mike or Mark.

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

*If it is too low*, it means that the kiln atmosphere is too dry. Check the flow meters. If Flow1 is about 10 L/min (its lower limit), make sure that Flow2 and Flow3 are turned off

*If it's too high*, then either the kiln atmosphere is too humid or the sock is not being wetted. If Flow 1 is near 200 L/min (its upper limit) add venting by opening Flow2 and/or Flow 3. The maximum for Flow2 is 50 L/min, if it reads over this value for several readings, reduce it to about 45 L/min. Don't change Flow3 often, rather set it and leave it for several hours if possible. Keep the Flow 3 reading constant by small adjustments. As Flow1 decreases or Flow2 turned down, there is more pressure behind Flow3 and the flow increased. Check for water in the wet-bulb reservoir (push the float down and make sure it's getting water).

Check both Wet-bulb1 and Wet-bulb2 and make sure they are reading about the same. If they differ by more than 2 C, call Mike or Mark.

If both wet-bulbs are reading the same as the dry-bulb, check the wet-bulb water.  
If these procedures do not correct the wet-bulb temperature within 30 minutes, call Mike or Mark.

**Line temperature:** Read from gray box on wall above analyzer. It should read about 275°F.

**Analyzer temperature:** Push the temperature button on the analyzer. It should be in the 160 to 190°C range. When the lab is hot, it will read lower. Analyzer should usually be on range setting 3. All lights on the front of the analyzer should be green. The pressure should read about 200. Does the reading make sense - is it the same before and after an analyzer check; does increasing dilution cause a lower reading?

**Chiller temperature:** Read the chiller temperature. It should be about -1°C.

**Flow 1:** Read from computer. The value of Flow1 changes depending on the wet-bulb. If Flow 1 is 10 L/min and the wet-bulb is too low, there's probably nothing we can do. If it's 200 L/min and the wet-bulb is too high, Flow2 and/or Flow3 can be opened. Flow2 and Flow3 should be adjusted so that Flow1 stays below 175 to 200 L/min.

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

**F/M Flow:** Read from rotometer. This should be about 400 to 500 cc/min.

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



## INSTRUCTIONS - FIELD DATA SHEET FOR TOTAL HYDROCARBON ANALYZER PRE-SAMPLE PROCEDURE

### BACKGROUND INFORMATION

Get the dry- and wet-bulb temperatures from the kiln schedule or off the computer. Use the highest expected values for the run.

Read absolute humidity off the psychrometric chart.

Calculate

Percent moisture =  $100 / [1 + 1 / 1.61 \cdot \text{AbHum}]$

Target Dilution Ratio (TDR) =  $15 / \text{Percent Moisture}$

Event = the name of the drying cycle.

Run = the number of the 3-hour interval.

Operator, that's you.

Date and time are now, as you start the data collection process.

### AMBIENT DATA

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

Local pressure in Pascals =  $(\text{Altimeter} - 0.23) \times 3.3867$

Read the laboratory temperature from the thermometer.

### ANALYZER CALIBRATION

Set valves so that 1, 2 = off; 3=on; 4=vent. This allows gas to flow out of the vents from the calibration tanks and shuts off all other sources. Only calibration gas should go through the detector.

Open the zero gas tank valve

- zero toggle switch up (on), others down (off)
- set flow to 3.5 L/min using regulator on tank
- wait for a stable reading (about 30 to 60 seconds)
- use the zero dial (pot) on THA to get a zero reading
- read the analyzer
- read computer
- note pot setting
- close valve on zero gas tank

Open span gas tank valve

- span toggle switch up (on), others down (off)
- set flow to 3.5 L/min using regulator on tank
- set analyzer to range 4
- wait for a stable reading (about 30 to 60 seconds)
- use the span dial (pot) on THA to get a reading of 1527 ppm
- read the analyzer, record, for example, 1.53 as 1530
- read computer (should read about 153 due to range 4 setting)
- note pot setting

Open mid gas tank valve

- mid toggle switch up (on), others down (off)
- set flow to 3.5 L/min using regulator on tank
- set analyzer to range 3
- wait for a stable reading (about 30 to 60 seconds)
- read analyzer (do not adjust pot settings), record, for example, 8.50 as 850
- read computer (should about 850 with analyzer on range 3)
- check for within tolerance
- turn off mid gas
- all toggle switches off

### **SET DILUTION FLOW BEFORE RUN**

Set valves so that 1, 2, 3 = off; 4=meter. This allows gas to flow only from the meter to the detector.

