E.P.A. PROTOCOL METHODS 28 AND 5H
CERTIFICATION TESTING

PERFORMED FOR

MARK'S CUSTOM STOVES
MODEL K-400 FREESTANDING

P.O. Box 17126 • 5405 N. Lagoon Avenue • Portland, OR 97217 • (503) 289-1778

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NORTHWEST TESTING LABORATORIES, INC.

CONSTRUCTION INSPECTION
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PHYSICAL TESTING

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NON-DESTRUCTIVE TESTING
WELDING CERTIFICATION
SOIL TESTING
ASSAYING

May 17, 1989

Mark's Custom Stoves
13736 South Locan
Selma,CA 93662

Attention: Mr. Mark Freeman

In accordance with E.P.A. test protocol as specified in Methods 28 and 5H for the certification and auditing of wood heaters, seven certification tests were performed on the model K-400 Freestanding manufactured by Marks Custom Stoves.

All testing was conducted at Northwest Testing Laboratories, Inc. located at 5405 N. Lagoon Ave. Portland, Oregon. The laboratory is approximately 40 feet above sea level. Test team personnel included Michael Cave, Environmental Supvisor; Fred Thomas, Chemist; David Windsor, Assistant Environmental Supervisor; Tony Palmer, E.P.A. Operations; and Howard Kitt, E.P.A. Technician.

The wood heater was received on April 3, 1989 for E.P.A. certification testing and installed immediately into a safety test cell for the fifty hour catalyst aging. Aging was performed between April 3, 1989 and April 7, 1989. The wood heater was then installed into the certification test cell on April 8, 1989. Tesing began on April 10, 1989 and continued through April 18, 1989.

The model K-400 Freestanding is a catalytic wood heater and is equipped with two identical primary combustion air inlets located below the firebox opening. The woodstove also includes secondary air inlets which are four holes drilled above the door. The unit is designed with a front loading double door with neo-ceram glass and a top flue exhaust. The firebox is brick lined with a calculated volume of 3.55 cubic feet.

One abnormality was encountered during test run No. 1 in which a thermocouple on the skin of the wood heater fell out. The thermocouple was re-attached with cement and testing continued with no other problems.

The weighted average was calculated using six test runs, Nos. 2 through 7, with a result of 2.88 g/hr. Test run No. 1 was not included in the calculation of the weighted average since the emission rate was excessive. Thus the manufacturer reduced the primary combustion air inlet to 2 inches which eliminated test run No. 1 from the weighted average. Excluding test run No. 1, burn rates were achieved between 0.88 to 4.73 kg/hr with emission rates ranging from 0.90 to 8.99 g/hr. The model K-400 Freestanding manufactured by Marks Custom Woodstoves meets the Wood Heater Emission Limits, Phase II criterion for catalytic wood heaters.

The organization of this application is as follows: Introduction, Summary of Results, Discussion of Results, Wood Heater Information, Procedure and Sampling Approach, Calibrations, Example Calculations, and Raw Test Data. If there are any questions regarding this application for certification please contact either Michael Cave or David Windsor at Northwest Testing Laboratories, Inc.

Respectfully,
NORTHWEST TESTING LABORATORIES, INC.

Michael Cave

Michael Cave,
Environmental Supervisor

SUMMARY OF RESULTS

SUMMARY OF EMISSION RESULTS

Lab Name: NORTHWEST TESTING LABS, INC.
Stv Manu: MARKS CUSTOM STOVES
Model No: K-400 FS
Date : MAY 15, 1989

Run Number	Dry Burn Rate (kg/hr)	Method 5H Particulate Matter Emission Rate (g/hr)
1	6.81	20.79
2	2.57	4.76
3	0.98	1.56
4	0.88	0.90
5	2.34	7.87
6	1.39	1.78
7	4.73	8.99

Re-tested #1 Test Run

Weighted Emission Rate = 2.88 g/hr
(Excludes Test Run No. 1)

TEST FACILITY CONDITIONS

Lab Name: NORTHWEST TESTING LABS, INC.
Stv Manu: MARKS CUSTOM STOVES

Model No: K-300 FS
Date : MAY 15, 1989

Run Number	Room Temperature (F) Before	After	Barometric Pressure (in. Hg) Before	After	Relative Humidity (%) Before	After	Air Velocity (ft/min) Before	After
1	75	78	29.93	29.98	39	44	<5	<5
2	71	77	30.11	30.10	53	49	<5	<5
3	70	76	29.98	29.87	46	43	<5	<5
4	71	76	29.84	29.82	51	49	<5	<5
5	74	79	29.91	29.93	48	46	<5	<5
6	68	73	29.94	29.95	47	42	<5	<5
7	81	84	29.99	29.94	62	42	<5	<5

SUMMARY OF HEATER OPERATION

Lab Name: NORTHWEST TESTING LABS, INC.
Stv Manu: MARKS CUSTOM STOVES

Model No: K-400 FS
Date : MAY 15, 1989

Test No.	Average Dry Burn Rate (kg/hr)	Average Catalyst Temperature Inlet (F)	Average Catalyst Temperature Outlet (F)	Average Surface Temperature (F)	Delta T Surface* (F)	Initial Draft (in. H2O)	Prim. Air Setting (in.)	Run Time (min.)	Average Draft (in. H2O)
1	6.81	1358	N/A	938	14	0.0	OPEN	74	------
2	2.57	1098	N/A	624	-147	0.0	7/8	200	-0.070
3	0.98	854	N/A	423	-143	0.0	1/8	580	-0.033
4	0.88	818	N/A	417	-123	0.0	3/16	610	-0.034
5	2.34	577	N/A	589	- 87	0.0	1/2	220	-0.065
6	1.39	900	N/A	505	-115	0.0	5/16	375	-0.052
7	4.73	1252	N/A	773	- 63	0.0	2	110	-0.090

*Difference between average surface temperature at beginning of test and average temperature at end of test.

SUMMARY OF STACK GAS MEASUREMENTS AND SAMPLING DATA (5H)

Lab Name: NORTHWEST TESTING LABS, INC Model No: K-400 FS
Stv Manu: MARKS CUSTOM STOVES Date : MAY 15, 1989

Run Number	Length of Test Run (minutes)	Average Stack Gas Measurements: CO % vol	CO2 % vol	Volumetric Flow Rate (dscf/hr)	Temperature (F)	Sampling Data: Total Sample Volume (dscf)	Particulate Catch (g)
~~1~~	~~74~~	~~0.96~~	~~16.13~~	~~1363.88~~	~~596~~	~~6.504~~	~~0.1539~~
2	200	0.18	12.79	667.47	293	23.047	0.1628
3	580	0.23	12.08	267.59	162	45.449	0.2600
4	610	0.14	11.98	243.64	147	54.001	0.1956
5	220	1.19	14.21	517.61	238	25.796	0.3897
6	375	0.26	12.86	357.28	274	36.960	0.1827
7	110	0.63	15.05	1028.27	449	17.982	0.1553

SUMMARY OF FUEL MEASUREMENTS

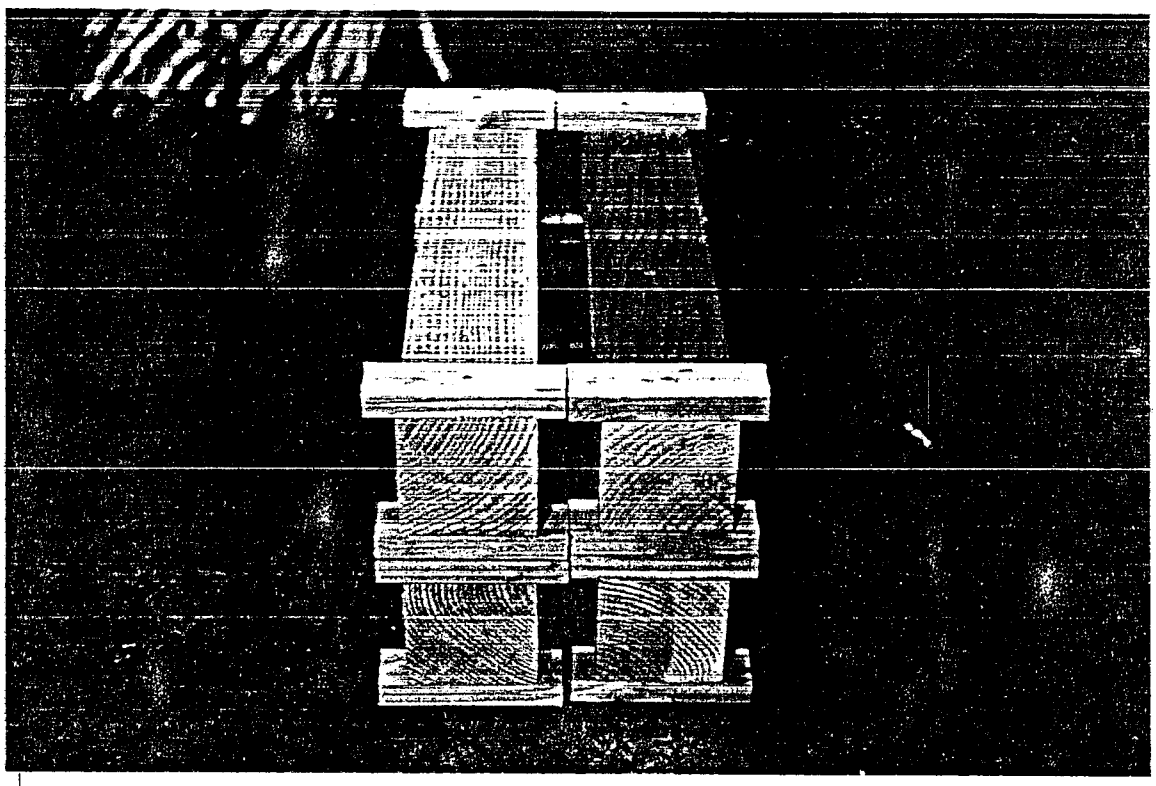
Lab Name: NORTHWEST TESTING LABS, INC.
Stv Manu: MARKS CUSTOM STOVES

Model No: K-400 FS
Date : MAY 15, 1989

Run Number	Pretest Fuel Weight (lb)	Pretest Fuel Moisture Dry Basis (%)	Coal Bed Weight (lb)	Test Fuel Weight Wet Basis (lb)	Fuel Loading Density Wet Basis (lbs/ft3)	Fuel Moisture Content Dry (%)	Piece Length (in)	No. of 2x4's	No. of 4x4's
1	24.9	19.35	4.6	23.0	7.0	24.41	20.0	0	4
2	26.4	19.65	4.6	23.1	7.0	22.35	20.0	0	4
3	25.5	19.46	5.2	25.6	7.0	23.07	20.0	0	4
4	25.0	20.08	5.4	24.5	7.0	24.80	20.0	0	5
5	23.2	21.76	4.6	22.7	7.0	20.29	21.0	0	4
6	25.6	19.41	4.9	23.4	7.0	22.62	19.0	0	5
7	35.6	20.30	4.7	23.4	7.0	22.43	20.0	0	5

NO PHOTO DOCUMENTATION AVAILABLE

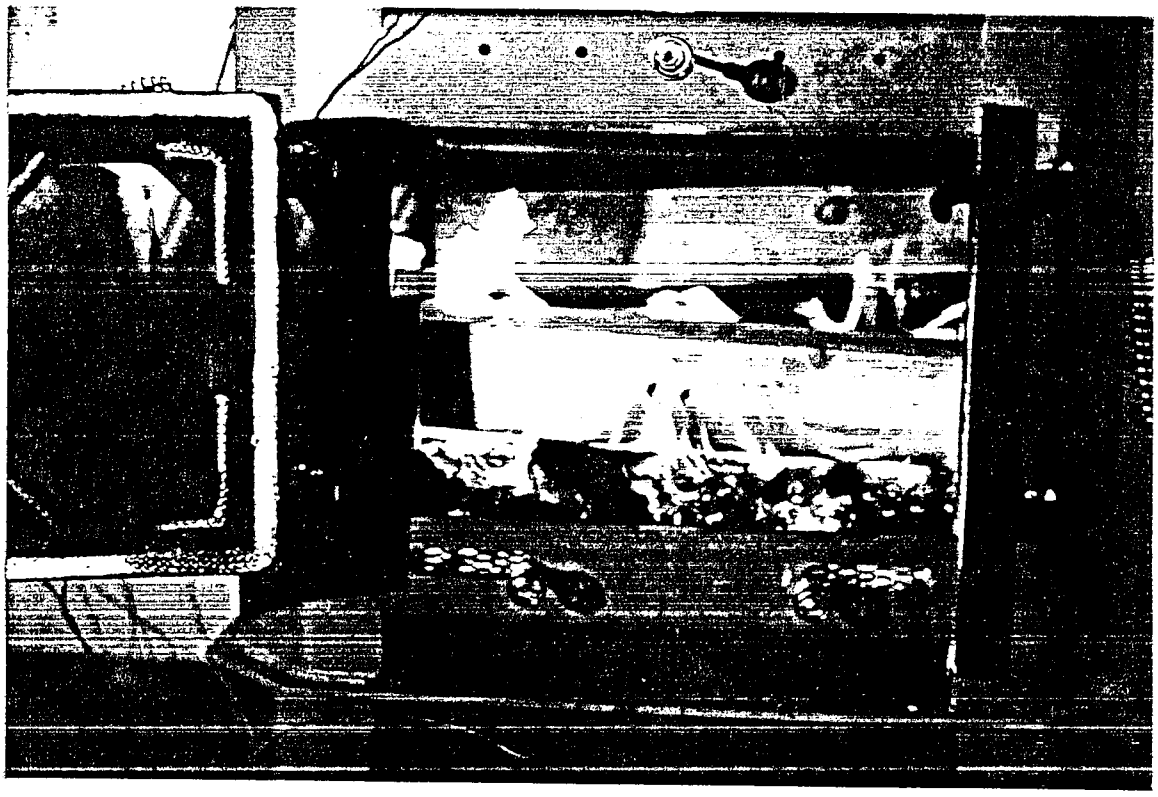
TEST FUEL LOAD RUN NO. 1

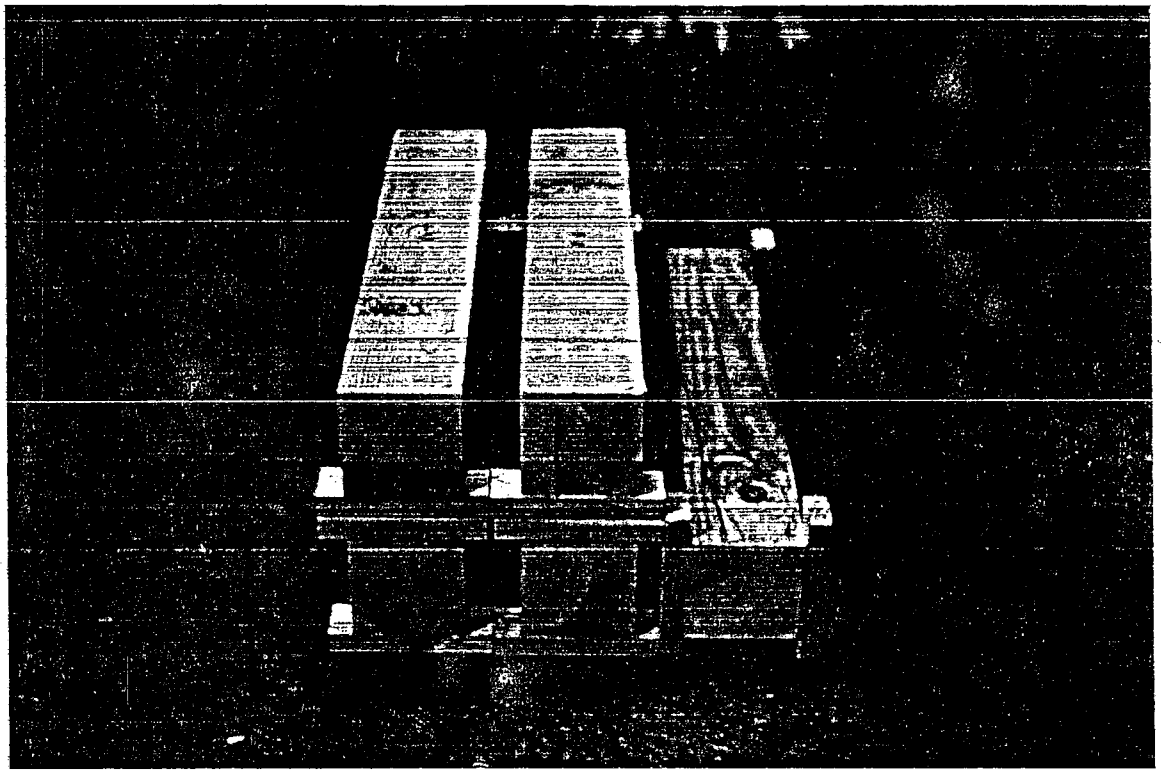


TEST FUEL LOAD RUN NO. 2

NO TEST FUEL PHOTO DOCUMENTATION AVAILABLE

TEST FUEL LOAD RUN NO. 3





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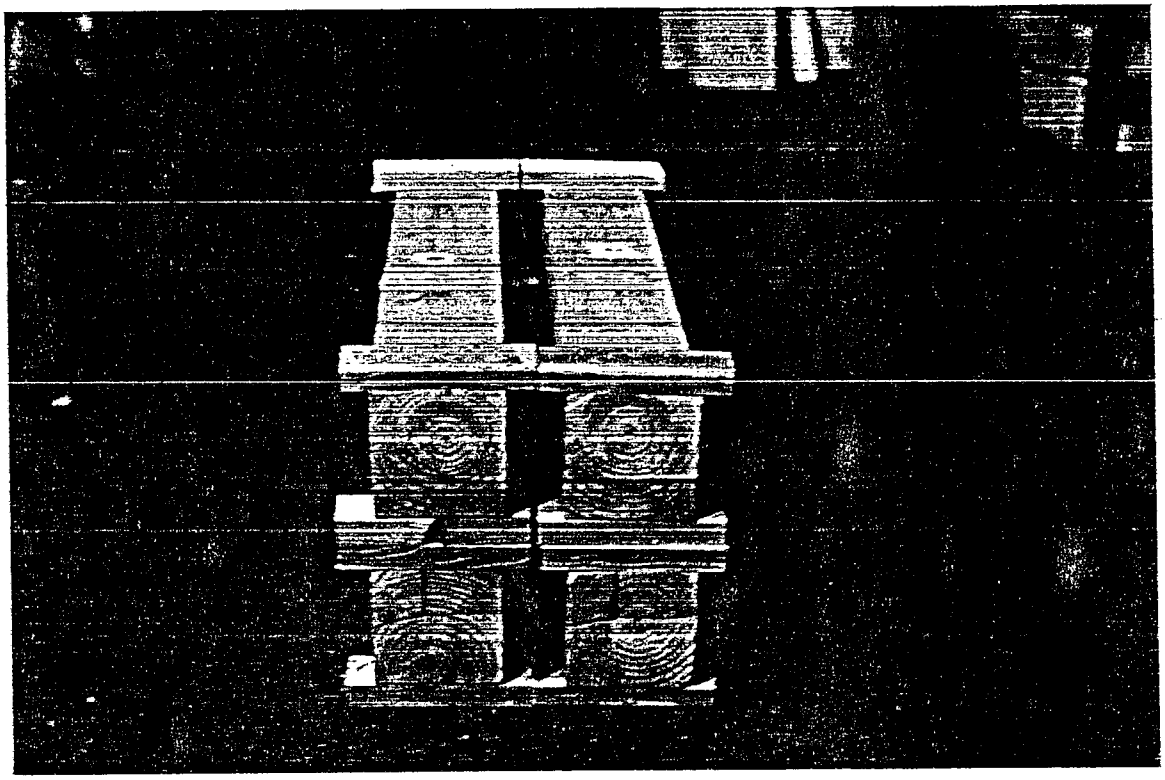

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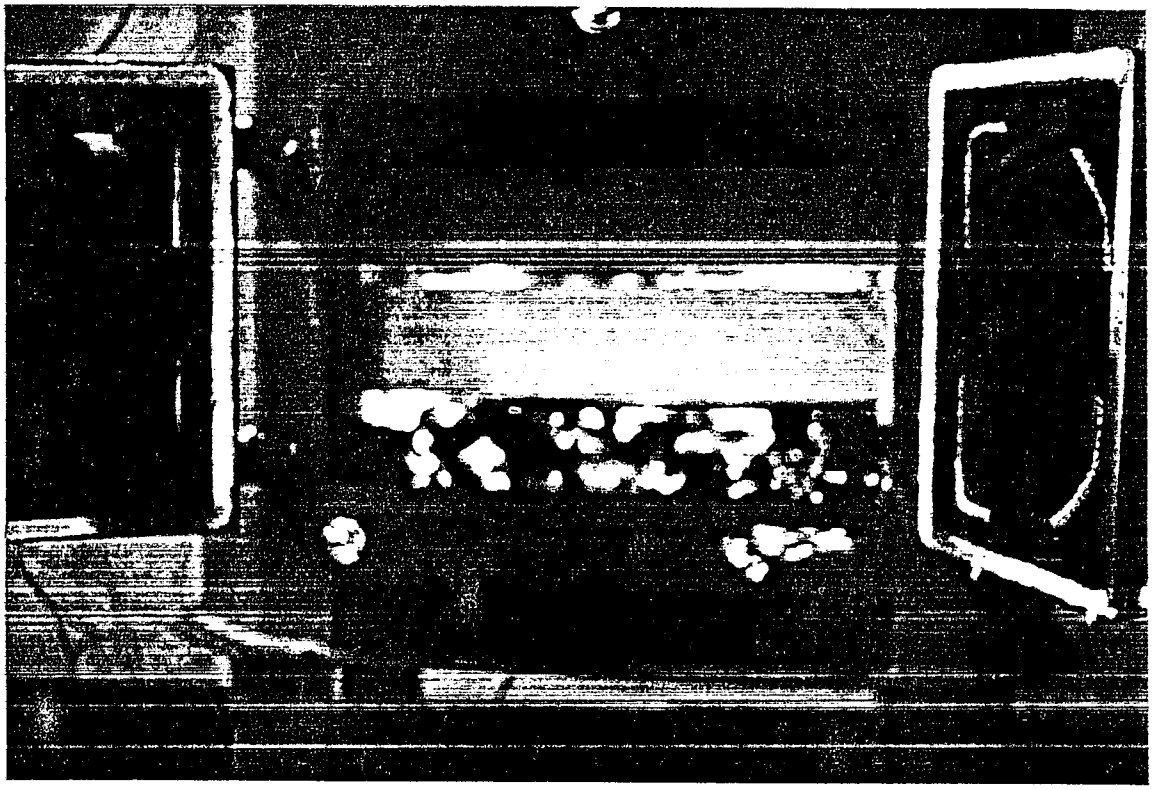
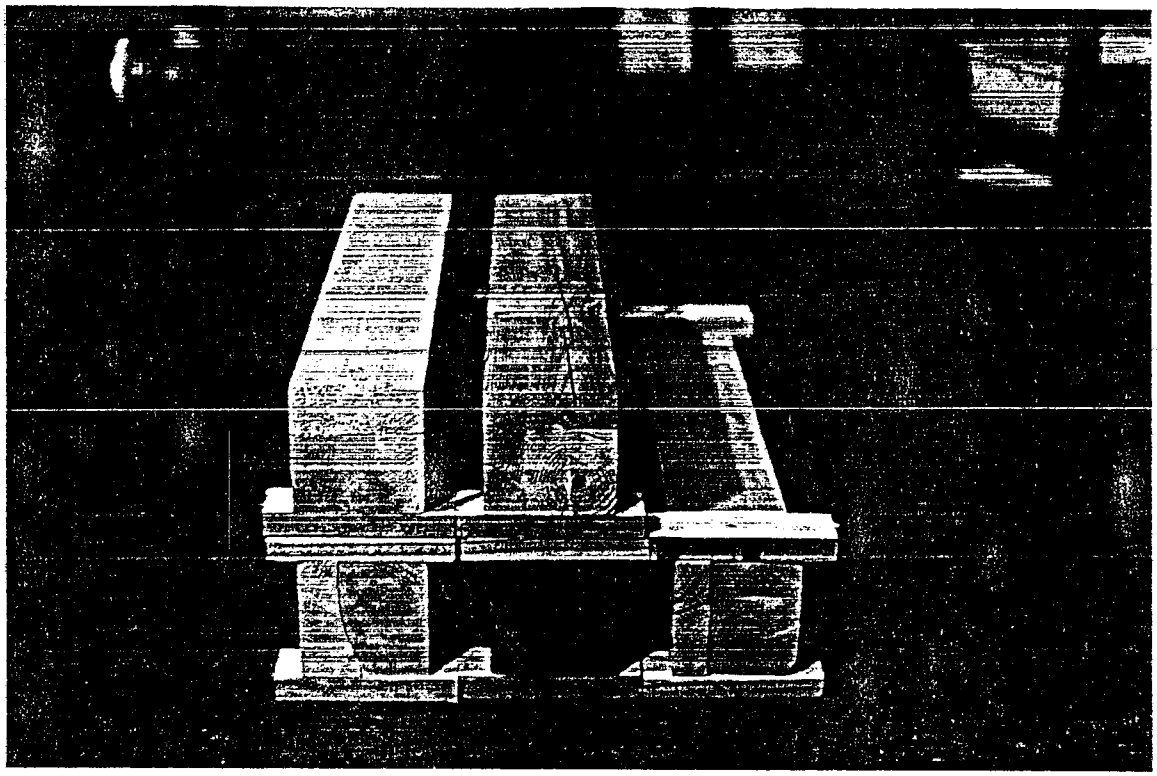
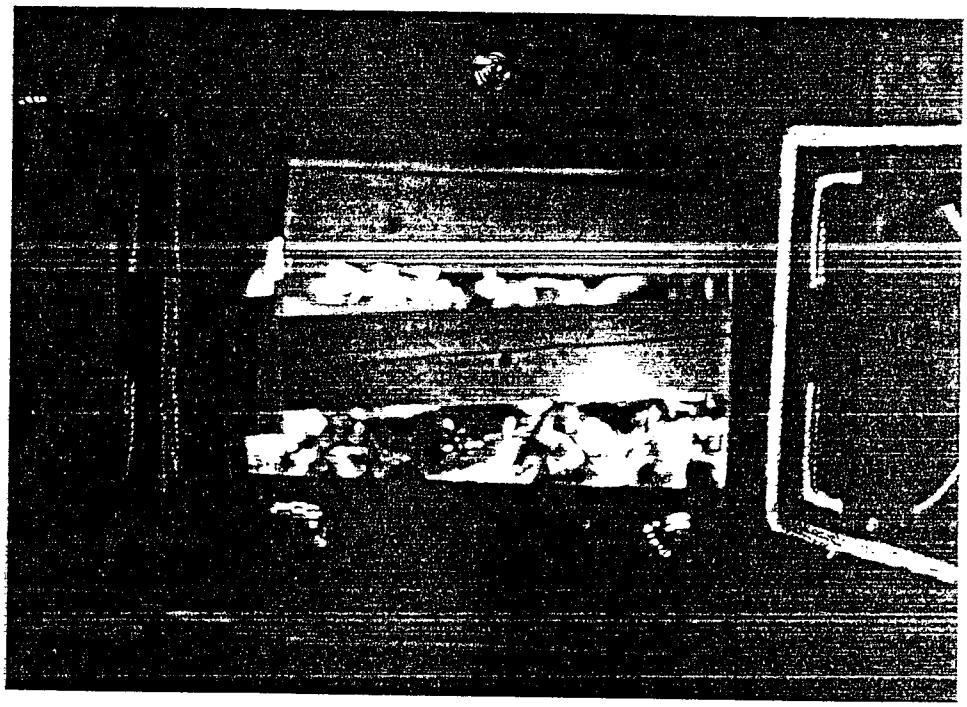
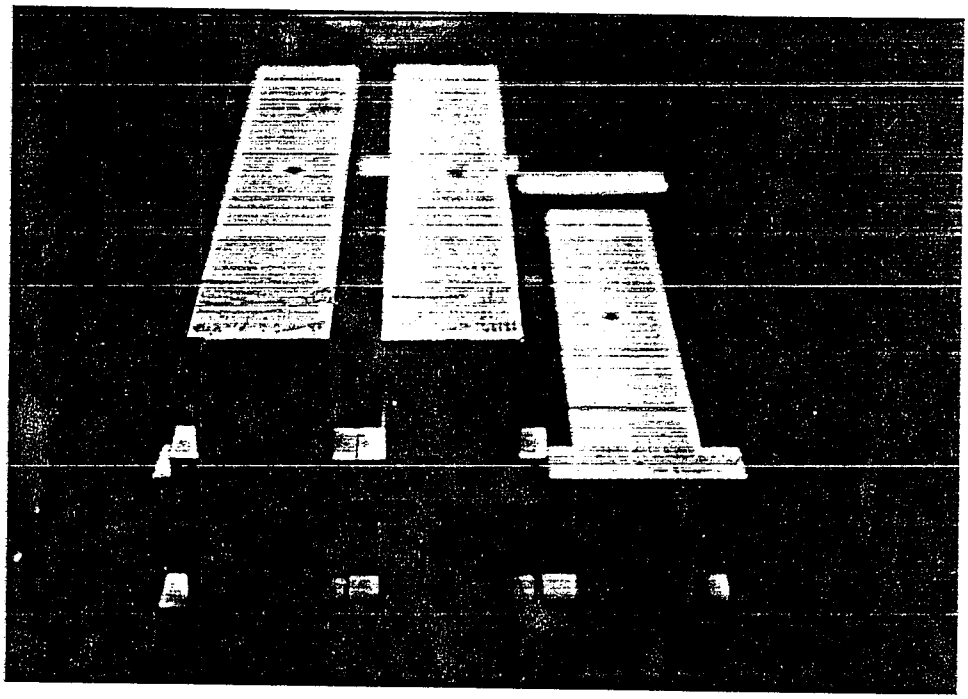