Use the Gilibrator to take 5 readings of the total flow rate (TFR). This is the total flow drawn by the analyzer and should be about 2.6 L/min

Make sure the average does not include any "bad" readings

Record the average, L/min = cc/min / 1000

Write the Event, Run, and "Pre-TFR" on the Gilibrator printout.

Calculate the next two values -

Target dilution flow rate (TDFR) is the TFR x (1 - DR)

Target sample flow rate (TSFR) is the TFR x DR

Check that the sum of these is the Total Flow Rate

Set dilution flow

Set red pointer to desired dilution flow (on meter with valve 1)

Slowly open lower valve on dilution flow meter (1=on; 2, 3=off; 4=meter)

Use upper valve on dilution flow meter to adjust flow

Do not adjust this meter after this point

Read the meter that you just set and record the value

Use the Gilibrator to take 5 readings of the sample flow rate (SFR). This is the flow through the analyzer after dilution is set. It will vary, depending on the dilution setting.

Make sure the average does not include any "bad" readings

Record the average, L/min = cc/min / 1000

Write "Pre-SFR" on the Gilibrator printout.

### **CHECK DILUTION FLOW BEFORE RUN**

Set valves so that 1, 3 = on; 2=off; 4=vent. This allows gas to flow out of the vent from the calibration tank and shuts off all other sources. Calibration gas and dilution air will go through the detector.

Open span gas tank valve

span toggle switch up (on), others down (off)

set flow to 3.5 L/min using regulator on tank

wait for a stable reading (about 30 to 60 seconds)

if reading is >9.99, switch to range 4

record

set analyzer to range 3

turn off all calibration gas tank valves

all toggle switches off

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

Calculate the dilution ratio based on span gas by dividing the Diluted span by the undiluted span.

If the Dilution ratios do not agree within 5% - DO NOT PROCEED\*\*\*\*. Use

$100 * (DR_{\text{Span}} - DR_{\text{Flow}}) / DR_{\text{Flow}}$  to calculate the % difference.

\*\*\*\* check calculations, check that values for ppm and flows make sense, remeasure everything. If it still does not agree, call Mike or Mark

### **START RUN**

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

Record the start time. Use the computer clock for all times or set your watch to the computer time.

Make sure analyzer is on appropriate range, usually range 3, to keep THC reading on computer between 60 and 750.

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

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



## POST-SAMPLE PROCEDURE

### AT END OF RUN

---

Record your name as the operator.

Event = the drying cycle. Run = the 3-hour interval.

Operator, that's you. Date and time are now, as you start the data collection process.

### AMBIENT DATA

---

Call 9-754-0081 and get temperature and altimeter

Local pressure = (Altimeter - 0.23) x 3.3867

Read the laboratory temperature from the thermometer.

Fill out appropriate information on Pre-sample side of data sheet for next run. This will save time in between runs.

### END TIME

---

Record computer time.

DO NOT adjust dilution gas yet.

### CHECK DILUTION FLOW AFTER RUN

---

Set valves so that 1, 3 = on; 2=off; 4=vent. This allows gas to flow out of the vent from the calibration tank and shuts off all other sources. Calibration gas and dilution air will go through the detector.

Open span gas tank valve

span toggle switch up (on), others down (off)

set flow to 3.5 L/min using regulator on tank

wait for a stable reading (about 30 -60 seconds)

record

all toggle switches off

**Sample flow rate.** Set valves so that 1=on; 2, 3 = off; 4=meter. This allows gas to flow only from the meter and the dilution to the detector.