TEST FUEL LOAD RUN NO. 6





TEST FUEL LOAD RUN NO. 7

DISCUSSION OF RESULTS

DISCUSSION OF RESULTS

Discussion of Run Included in Weighted Average

Six of the seven certification tests performed on Mark's Custom Stoves K-400 Freestanding Wood Heater were used to calculate the weighted average. A design change was made to the combustion air inlet, limiting the opening to 2.0 inches. Thus test run No. 1 is eliminated from the weighted average, since the resulting burn rate is no longer achievable.

Discussion of Specific Problems

There were no specific test run problems with quality checks, train components, or aborted test runs. One equipment problem occurred during test run No. 1 in which a thermocouple fell off the wood heater during certification testing. The thermocouple was re-adhered to the unit and no other problems were experienced.

Discussion of Special Test Considerations

There were no special test considerations. All burn rates were achieved with a flue damper and there were no special pre-test procedures used.

WOOD HEATER INFORMATION

WOOD HEATER DESCRIPTION

Heater Type: Catalytic

Manufacturer: Mark's Custom Stoves

Appliance I.D.: Model K-400 Freestanding

Distinguishing Features: Freestanding, firebrick lined firebox, double door on firebox opening, without thermal transfer blower or grate.

Air Introduction and Controls:

The inlet of primary air includes two opening locations. Two identical oval holes are cut below the doors and are adjustable slide controls. The two controls are to be operated in unison and measure 7/8" high by 2" at their widest opening.

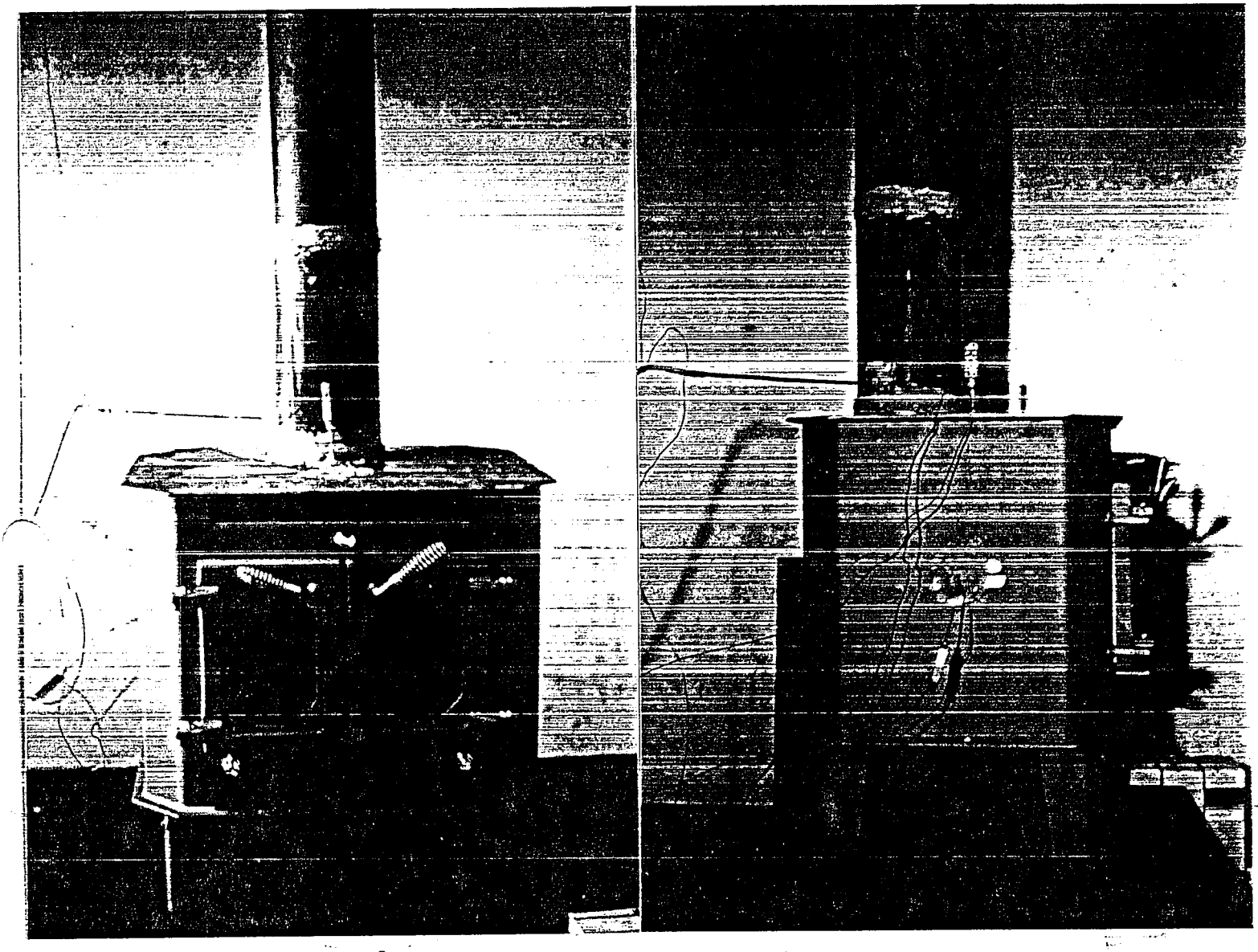
The inlet of secondary air includes four 5/16" holes drilled over the firebox door opening. The inner two holes are located 2-7/8", on center, from by-pass control and the outer two holes are 2-7/8", on center, from inner holes. No adjustments can be made to these air inlets.

WOOD HEATER OPERATING INSTRUCTIONS

Written instructions for testing were provided in a letter by Mark's Custom Stoves and are enclosed on the following page. Adjustments were made during certification testing to combustion air inlet settings and during 5 minute test fuel loading period. Alterations were made in the air inlet settings to achieve burn rates in the appropiate categories. In the past the laboratory has found it to be beneficial for catalytic wood heaters to have the door and by-pass closed as soon as the test fuel is loaded and to adjust the combustion air inlet to the desired setting at the end of the five minuted test fuel loading period. All operating procedures performed during certification testing have been documented in this application.

SPECIAL WOOD HEATER INSTALLATION INSTRUCTIONS

There were no special wood heater installation instructions.



WOOD HEATER INSTALLATION

WOOD HEATER AND CATALYST AGING DOCUMENTATION

The fifty hour catalyst aging was performed and documented on the Mark's Custom Stoves Model K-400 Freestanding and is included on the following pages entitled Wood Heater & Catalyst Aging Documentation.

NORTHWEST TESTING LABORATORIES, INC.

WOOD HEATER & CATALYST AGING DOCUMENTATION

Manufacturer: marks Custom Stoves
Model: K400 FS
Technician: m.Caux

Date: 4/3/89
I.D. No.: 184
Burn Rate: med/high

Type: NON-CAT [ ] CAT [X] PELLET [ ]

Setting: 7/8" to 1" draft setting
Catalyst Info.: SN#: _____ Length in.: _____
Grid, #/in2: _____ Coating: _____
Manufacturer: _____
Pellet Info.: Feed Cycle: ON N/A sec. OFF N/A sec.
Type of pellet fuel : N/A
Fuel Info.: Type: Douglas Fir
Fuel Moisture: 22.3 % Fuel Weight: 52.8 lbs. Load No.: 1
Fuel Moisture: 20.0 % Fuel Weight: 51.4 lbs. Load No.: 2
Fuel Moisture: 21.0 % Fuel Weight: 3.0 lbs. Load No.: 1

DATE	TIME	TEMP °F	FUEL	COMMENTS
4/3/89	11:00	60	#1	Initial - 20 lbs
	12:00	1151		
	13:00	1313		
	14:00	1000		
	15:00	1153		ADDED - 6 lbs
	16:00	1100		
	17:00	1210		7 hrs
	18:00	959	↓	
4/4/89	06:00	65	#1	Initial - 22 lbs
	07:00	1332		
	08:00	1400		
	09:00	1211		
	10:00	1000		
	11:00	948		ADDED - 8.5 lbs
	12:00	1334		
	13:00	1212		
	14:00	1014		
	15:00	988		
	16:00	899		11 hrs
	15:00	653	↓	
4/5/89	06:00	67	#2	Initial - 22.3 lbs
	07:00	1098		
	08:00	1270		
	09:00	1142		
	10:00	1031		
	11:00	1061		Added - 19.1 lbs
	12:00	1374		
	13:00	1232		
	14:00	1145		
	15:00	1099		
	16:00	1004		12 hrs
	17:00	920		
	18:00	801	↓	

Signature: Michael Caux
Date: 4/5/89

30 hrs

NORTHWEST TESTING LABORATORIES, INC.

WOOD HEATER & CATALYST AGING DOCUMENTATION

Manufacturer: Marks Custom Stoves
Model: K400FS
Technician: M. Cave

Date: 4/6/89
I.D. No.: 184
Burn Rate: CAT 3

Type: NON-CAT [ ] CAT [X] PELLET [ ]

Setting: 7/8" - 1" draft setting
Catalyst Info.: SN#: _____ Length in.: _____
Grid, #/in2: _____ Coating: _____
Manufacturer: _____
Pellet Info.: Feed Cycle: ON N/A sec. OFF N/A sec.
Type of pellet fuel : N/A
Fuel Info.: Type: _____
Fuel Moisture: 19.5 % Fuel Weight: 47.7 lbs. Load No.: 1
Fuel Moisture: 20.0 % Fuel Weight: 50.9 lbs. Load No.: 2
Fuel Moisture: _____ % Fuel Weight: _____ lbs. Load No.: _____

DATE	TIME	TEMP . F	FUEL	COMMENTS
4/6/89	07:00	64	#1	25.4 lbs initial
	08:00	1053		
	09:00	1197		
	10:00	1030		
	11:00	952		Added 22.7 lbs
	12:00	1212		
	13:00	1167		
	14:00	1089		
	15:00	1018		
	16:00	930		
	17:00	873	↓	10 lbs
4/7/89	06:00	67	#2	25.9 lbs initial
	07:00	1103		
	08:00	1285		
	09:00	1121		
	10:00	1061		
	11:00	994		added 25.0 lbs
	12:00	1311		
	13:00	1194		
	14:00	1070		
	15:00	1011		
	16:00	967		
	17:00	891	↓	

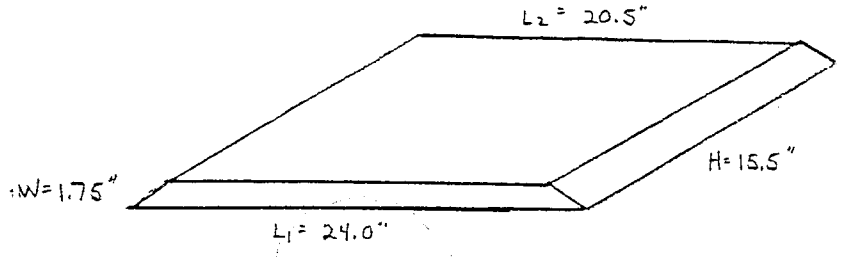
Signature: Michael Cave
Date: 4/7/89

WOOD HEATER DIMENSIONS AND USEABLE FIREBOX VOLUME

Useable Firebox Volume Calculation

Marks Custom Stoves Model K-400 Freestanding

V_1



$L_1 = 24.0"$

$L_2 = 20.5"$

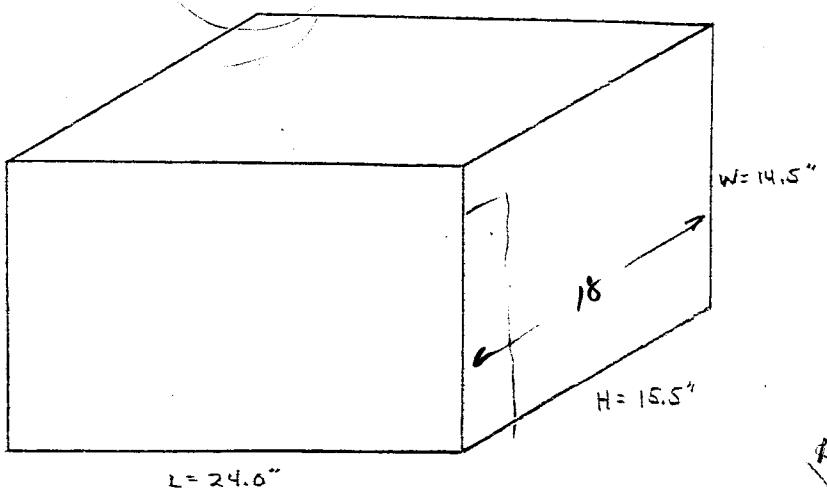
$H = 15.5$

$W = 1.75"$

$V_1 = (15.5)(.5)(175)(20.5 + 24.0$

$= 603.5$ cu. in.

V_2



$L = 24.0"$

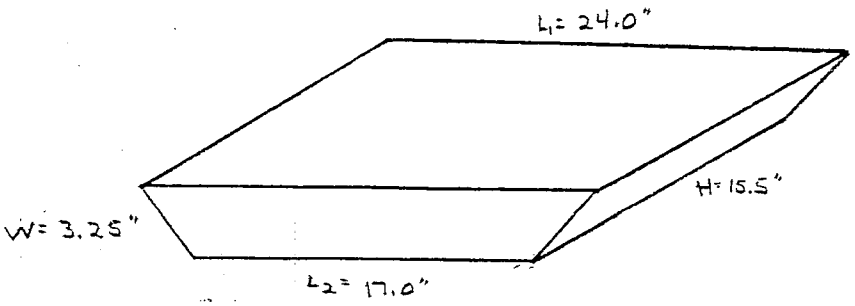
$W = 14.5"$

$H = 15.5"$

$V_2 = (24.0)(14.5)(15.5)$

$= 5394.0$ cu. in.

V_3



$L_1 = 24.0"$

$L_2 = 17.0"$

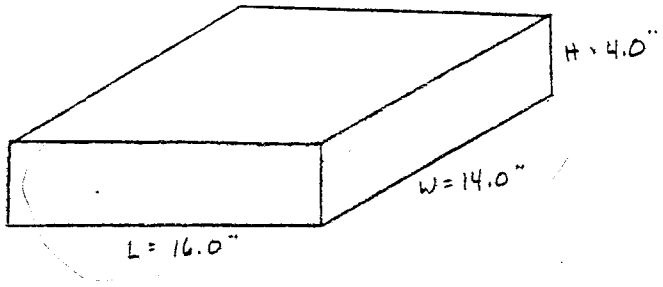
$W = 3.25"$

$H = 15.5"$

$V_3 = (15.5)(.5)(3.25)(17.0 + 24.0)$

$= 1032.7$ cu in.

V_4



L = 16.0"
W = 14.0"
H = 4.0"

V_4 = (16.0) (14.0) (4.0)
= 896.0 cu. in.

Calculation of Useable Firebox Volume:

$V_T = V_1 + V_2 + V_3 - V_4$

= 603.5 + 5394.0 + 1032.7 - 896.0

= 6134.2 cu. in.

= 3.55 cu. ft.

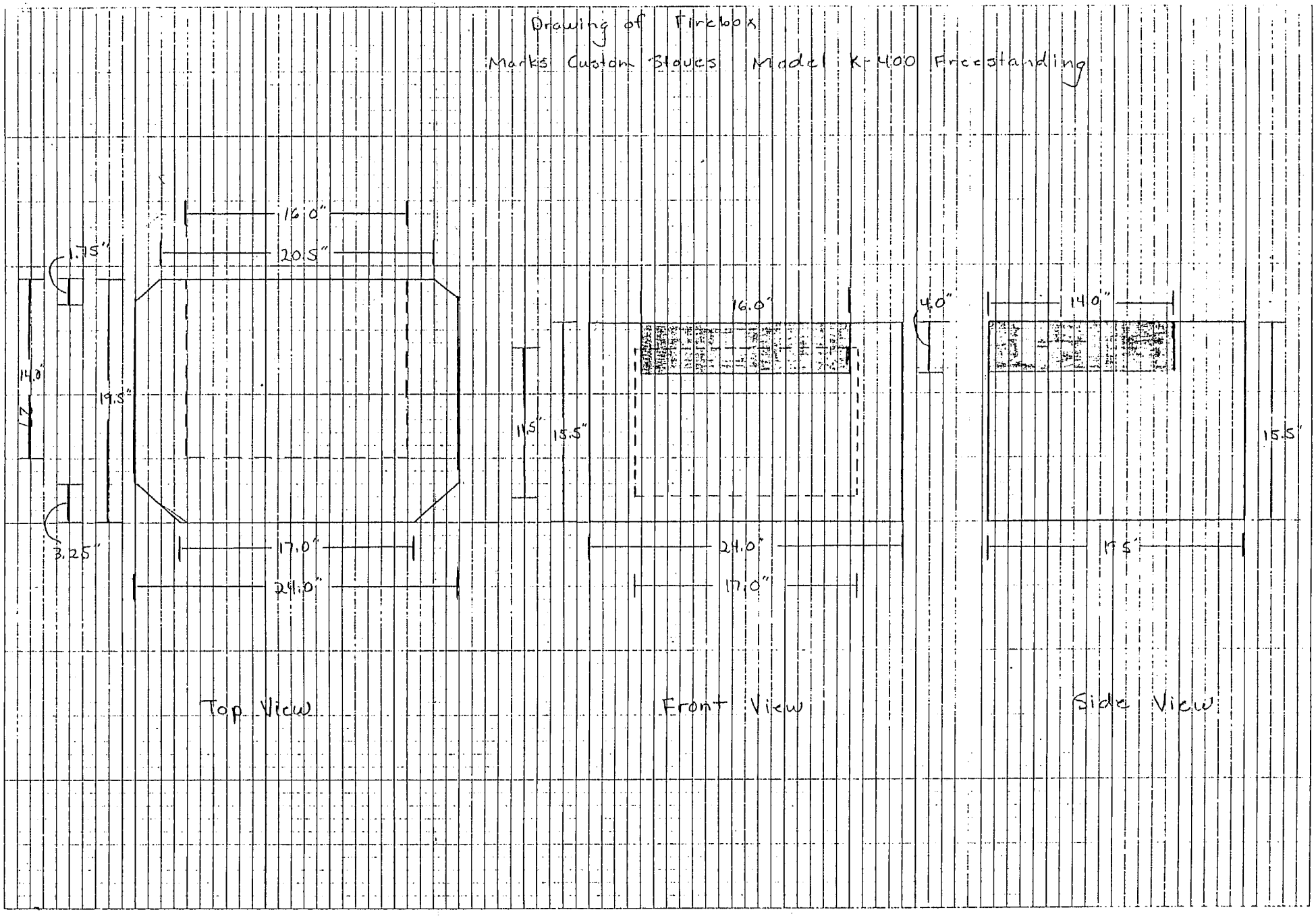
Ideal Test Fuel Weight = 24.8 lbs.

Test Fuel Weight Range = 22.3 to 27.3 lbs.

Test Fuel Length = 20.0 in.

Drawing of Firebox

Marks Custom Blowers Model KF-400 Freestanding



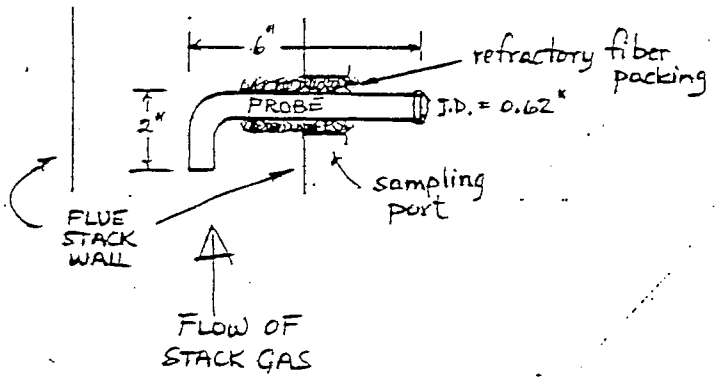
PROCEDURES/ SAMPLING

METHODS USED

PM Sampling Approach: E.P.A. Method 5H

Particulate matter is withdrawn proportionally from the wood heater exhaust and is collected on two glass fiber filters separated by impingers immersed in an ice bath. The first filter is maintained at 248 degrees F. The second filter and the impinger system are cooled such that the exiting temperature of the gas is maintained at 68 degrees F or less.

Sampling apparatus is identical to configurations shown in E.P.A. Method 5H-1 and 5H-2 and meets all specifications outlined in Method 5H, section 2. The probe nozzle/sample probe used for the particulate sampling train is one piece, all pyrex glass, 6 inches in length with a 90 degree bend at one end, and having an internal diameter of 0.62 inches. The bend is pointed in to the stack gas flow at the centriod of the stack and extends 2 inches below the horizontal plane of the probe.



The probe is connected directly to the sampling train just before the first filter. The probe is always at stack temperature and leads directly into the 248 degrees F oven containing the first filter.

Both filter holders are glass with a glass frit filter support and measure 5 inches (125 mm) in diameter. All sampling train components are glass with ground glass ball and socket connections. The differential pressure gauge used for orifice differential pressure readings is a Magnehelic Gauge manufactured by Dwyer Instruments, Inc. with a range of 0 to 0.25 inches of H2O. Orifice Delta H settings are generated using an equation which insures particulate sampling flow rates are proportional to the stack flow rate, (See Example Calculations). A Fortin mercurial barometer is used for atomspheic pressure measurements.

PM Sampling Approach: E.P.A. Method 5H (cont.)

The stack flow rate measurement system consists of a 1/4 inch stainless steel probe bent at 90 degrees and pointing into the gas flow. It is located near the center of the stack at 8' above the platform scale. The probe leads to two impingers immersed in an ice bath, the first impinger is used for condensation, the second contains drierite to further remove moisture. The gas sample then passes through a glass fiber filter (Gelman A/E 61631) and stainless steel filter support, to the inert sampling pump, a sampling manifold, rotameter, and finally to the gas analyzer. CO2, CO, and O2 are measured from this manifold.

The proportional flow rate system is identical to that descrbed in Method 5H, section 2.3. The injection loop is 3/8-inch stainless steel, having an overall diameter of 3-1/2 inches, and 19 (1/8 inch) holes on the top side of the loop. An identical loop with slightly larger holes is used as the tracer sample probe. Between the injection loop and tracer sample probe a static mixer comprised of three slightly twisted plates are suspended by wire to insure complete mixing of the 100% SO2 tracer gas with the stack gas. These plates in no way impede flow and do insure homogeneous mixing. The conditioning system is as described in Method 5H, section 2.3.3 a tube furnace combustor maintained @ 1350 degrees F preceeds two impingers immersed in an ice bath, a glass fiber filter (Gelman A/E 61631) and stainless steel support, inert sampling pump, flowmetr and SO2 analyzer. All lines are stainless steel, glass or teflon and a quartz tube is used in the combustor.

Efficiency Procedure

Northwest Testing Laboratories, Inc. opts to use the default efficiency values as provided in the E.P.A. test protocol.