Use the Gilibrator to take 5 readings of the sample flow rate (SFR). This is the flow through the analyzer with dilution on.

Make sure the average does not include any "bad" readings

Record the average, L/min = cc/min / 1000

Write "Post-SFR" on the Gilibrator printout.

Read dilution flow meter

To calculate the L/min, divide scfh by 2.12

Turn off dilution flow meter using valve 1

**Total flow rate.** Set valves so that 1, 2, 3 = off; 4=meter. This allows gas to flow only from the meter to the detector.

Use the Gilibrator to take 5 readings of the total flow rate (TFR). This is the total flow drawn by the analyzer and should be about 2.6 L/min

Make sure the average does not include any "bad" readings

Record the average, L/min = cc/min / 1000

Write "Post-TFR" on the Gilibrator printout.

### CHECK CALIBRATION OF ANALYZER

---

Set valves so that 1, 2 = off; 3=on; 4=vent. This allows gas to flow out of the vents from the calibration tanks and shuts off all other sources. Only calibration gas should go through the detector.

Span gas tank valve should be open

span toggle switch up (on), others down (off)

set flow to 3.5 L/min using regulator on tank  
set analyzer to range 4  
wait for a stable reading (about 30 -60 seconds)  
read analyzer (do not adjust pot settings), record, for example, 1.50 as 1500  
read computer (should read about 152 due to range 4 setting)  
note pot setting  
check for within tolerance - between 1483 and 1573

Open mid gas tank valve

mid toggle switch up (on), others down (off)  
set flow to 3.5 L/min using regulator on tank  
set analyzer to range 3  
wait for a stable reading (about 30 -60 seconds)  
read analyzer (do not adjust pot settings), record, for example, 8.50 as 850  
read computer (should read same as analyzer)  
check for within tolerance

Open the zero gas tank valve

zero toggle switch up (on), others down (off)  
set flow to 3.5 L/min using regulator on tank  
wait for a stable reading (about 30 -60 seconds)  
read analyzer (do not adjust pot settings)  
read computer  
note pot setting

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

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

Calculate % difference as  $100 * \{ \text{Absolute Value } (DR_{\text{Span}} - DR_{\text{Flow}}) \} / DR_{\text{Flow}}$

Record the time now as the end time for check.

Tear off the four sets of Gilibrator readings (Pre-TFR, Pre-SFR, Post-SFR, Post-TFR) and staple to paper with other records.

Start Pre-Sample procedure for next run.



### **Appendix 3. Samples of field data sheets.**







# FIELD DATA SHEET FOR TOTAL HYDROCARBON ANALYZER - PRE

## BACKGROUND INFORMATION

Dry-bulb temperature: 71.1

Event (kiln charge): NW HW 1

Wet-bulb temperature: 65.6

Run (sample): 2

Absolute humidity: 0.21

Operator: MRM

Percent moisture: 25

Date: 10-16-01

Target Dilution Ratio (TDR): 0.6

Time now: 13:55

## AMBIENT DATA

Altimeter setting: 30.09 inHg

Laboratory temperature: 15 °C

## ANALYZER CALIBRATION

[ 1, 2 = off; 3=on; 4=vent ]

	Analyzer, ppm	Computer	Within range	Pot settings
zero	0 (0)	0.5	does not apply	486
span	1520 (1527)	1543	does not apply	380
mid	874	876	804 - 957	none

## SET DILUTION FLOW BEFORE RUN

Total flow rate (TFR): 2.523 L/min [ 1, 2, 3 = off; 4=meter ]

Target dilution flow rate (TDFR) 1.009 L/min [ TFR x (1 - DR) ]

sample flow rate (TSFR) 1.514 L/min [ TFR x DR ]

Set and read dilution meter: 2.14 scfh [ scfh = L/min \* 2.12 ]

Sample flow rate (SFR): 1.490 L/min [ 1 = on; 2, 3 = off; 4=meter ]