Description of Pretest

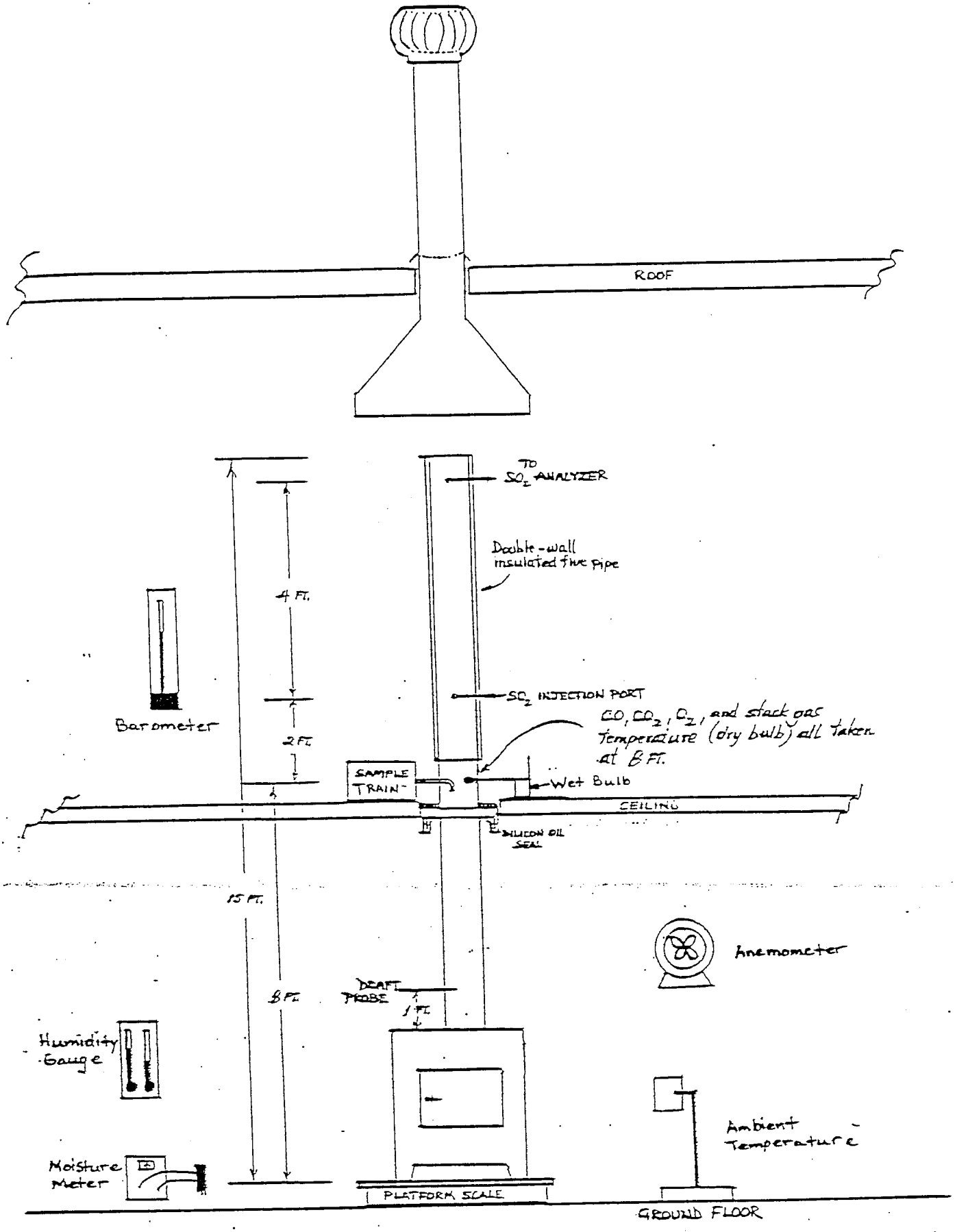
Crumpled newspaper was loaded with kindling, averaging 4.3 lbs. in weight, and a fire was ignited in the Marks Custom Stoves model K-400 freestanding woodstove. The pretest fuel charge consisted of 2x4's cut to 7.0" lengths and had approximately the same weight as the test fuel charge. In test run no. 7 an additional pretest fuel load was used and during the lower burn rate test runs there was an occassional coalbed raking to achieve uniform charcoalization. Both air inlet supply controls were set at 100% open to maintain combustion of the pretest fuel load. The air inlet supply controls are adjusted to achieve the desired burn rate and the unit was operated at the desired burn rate for a minimum of 60 minutes before the start of the test runs.

Description of Pretest: E.P.A. Method 5H (cont.)

The coalbed raking adjustments were made up to 15 minutes prior to the start of the test run and were recorded. At the end of the preburn period the platform scale was zeroed, and the test run started. The kindling and pretest fuel consumed to leave a fuel weight between 20 and 25 percent of the weight of the test fuel charge.

DESCRIPTION OF ALLOWABLE ALTERNATIVES

No variation throughout testing performed for K-400 Freestanding Wood Heater manufactured by Mark's Custom Stoves



Facility and Wood Heater

FACILITY AND WOOD HEATER LIST

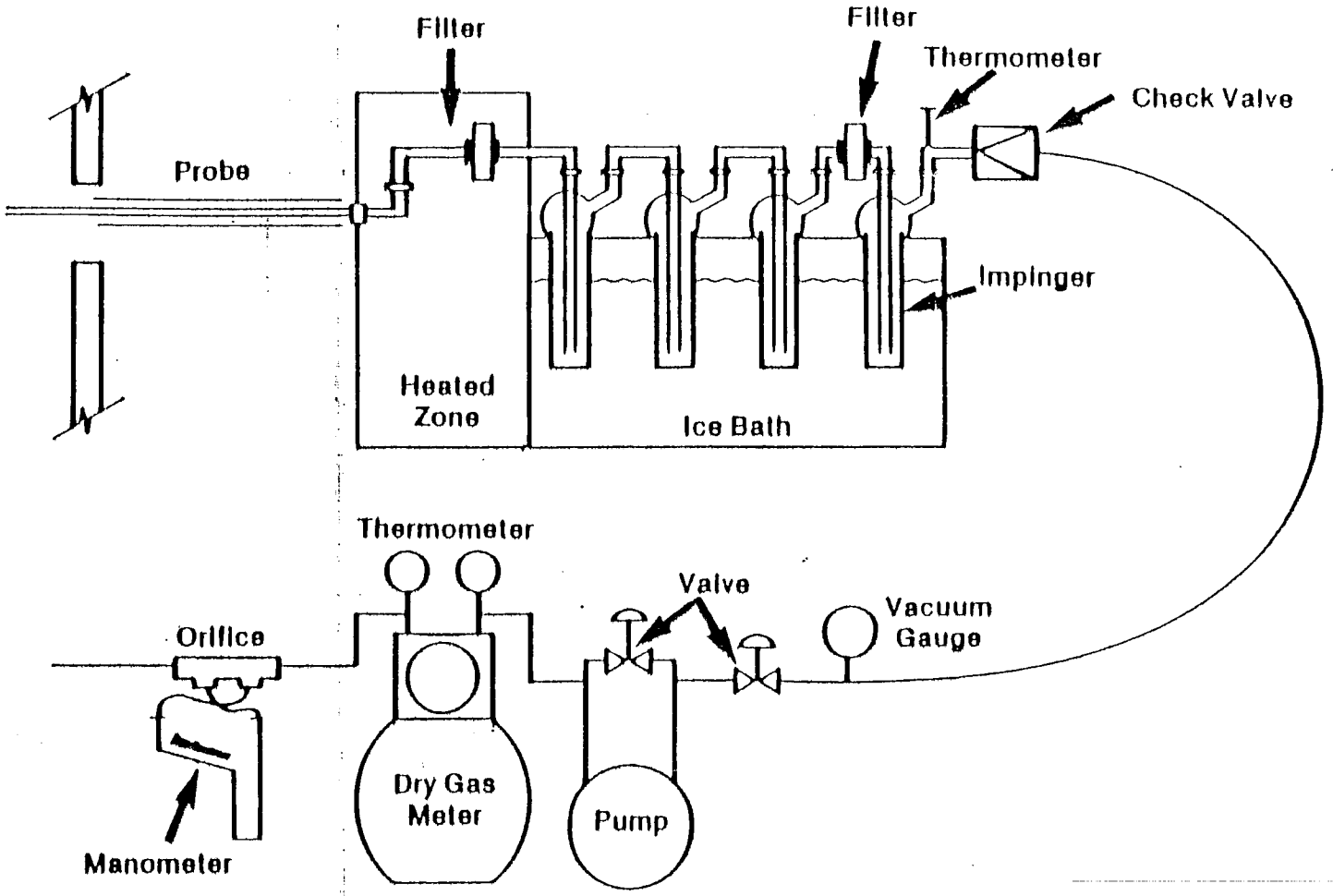
Item from Figure	Description
Flue Pipe :	It is a 6" or 8" diameter by 24" lengths, 24 gauge steel single wall pipe painted black. Sealing compound is Grant Wilson's Furnace and Retort Cement.
Insulated Flue Pipe :	It is a 6" diameter by one 36" length and one 24" length, double wall insulated stainless steel pipe. Manufactured by Jackes Evans Subsidary G.S.W., Inc. U.L. Listed 98H3. OR It is a 8" diameter by two 36" lengths, double wall insulated stainless steel pipe. Manufactured by Security Chimneys Ltd. U.L. Listed 377X.
Liquid Seal:	The oil pan is an U-shaped trough in the form of a square which measure 14-1/8" in length by 14-1/8" in width by 5-1/4" in depth on the outside. The trough, which holds the oil, measures 3" in depth by 2" in width. The collar, which is put into the oil, is a single wall square box measuring 12" x 12" x 3" in depth with a 6" or 8" diameter, 24 guage single wall flue pipe located in the center of the box. All materials are constructed out of 24 guage steel. The oil is L-45 Polydimethylsiloxane with viscosity of 350 cSt manufactured by Union Carbide Silicones.
Supports :	Three rubber coated cords connected to the top of the insulated flue pipe with lengths 54-1/2", 56", and 28". The two longest lengths are connected to the wall and the third to a brace from the ceiling. The cords are evenly spaced around the circumference of the pipe, with a turn buckle centrally located on each cord to take up the stack.

Item from Figure		Description
Platform Scale	:	It is a digital dormant scale manufactured by Electroscale Corporation, Model 3030 with a StreeterAmet, Quantomatic 9000 digital weight indicator. Range is 0 to 1000 lbs. Capacity is 1000 lbs. Resolution is 0.1 lbs. Accuracy is ± 0.05 lbs.
Fuel Storage Area	:	The humidifing room's dimensions are 75" in length by 48" in width by 93-1/2" in heighth and is lined with Celotex Thermal Sheathing. Joints in the sheathing are sealed with sprayed foam insulation and duct tape. There is one 11" x 11" ventilation hole and one 80" x 35" door which seals closed. The room is equipped with an Edison humidifier with an outlet capacity of 8 gallons per 24 hours.
Moisture Meter	:	It is an electrical resistance type moisture meter, Model G-30 manufactured by the Delmhorst Instrument Company and equipped with the 26-E electrode fitted with insulated pins. Range is 6 to 30%. Resolution is 0.25% from 6 to 15% and 0.5% from 15 to 30%. Accuracy is within ± 0.5% from 6 to 12%, within ± 1.0% from 12 to 20%, and within 2.0% from 20 to 30%. A calibration check is made at 12% and 22% using calibration moisture standards. Pins are driven into the wood with a sliding hammer on a shaft to desired depth. Then the moisture content is read on the meter scale.

Item from Figure	Description
Surface and Catalyst Temperature Monitiors :	Surface temperature monitors are, in all cases, 24 guage Type K (chromel-alumel) thermocouple wire. The ends of the wire are twisted together and cemented to the stove on the top, sides, rear, and bottom. Catalyst and primary tempertures are measured using 12" long and 1/8" diameter stainless steel Type K probes. Holes are drilled into the desired locations, the probe is inserted through the hole to the appropriate point and furnace cement is used to seal the hole. Thermocouples are used with a digital indicator calibrated for Type K thermocouples. Range is 0 to 2280 degrees F. Resolution is 1.0 degree F. Accuracy is ± 0.5 degrees F.
Draft Guage:	It is an adjustable level, inclined 1" manometer manufactured by Dwyer Instruments, Inc. Range is -0.10 to 1.0 inches in H2O. Resolution is 0.005 inches in H2O. Accuracy is ± 0.002 inches in H2O.
Anemometer :	It is a swing vane anemometer manufactured by Dwyer Instruments, Inc. and the model no. is 480 Vaneometer. Range is 0 to 400 ft/min. Resolution is 10 ft/min from 0 to 50 ft/min, 5 ft/min from 50 to 200 ft/min, and 50 ft/min from 200 to 400 ft/min. Accuracy is ± 5% of full scale from 0 to 100 ft/min and ± 10% from 100 ft/min to top of scale.
Humidity Guage :	It is a mason type, hygrometer manufactured by Taylor, part no. 59-377. Range is 30 to 120 degrees F. Resolution is 1.0 degree F. Accuracy is ± 0.5 degrees F.

Item from Figure		Description
Barometer	:	It is a Fortin-type mercurial barometer manufactured by the Sargent-Welch Scientific Company. Range is 21.70 to 32.70 inches. Resolution is 0.01 inches. Accuracy is ± 0.005 inches.
Wet Bulb	:	It is a 3/16" diameter x 25-1/2" in length stainless steel Type K temperature probe with an 1/8" diameter copper tubing running along the top of the probe. A gauze spomge is wrapped around the end of the tubing and probe. The gauze tip is moistened and placed into the stack at 8' above the top of the platform scale. The gauze tip is kept moist, throughout the test, by introducing water through the copper tubing.

SAMPLING TRAIN (5H)



SAMPLING TRAIN 5H

Item from Figure		Description
Probe	:	The probe nozzle/sample probe is one piece, all pyrex glass, 6" in length with a 90 degree bend at one end, and having an internal diameter of 0.62". Refactory fiber packing seals the probe in the port and the probe is always at stack temperature.
Front Filter Holder	:	The filter holder is a four piece, all glass, 4" filter support assembly. The first outer part has a 28/15 outer joint bent perpendicular to the flow path. Next in line is a neoprene gasket used to hold the filter paper and prevent leakage around filter. The third piece is a porosity B fritted disc measuring 4-1/2" in diameter. And the last part is seated for the fritted disc and has a 28/15 inner joint
Front Filter	:	The filter is a 125 mm diameter, glass fiber paper manufactured by Reeve Angel. The effective surface area is approximately 122.66 sq. cm.
Back Filter Holder	:	Same as Front Filter Holder.
Back Filter	:	Same as Front Filter.
Thermometer	:	There are two thermometers which are 24 gauge Type K thermocouple wire with the same range, resolution, and accuracy as the surface temperature monitors. The first wire is located in the heated zone of the train, it is wrapped around the arm of the filter holder. The second wire is located on the arm of the third impinger and is held on by duct tape.
Desiccant	:	It is a grade H, type IV, indicating, 6-16 mesh silica gel. The amount used is approximately 200 grams.

SAMPLING TRAIN 5H cont.

Item from Figure	Description
Dry Gas Meter:	It is a standard T 110 Rockwell Dry Gas meter with test index. Capacity is 1000.0 cu. ft. range is 0 to 1000.0 cu. ft. Resolution is 0.001 cu. ft. and is certified as 100% accurate ± 1.0% of total flow.
Orifice :	The differential pressure gauge used for orifice differential readings is a Magnehelic Gauge manufactured by Dwyer Instruments, Inc. with a range of 0 to 0.25 inches of H2O. Readout resolution is 0.0025 inches of H2O. Accuracy is ± 0.001 inches of H2O. Orifice delta H settings are generated using an equation which insures particulate sampling flow rates are proportional to the stack flow rate (See Example Calculations).