## CHECK DILUTION FLOW BEFORE RUN

[ 1, 3=on; 2=off; 4=vent ]

	Analyzer	DR <sub>Span</sub> [ Span <sub>Diluted</sub> / Span ]	DR <sub>Flow</sub> [ SFR / TFR ]	Difference, % 100*(DR <sub>Span</sub> - DR <sub>Flow</sub> )/DR <sub>Flow</sub>
Span <sub>Diluted</sub>	901	<del>905.2</del> 0.593	<del>0.60</del> 0.591	0.4

START TIME: 14:08 (3,125) [ 1, 2, 5 = on; 3, 4 = off; tank valves off ]

ANALYZER RANGE: 3

[ 60 < computer reading < 750 ]



# FIELD DATA SHEET FOR TOTAL HYDROCARBON ANALYZER - POST

Operator: MRM

Event (kiln charge): NW HW 1

Time now: 5:00 p

Run (sample): 2

## AMBIENT DATA

Airport pressure: 30.16 inHg

Laboratory temperature: 14 °C

7:08

END TIME: 5:01 (6.00)

## CHECK DILUTION FLOW AFTER RUN

[ 1, 3=on; 2=off; 4=vent ]

	Analyzer	Computer
Span <sub>Diluted</sub>	<u>907</u>	<u>906.2</u>

Sample flow rate (SFR): 1508 L/min [1= on, 2, 3 = off, 4=meter]

Read dilution meter: 2.15 scfh 1.014 L/min [ L/min = scfh\*0.472 ]

Total flow rate (TFR): 2.515 L/min [ 1, 2, 3 = off; 4=meter ]  
(attach print out with all four sets of data)

Dilution ratio (DR<sub>Flow</sub>): 0.599 [ SFR / TFR ]

## CHECK OF ANALYZER CALIBRATION

[ 1, 2=off; 3=on, 4=vent ]

	Analyzer	Computer	Within range	Pot settings
span	<u>1530</u>	<u>1548</u>	1481 to 1573	<u>380</u>
mid	<u>879</u>	<u>880</u>	804 to 957	none
zero	<u>0</u>	<u>0</u>	-45 to +45	<u>480</u>

Dilution ratio (DR<sub>Span</sub>): 0.593 [ Span<sub>Diluted</sub> / Span ]

Dilution ratio difference: 1.1 % [ 100\*(Abs(DR<sub>Span</sub> - DR<sub>Flow</sub>))/DR<sub>Flow</sub> ]

End time for check: 17:05

Comments:

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#### **Appendix 4. Calibration Data**





Flow  
Calibration Record Sheet  
(200 SLM)

ERA #: 128989W

Customer: OREGON STATE UNIVERSITY

MKS Transfer Standard Type: 1559A-200L-SV

Serial Number: WS 136

MKS Primary Standard Type: A-200-1

Serial Number: 14952-1-1

Standard Flow Rate (SLM)	UUT Flow Rate (SLM)	UUT Error (SLM)	Percent of full scale Error
0.00	0.000	0.000	0.000%
50.000	50.880	0.880	0.440%
100.000	99.880	-0.120	-0.060%
150.000	150.040	0.040	0.020%
200.000	200.000	0.000	0.000%

UUT Model: 1559A-200L-SV

UUT Process Gas: N2

Process Gas used: N2

Date of Calibration: 05/10/00

UUT Serial #: 000317785

UUT Range: 200 SLM

Calibrated by: DP

Verified by:

Notes:

1. All units must be operated on regulated heat (Power on) for a minimum of one hour before any adjustment is made.
2. Flowmeters and/or Controllers are Calibrated at atmospheric pressure.
3. This Calibration is referenced to 0 Degrees Centigrade and 760 Torr.

3350 Scott Blvd., Bldg. #4, Santa Clara, CA 95054

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-





TC Calibration  
6-4-00

Omega  
Calibrator

PC  
Readout

30 °C

29.8

50

50.0

70

~~89.9~~

90

90.1

110

110.2