GLASS MICROFIBER FILTERS

Unique Material

Glass microfibers are unique among fibrous materials used for laboratory filter media. They differ from naturally occurring cellulose fibers in that they are circular in cross section and are made extremely fine.

Superior Performance

The glass microfibers are used in a modified paper making process to produce filter media with filtration characteristics markedly superior to cellulose-based filter papers. In terms of loading capacity, Reeve Angel brand glass microfiber filters far outperform filter papers; increased loading does not cause a proportional decrease in flow rate, and pressure increase with loading is nearly undetectable for most of the effective life of the filter. They are capable of much better retention efficiencies yet have higher flow rates than the fastest filter papers.

High Purity

Since Reeve Angel brand glass microfiber filters are 100% borosilicate glass they have the purity characteristic of this material inasmuch as great care is taken to avoid contamination during manufacture. The composition of borosilicate glass is typically*:

Constituent	%	Constituent	%
SiO_2	57.9	K_2O	2.9
B_2O_3	10.7	CaO	2.6
FeO_3	5.9	MgO	0.4
Al_2O_3 / Na_2O	10.1	BaO	5.0
		ZnO	3.9
F	0.6		

*Surface extractables. Determined by dispersing pre-washed filter material in 200 ml distilled water and filtering through an acid-washed funnel and diluting to 250 ml.

7

Binder Free

No binders of any kind are present in Reeve Angel brand glass microfiber filters. Although binders facilitate the manufacturing process, they adversely affect filter performance. For example, binders may make the filter hydrophobic. Organic binders introduce adsorptive characteristics and thus can influence the concentration of low molecular solution compounds in the filtrate. It is important that the final filter be "binder free".

Excellent Chemical Resistance

Since the only constituent of Reeve Angel brand glass microfiber filters is borosilicate glass, they have excellent chemical resistance except to hydrofluoric acid and strong alkalies. The material is little affected by organic solvents; wet strength actually increases in non-polar solvents. These filters can thus be used in chemical environments where other filter materials cannot. The fibers do not swell in either organic solvents or in water.

Non-Hygroscopic, Yet Highly Absorbent

Glass microfibers are non-hygroscopic; Reeve Angel brand glass microfiber filters will maintain constant weight over a wide range of ambient humidity. At the same time the filter material will absorb relatively large amounts (three to five times the amount of paper filter material) of liquid. This is because of the fine capillary structure between the fibers. The individual fibers themselves do not absorb the liquid.

Biologically Inert

Reeve Angel brand glass microfiber filters are unaffected by and will not denature biological fluids. They will not absorb soluble proteins or other macromolecules even at low molecular concentrations. They can, of course, be easily sterilized by standard techniques.

High Use-Temperature Range

Borosilicate glass softens at about 700°C. Glass microfiber filters should not, however, be used above about 500°C, since above that temperature the stability of the inter-fiber bonds is affected. Of course, 500°C is far above the temperature-use limit of other filter materials. High use-temperature makes Reeve Angel brand glass microfiber filters useful for, e.g., filtration of hot gases. It also permits them to be used in gravimetric analyses where ignition of the precipitate is involved.

It is useful to note that Reeve Angel brand glass microfiber filters can be used as well at extremely low temperatures without embrittlement.

Typical Applications

Highly versatile because of the nature of the material used and the absence of binders, Reeve Angel brand glass microfiber filters are used in a wide variety of applications. A few of these uses are:

- Liquid Scintillation Counting
- Air Pollution Analyses
- Radioimmunoassay
- Water Pollution Analyses
- Cell Harvesting
- Wasterwater Analyses

Non-Filtration Uses

Reeve Angel brand glass microfiber filter sheets and circles have been used in paper chromatography and paper electrophoresis with great success. They have been used as matrices of impregnation with, e.g., silic acid, and to bond various functionalities for specialized chromatography. In both chromatography and electrophoresis these materials are ideal for conditions where paper cannot be used, such as at high temperatures or acidity.

Typical Characteristics

Characteristic	Grade 900-AF*	Grade 934-AH	Grade 984-H
Particle Retention(1)	n/a	96+%	100%
DOP Penetration (0.3 μm smoke)	0.03%	0.022%	0.001%
Ash, %	0	0	0
Thickness, mm	0.304	0.304	0.304
Tensile Strength, dry, g/in. wd.	900+	700+	1000
Wet Strength, g/in. wd.	n/a	150+	150+
Air-flow Resistance, mm H_2O(2)	39	75	220
Color	White	White	White
Surface	Smooth	Smooth	Smooth

* Used for gas filtration.
(1) Precipitated calcium oxide.
(2) 934-AH, 984-H @ 85 liters/min; 900-AF @ 32 liters/min.

REEVE ANGEL 934AH

(BOROSILICATE TYPE)

GLASS FIBER COMPOSITION

CHEMICAL COMPONENT	%
SiO_2	57.9
B_2O_3	10.7
R_2O_3	5.9 (Mainly Al_2O_3, Trace Fe_2O_3)
Na_2O	10.1
K_2O	2.9
CaO	2.6
MgO	0.4
BaO	5.0
ZnO	3.9
F	0.6

SOFTENING POINT - 1254°F (678°C)

SOLUBILITY - 1 Hour At Boil

0.1 N. NaOH - 6.4%

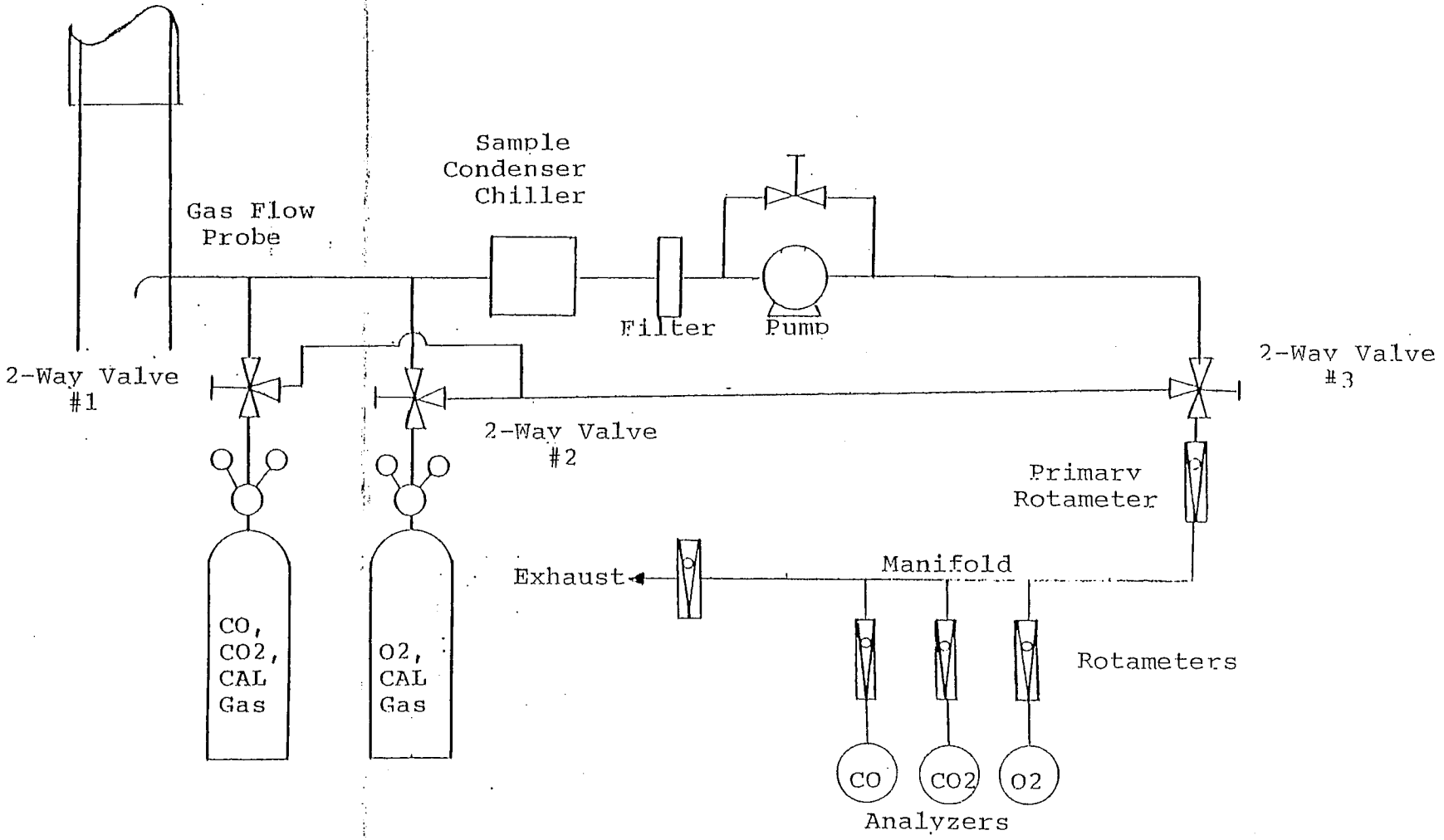
1.0 N. H_2SO_4 - 2.34%

SPECTRAL ANALYSIS

Reeve Angel Grade 934-AH

Non-metals (water extractable)		Micrograms/8 1/2" x 11" Filter
sulfate	(SO_4^-)	700
nitrate	(NO_3^-)	4.4
ammonium	(NH_4^+)	115
fluoride	(F^-)	20
chloride	(Cl^-)	50
Benzene Soluble Organics		2940
Metals (Nitric acid extractable)		
cadmium		4.0
beryllium		0.1
iron		>2000
lead		96
chromium		60
copper		7.5
tin		<0.2
antimony		27
manganese		30
nickel		20
bismuth		<.1
molybdenum		<.5
vanadium		20
titanium		50
zinc		85
cobalt		2
barium		20

CO, CO2, and O2 EQUIPMENT



O2, CO, AND CO2 FLOW MEASUREMENT EQUIPMENT

Item from Figure		Description
CO, CO2 Calibration Gas	:	Concentrations: .5% CO, 3.0% CO, Balance Air; 1% CO, 7.0% CO2, Balance Air or N2; 1.5% CO, 12.0% CO2, Balance N2; 6.5% CO, 17.0% CO2 Balance N2. All gas mixtures are traceable to NBS standards per E.P.A. Protocol #1. Size of cylinder for each gas mixture is 150.
CO, CO2 Flow Regulator	:	It is a two stage brass regulator manufactured by Smiths Welding Equipment, Model H713. It has a maximum inlet pressure of 3000 psi and ranges of 0 to 4000 psi on gauge 1 and 0 to 150 psi on gauge 2.
O2 Calibration Gas	:	Concentrations: 7% oxygen in balance nitrogen; 14% oxygen in nitrogen; and 21% oxygen in nitrogen. The gas is contained in 200 size cylinders.
O2 Flow Regulator	:	It is a two stage brass with stainless steel diaphram regulator manufactured by Airco, Model 806-9621. It has a maximum inlet pressure of 3000 psi and ranges of 0 to 4000 psi on gauge 1 and 0 to 60 psi on gauge 2.
Point of Injection	:	The calibration gas can enter the system in two locations. It can enter at the two-way valve #3 which then goes directly to the analyzers, or it can enter the sample line right befroe the sample condenser, so it flows through the whole system. The limiting restriction of the flow would be from the flowmeters.

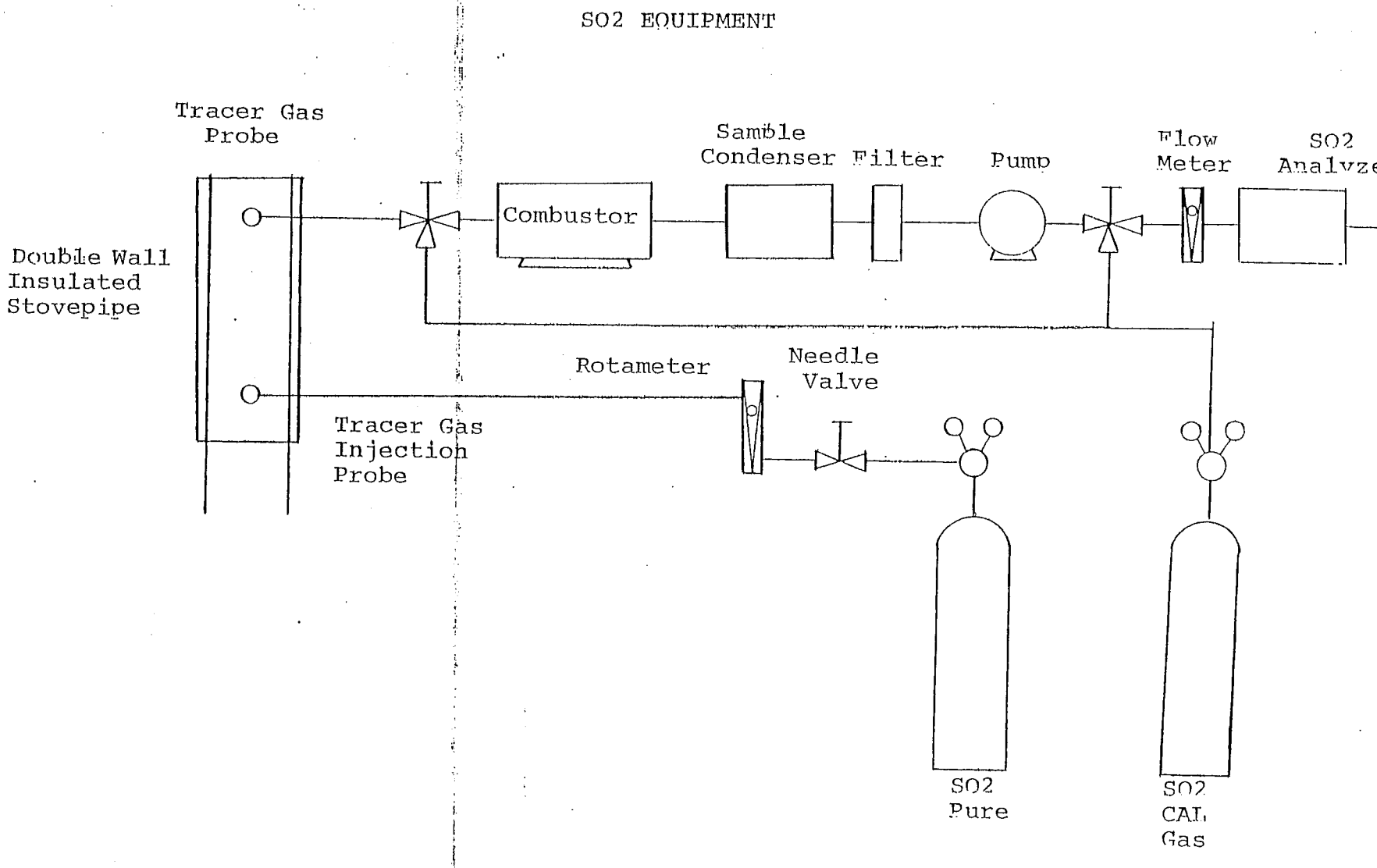
Item from Figure		Description
Condenser	:	The condenser consists of two glass impingers, one modified and one standard, which are connected with a U-adapter. The standard impinger is filled with approximately 100 ml of water and the modified impinger is filled with approximately 200 grams of Drierite indicating desiccant. Both impingers are placed in an ice bath (about 32 degrees F). Moisture is removed two ways; by maintianing the temperature below the dew point of water and by the desiccant. The efficiency indicators are the change in color, from blue to pink, and the accumulation of water in the first impinger. To clean the standard impinger, water is drained and the impinger is rinsed with water and acetone. To clean the modified impinger, when the Drierite is spent it is discarded and the impinger rinsed with water and acetone.
Filter	:	An in-line type, stainless steel 47 mm, filter holder with type A/E 47 mm, glass fiber filter manufactured by Gelman Sciences, Inc. The filter holder contains filter, support screen, perforated support disc of stainless steel, Teflon compression ring, and O-ring seal of Viton. It is tightened using a threaded collar assembly. The glass fiber filter is changed after each run and the stainless steel parts are rinsed with acetone. Also a filter is changed if it becomes necessary during a test run.
Primary Rotameter	:	It is a direct reading precision flowmeter manufactured by Dwyer Instruments, Inc., Model RMA-SSV. The range is from 2 to 20 scfh air and is constructed of polycarbonate plastic. The accuracy is ± 4% of the full scale. The control is a precision metering valve, made of stainless steel.
Manifold	:	It is a 7" section of 1/4" diameter stainless steel tubing with three stainless steel branch tee ports which lead to the secondary flowmeters.

O2, CO, AND CO2 FLOW MEASUREMENT EQUIPMENT cont.

Item from Figure		Description
Exhaust	:	The exhaust flow meter is a plastic direct reading model with a range from 0 to 4.5 scfh air.
CO Analyzer:		The Horiba Model PIR-2000 General Purpose Infrared Gas Analyzer is a precision gas analyzer based on non-dispersive infared ray absorption for continuously determining the concentration of a given component is a gaseous stream. Zero gas is introduced into the instrument and the front panel zero control is adjusted until the meter indicates zero. Next, span gas is introduced into the instrument and the span control is adjusted to indicate the concentration of the span gas. The procedure of zero/span is repeated to insure reproduceability and then sample gas is introduced into the analyzer and the concentration is read on the digital display.
CO Range	:	The measuring range is from 100 ppm to 100% of full scale concentrations. Resolution is 0.005%. The response speed is set at 1.2 sec. Linearity is determined by a multi-point calibration using different concentrations of CO after each test series. The results are always linear.
CO Flow Indicator	:	It is a direct reading precision flowmeter manufactured by Dwyer Instruments, Inc., Model RMA-SSV. The range is from 0.5 to 5.0 scfh air and is constructed of polycarbonate plastic. A flow rate of 1.5 scfh air is maintained. The accuracy is $\pm$ 4% of full scale. It is located in the gas sample line right before the CO2 analyzer.
CO2 Analyzer:		Same as CO Analyzer, except unit is equipped with an analog readout.
CO2 Range	:	Same as CO Range.

O2, CO, AND CO2 FLOW MEASUREMENT EQUIPMENT cont.

Item from Figure		Description
CO2 Flow Indicator	:	Same as CO Flow Indicator.
O2 Analyzer	:	The Horiba Model PMA-200 is a high precision oxygen anlyzer based on the magnetic dumb-bell sphere method for continuously measuring the oxygen concentration change in the sample gas. Zero gas is introduced into the instrument and the front panel zero control is adjusted until the meter indicates zero. Next, introduce span gas into the instrument and adjust the span control until the meter indicates the concentration of the span gas. Repeat. Lastly, sample gas is introduced into the analyzer and measurement commences.
O2 Range	:	There are two measuring ranges, from 0 to 10% and from 0 to 25%. Resolution is 0.5. The response speed is within 20 sec. Linearity is determined by a multi-point calibration using different concentrations of O2 after each test series. The results are always linear. Accuracy is $\pm$ 1% of full scale. The unit is equipped with an analog readout.
O2 Flow Indicator	:	It is a direct reading precision flowmeter manufactured by Dwyer Instruments, Inc., Model RMA-SSV. The range is from 1 to 10 scfh air and is constructed of polycarbonate plastic. A flow rate of 1.0 scfh air is maintained. The accuracy is $\pm$ 4% of full scale. It is located in the sample gas line right before the O2 analyzer.


SO2 EQUIPMENT
Tracer Gas Probe
Double Wall Insulated Stovepipe
Combustor
Samble Condenser
Filter
Pump
Flow Meter
SO2 Analyze
Rotameter
Needle Valve
Tracer Gas Injection Probe
SO2 Pure
SO2 CAL Gas

TRACER GAS EQUIPMENT

Item from Figure		Description
Injection Probe	:	The injection loop is 3/8" stainless steel tubing, having an overall diameter of 3-1/2", and nineteen 1/8" holes on the top side of the loop. The loop is inserted into the pipe from the inside at 10 ft. above the top of the platform scale.
Rotameter	:	The Matheson Series 601 rotameter is made of borosilicate glass, have plain tapered ends, and integral rib guides to center the floats. The tube contains two floats, one glass and one stainless steel. The range is 4 to 262 scc/min and is controlled by a high accuracy valve. The tube is accurate to ± 5% of full scale.
Control Valve	:	It is a Matheson, Series 4170 high accuracy needle valve. Constructed of stainless steel and has a range from 0 to 400 scc/min.
Injection Gas	:	Pure SO2 is used for the tracer gas and is contained in a 300 size cylinder. The regulator is a two-stage, high purity, stainless steel, Model 3500 Series manufactured by Matheson. The delivery pressure gauge has a range from 0 to 100 psig and the cylinder pressure gauge range is from 0 to 3000 psig.
Calibration Gas	:	Concentrations are 100 ppm of SO2, 250 ppm of SO2, 500 ppm of SO2, and 2000 ppm of SO2 in which all concentrations are in nitrogen. They are all in 150A size cylinders and are NBS traceable per E.P.A. protocol #1. SO2 calibration gas can be injected into the sample line before the combustor or it can be injected directly through the flow meter to the analyzer. The injection is controlled by a 3-way stainless steel ball valve.

Item from Figure	Description
Sample Probe:	It is an identical loop to the injection probe with slightly larger holes. It is inserted into the double insulated flue pipe, from the inside, at eight flue pipe diameters from the injection probe. Between the injection probe and the sample probe is a static mixer comprised of three slightly twisted metal plates and are suspended by wire to insure complete mixing.
Combustor :	The combustor is a tube furnace manufactured by Thermolyne Corporation Model No. F21100. The range is 400 to 1800 degrees F for continuous use and 1800 to 2000 degrees F for intermittent use. Resolution is 25 degrees F. The control tolerance is ± 20 degrees F. Overall dimensions are 16" in width x 14-5/8" in height x 12" in depth. The tube is made of quartz, it is 20-1/2" in length and 1.0" diameter. The 1.0" diameter section is 16" in length and has a capacity of 12.6 cu. in.
Filter Assembly :	An in-line type, stainless steel 47 mm, filter holder with type A/E 47 mm, glass fiber filter both manufactured by Gelman Sciences, Inc. The filter holder contains filter, support screen, perforated support disc of stainless steel, Teflon compression ring, and O-ring seal of Viton. It is tightened with a threaded collar assembly. The glass fiber filter is replaced after each test run or when the filter becomes clogged.
Sample Condenser :	The sample condenser consists of two glass modified high velocity, 28/15 ball on the inlet and outlet, impingers. The impingers are connected with a U-adapter and placed into an ice bath. The moisture is removed because the impingers are kept at a temperature (about 32 degrees F) below the dew point of water.

Item from Figure		Description
Sample Condenser cont.	:	Since the flow rate through the impingers is slow and the impingers are always kept in the ice bath, this method proves to be efficient. To clean, all glassware is rinsed with acetone and water to remove any particules which collected.
SO2 Analyzer:		The Horiba Model PIR-2000 General Purpose Infrared Gas Analyzer is a precision gas analyzer based on non-dispersive infared ray absorption for continuously determining the concentration of a given component in a gaseous stream. Zero gas is introduced into the instrument and the front panel zero control is adjusted until the meter indicates zero. Next, introduce span gas into the instrument and adjust the span control until the meter indicates the concentration of the span gas. Repeat. Lastly, sample gas is introduced into the analyzer and measurement commences.
Instrument Range	:	The measuring range is from 100 ppm to 100% of full scale concentrations. Resolution is 0.5%. The response speed is set at 1.2 sec. Linearity is determined by a multi-point calibration using different concentrations of SO2 after each test series. The results are always linear. The type of readout is an analog meter. The accuracy of the unit is ± 0.5%.
Flow Indicator	:	It is a direct reading precision flowmeter manufactured by Dwyer Instruments, Inc., Model RMA-SSV. The range is from 0.5 to 5.0 scfh air and is constructed of polycarbonate plastic. A flow rate of 2.0 scfh air is maintained. The accuracy is ± 4% of full scale. It is located in the SO2 sample line right before the SO2 analyzer.

CALIBRATIONS

METHOD 28 EQUIPMENT CALIBRATION

Platform Scale

The platform scale is serviced and calibrated at least annually by a qualified service representative and is audited before each certification test. With the wood heater in place at least five N.B.S. traceable calibration weights are used to span the operational range of the scale to 0.1 lbs. or 1 percent of the expected test fuel charge weight.

Scale Model: Platform Streeter Amet Electroscale Balance Quantomatic 9000 Indicator Test Facility NW Testing Labs, Inc.

Calibration Performed By O. Windoor Date 4/10/89 to 4/18/89

Wood Heater Model K-400 freestanding Marks Custom Stoves Weight of Test Fuel 24.8 lbs.

	Time	Test Run Number	Platform Temperature	Class F Calibration Weight (A)	Initial Scale Reading or Tare (B)	Final Scale Reading (C)	Measured Calibration Weight (D = C − B)	Difference (D minus A)
09:30	4/10/89	1	60	15.0	0.0	15.0	15.0	0.0
08:00	4/11/89	2	61	15.0	0.0	15.0	15.0	0.0
09:00	4/12/89	3	65	15.0	0.0	15.0	15.0	0.0
09:00	4/13/89	4	66	15.0	0.0	15.0	15.0	0.0
09:50	4/14/89	5	67	15.0	0.0	15.0	15.0	0.0
10:00	4/17/89	6	62	15.0	0.0	15.0	15.0	0.0
11:00	4/18/89	7	64	15.0	0.0	15.0	15.0	0.0

Single Point Scale Calibration Check

Instrument to be Calibrated Platform Scale Test Facility NW Testing Labs, Inc.

Model Number Electro Scale Model 3030 Calibration Performed by D. Windsor

Date of Calibration 4-21-89

Method of Measurement	Reference Value (A)	Measured Value (B)	Difference (A minus B)	Acceptable Tolerance
Dual Load Cell	50.0	50.0	0.0	0.1
↓	35.0	35.0	0.0	0.1
	25.0	25.0	0.0	0.1
	10.0	10.0	0.0	0.1
	5.0	5.0	0.0	0.1
	1.0	1.0	0.0	0.1

Semiannual Calibration Sheet

Instrument to be Callbrated Platform Scale

Model Number Electroscale Corp. Model 3030

Test Facility NW Testing Labs, Inc.

Callbration Performed by D Windsor

Date of Callbration 4-7-89

Method of Measurement	Reference Value (A)	Measured Value (B)	Difference (A minus B)	Acceptable Tolerance
Dual Load Cell	50.0	50.0	0.0	0.1
↓	35.0	35.0	0.0	0.1
	25.0	25.0	0.0	0.1
	10.0	10.0	0.0	0.1
	5.0	5.0	0.0	0.1
	1.0	1.0	0 0	0.1

Semiannual Callbration Sheet

METHOD 28 EQUIPMENT CALIBRATION

Barometer

The Fortin-type mercurial barometer used for measuring atmospheric pressure was standardized and calibrated upon initial installation as described in ASTM D-3631. The secondary standard used was the barometric pressure as measured by the U.S. Weather Bureau at Portland International Airport. Appropriate altitude and temperature corrections were applied. Subsequent comparison with U.S. Weather Bureau barometric pressure readings showed consistent reproduceability. Periodic checks are made with the U.S. Weather Bureau to insure accuracy of atmospheric pressure readings.

Draft Gauge

The draft gauge is always zeroed prior to a certification test and requires no calibration since a liquid manometer is used. Periodic cleaning and replacement of liquid in the manometer insures accurate measurement of the draft.

Anemometer

It is physically inspected and cleaned before each certification test. No calibration is needed as stated in advertisement enclosed.

Moisture Meter

The moisture meter is calibrated before and after each certification series with a calibrated moisture block supplied by Delmhorst Instrument Company. On the following page it explains how the calibration is performed (N.T.L. uses the MCS - Pin Type Electrode).

Relative Humidity Gauge

Relative humidity is determined using a hygrometer, Mason type. Wet bulb and dry bulb temperatures are read directly and the relative humidity is determined from the tables supplied. Thermometers are calibrated mercury-in-glass with a range of 30 to 120 degrees F. Periodic verification of wet bulb/dry bulb readings are made by comparison with a sling psychrometer.

HOW TO USE
A MOISTURE CONTENT STANDARD

The "MCS" contains two "standards", to check the calibration of Delmhorst Moisture Detectors.

PROCEDURE

1. Adjust the Moisture Detector, according to instructions.

2. Using a pin-type electrode, touch the center (common) lug and one of the side lugs of the "MCS" with the pins of the electrode, FIG A, turn the meter on and take a reading; the meter should read the same value as indicated on the "standard".

3. If a prod-type electrode is used, FIG B, contact between electrode and MCS is made by inserting the prod in the clips, with the tip held in the center clip and the lower metal band held in either of the outer two clips.

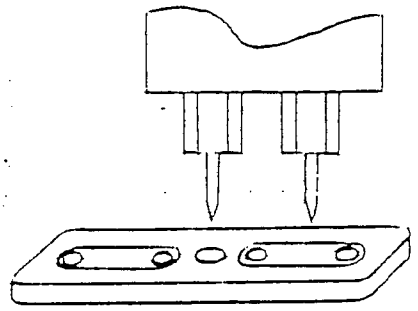


FIGURE A
MCS - PIN TYPE

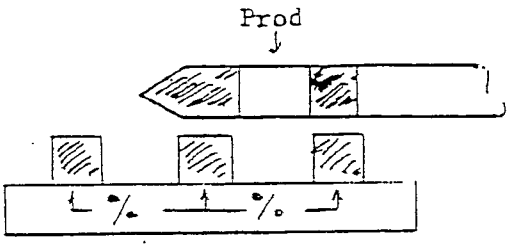


FIGURE B
MCS - PROBE TYPE

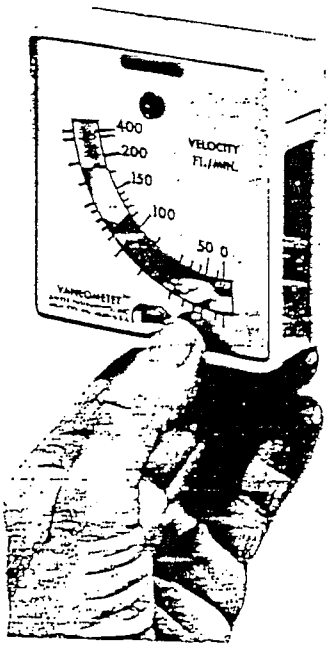
Delmhorst Instrument Co.
51 Indian Lane East
Towaco, N.J. 07082

Dwyer

No. 480 Vaneometer™

Swing Vane Anemometer. Use this sensitive new Dwyer unit to measure low air velocities — at low cost.*

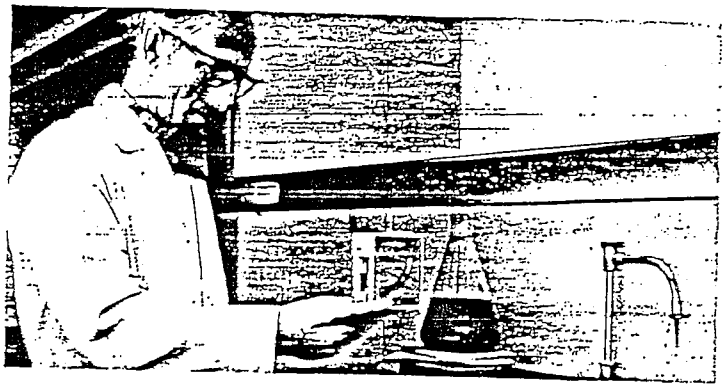
The Dwyer 480 Vaneometer™ Swing Vane Anemometer is a durable low-priced instrument specifically designed to simplify the measurement of low air velocities from 25 to 400 feet per minute. OSHA, EPA and other safety ventilation requirements for spray booths and at fume, smoke and dust exhaust hoods can now be quickly checked, even by untrained personnel. Its small size and light weight – only four ounces make it ideal to carry from one work station to another. A versatile steel mounting bracket for continuous monitoring is also included. The Vaneomometer Swing Vane Anemometer is accurate to ±5% of full scale to 100 FPM and ±10% from 100 FPM to top of scale. It has a spirit level to insure accurate readings and the large scales are easy to read and visible from both sides. The housing is molded from tough ABS plastic and easy to clean with soap and water. The polyester vane can be cleaned with lacquer thinner. A spare vane is provided.



The Vaneomometer's large scales are easy to read. Both sides have factory calibrated scales. Recessed spirit level at top helps insure accurate readings.

*U.S. Patent No. 4,154,101

Use a Vaneometer to measure velocity of air flow into laboratory fume hoods and at paint spray booths to determine when to change filters. Or wherever needed to meet OSHA standards of ventilation for smoke, dust or fume removal.



METHOD 28 EQUIPMENT CALIBRATION

Temperature Monitors

The temperature monitor meter is sent semi-annually to Grant Edgel Company for calibation and thermocouple wires are semi-annually calibrated to within 1 percent of expected temperature with a mercury-in-glass thermometer.

TEMPERATURE MONITOR CALIBRATION SHEET

TEMPERATURE MONITOR TYPE Chromel-Alumel K TEST FACILITY NW Testing Lab
REFERENCE TEMPERATURE MONITOR TYPE Mercury in Glass Thermometer DATE January 6, 1989
READOUT DEVICE Omega Engineering Model 14, Type K CALIBRATION PERFORMED BY D Windsor
AMBIENT TEMPERATURE 70 BAROMETRIC PRESSURE 30.00

Reference Point Source	Temperature of Reference Point	Observed Temperature Temperature Monitor	Difference in Percent of Absolute Temperature
Amb #1	32°F	30°F	0.4%
" "	211°F	208°F	0.4%
Top #2	32°F	31°F	0.2%
" #2	210°F	210°F	0%
Bottom #3	32°F	31°F	0.2%
" #3	209°F	209°F	0%
Rear #4	212°F	210°F	0.3%
" #4	32°F	31°F	0.2%
Right Side #5	32°F	31°F	0.2%
" " #5	212°F	212°F	0%
Left Side #6	212°F	212°F	0%
" " #6	32°F	32°F	0%
Primary #7	32°F	33°F	0.2%
" #7	212°F	213°F	0.1%
Secondary #8	212°F	212°F	0%
" #8	34°F	35°F	0.2%
Flue db #9	32°F	31°F	0.2%
" #9	212°F	211°F	0.1%
Flue wb #10	212°F	212°F	0%
" " #10	32°F	32°F	0%
Oven #13	32°F	30°F	0.4%
" #13	212°F	210°F	0.3%
Impinger #14	32°F	32°F	0%
#14	212°F	210°F	0.3%

Thermocouple #9 (Secondary) was not calibrated since it is not used.

Thermocouples #11 (Inlet), #12 (outlet), #15 (Tracer) were not calibrated because they are inaccessable.

METHOD 5H EQUIPMENT CALIBRATION

Thermometers

Calibrated the same as Temperature Monitors in Method 28 Equipment Calibration.

Barometer

See Barometer in Method 28 Equipment Calibration.

Analytical Balance

The analytical balance is calibrated quarterly by Quality Control Services and the last date of calibration was September 1987. The unit also contains a self-calibration check and audit when turned on. A further calibration can be performed by the balance, by engaging the calibration phase.

METHOD 5H EQUIPMENT CALIBRATION

SO2 Injection Rotameter

The SO2 injection rotameter calibration is performed each certification series. During calibration pure SO2 is metered through the injection flowmeter at different rates. A constant head pressure of 20 psig is maintained and the injection is measured and verified to be at 0.12 in. of H2O. A 100-ml soap film flowmeter and stopwatch are used to measure actual flowrates at different settings of the fine metering valve. The linear calibration curve generated gives calibrated flowrates at any setting using the stainless steel float.

Date: 4-20-89

Technician: T. Palmer

SO_2 INJECTION RATE CALIBRATION SHEET

SO2 Injection Rate mm/min.	t Min.	Volume Measured ml	SO2 Tank Inj. Tank psi	Calculations
50	2.11	99	20	99/2.11 = 46.92 = .099 ft³/hr
50	2.11			99/2.11 = 46.92 = .099 ft³/hr
55	1.77			99/1.77 = 55.93 = .119 ft³/hr
55	1.77			99/1.77 = 55.93 = .119 ft³/hr
60	1.49			99/1.49 = 66.44 = .141 ft³/hr
60	1.49			99/1.49 = 66.44 = .141 ft³/hr
65	1.29			99/1.29 = 76.74 = .163 ft³/hr
65	1.29			99/1.29 = 76.74 = .163 ft³/hr
70	1.15			99/1.15 = 86.09 = .182 ft³/hr
70	1.15	↓	↓	99/1.15 = 86.09 = .182 ft³/hr

Date: 4-20-89

Signature: T. Palmer

Date: 4-7-89

Technician: T. Palmer

30.27

SO_2 INJECTION RATE CALIBRATION SHEET

SO2 Injection Rate mm/min.	t Min.	Volume Measured ml	SO2 Tank Inj. Tank psi	Calculations
50	1.89	99	20	99/1.89 = 52.38 = .111 ft³/min
50	1.89	"	"	99/1.89 = 52.38 = .111 ft³/min
55	1.67			99/1.67 = 59.28 = .126 ft³/min
55	1.67			99/1.67 = 59.28 = .126 ft³/min
60	1.45			99/1.45 = 68.28 = .145 ft³/min
60	1.45			99/1.45 = 68.28 = .145 ft³/min
65	1.24			99/1.24 = 79.84 = .169 ft³/min
65	1.24			99/1.24 = 79.84 = .169 ft³/min
70	1.17			99/1.17 = 84.62 = .179 ft³/min
70	1.17	↓	↓	99/1.17 = 84.62 = .179 ft³/min

Date: 4-7-89

Signature: T. Palmer

METHOD 5H EQUIPMENT CALIBRATION

Dry Gas Meter

The dry gas meter is calibrated annually with the wet test meter as described in Method 5, Section 5.3.1 and the last date calibrated was January of 1987. The dry gas meter is also calibrated before and after each certification series using the dry gas meter as a calibration standard found in Method 5, Section 7, for alternative calibration standards. The dry gas volume is corrected to standard conditions using the equation found in Example Calculations. Leak checks are done before and after each certification test and results can be found on pages 1 and 7, respectively, of the raw data. To perform a leak check first plug the inlet to the filter, open the flow adjustment completely and adjust to a vacuum of 5 in. Hg, and measure the leakage rate for 1 minute and record. A leakage rate of less than 0.02 cfm at 5 in. Hg is acceptable.

WET TEST METER CALIBRATION

Date 1-10-89

Meter Reading - one revolution of index

Room Temperature = 62.6°F = 17°C

Meter Temperature = 62.0°F = 16.7°C

Bottle Temperature = 62.6°F = 17°C

ΔP_M = 2.9 in. H_2O = (2.9)(0.0737 in. Hg/in. H_2O) = 0.214 in. Hg

ΔP_B = 2.9 in. H_2O

Weight of water = $\left(\frac{2910.6 + 2912.5}{2}\right) - 85.0 = (2911.6 - 85.0) = 2826.6$ gm = 6.2314 lbs. @ 62.6°F

Correction for buoyancy = (6.2314)(0.00106) = 0.0066

Correction for density of water @ 62.6°F (17°C) to density @ 39.2°F = $(6.2314)\left(\frac{1.00000}{0.99879} - 1\right)$ = 0.0075

Correction for temperature difference = $(6.2314)\left(\frac{460 + 62.0}{460 + 62.6} - 1\right)$ = −0.0072

Correction for pressure difference = $(6.2314)\left(\frac{29.92 + 0.214 - 0.572}{29.92 + 0.214 - 0.561} - 1\right)$ = −0.0023
(29.562 / 29.573)

Bottle-vapor pressure H_2O @ 17°C = 14.530 mm Hg = 0.572 in. Hg

Meter-vapor pressure H_2O @ 16.7°C = 14.257 mm Hg = 0.561 in. Hg

Corresponding weight of H_2O @ max. density = (6.2314 + 0.0066 + 0.0075 − 0.0072 − 0.0023
= 6.2360

equivalent volume, ft^3 = 6.2360/62.4262 = 0.0999

One revolution of index = 0.0999 cu.ft.

Test Numbers _____ Date 4-19-89 Wood Heater _____

Barometric Pressure, P_b = 29.87 In. Hg Dry Gas Meter Number #1 Pretest Y .973

Rotameter or Orifice Manometer Setting, (ΔH), In. H_2O	Gas Volume: Wet Reference Test Meter (V_w), ft^3	Gas Volume: Dry Gas Meter (V_d), ft^3	Temperature: Wet Reference Test Meter (t_w), °F	Temperature: Dry Gas Meter: Inlet (t_{d_i}), °F	Temperature: Dry Gas Meter: Outlet (t_{d_o}), °F	Temperature: Dry Gas Meter: Average[a] (t_d), °F	Time (θ), min	Vacuum Setting, In. Hg	Y_i	$Y_i = \frac{V_w P_b (t_d + 460)}{V_d \left(P_b + \frac{\Delta H}{13.6}\right)(t_w + 460)}$
.01	3.055	3.148	75	83.5	71.5	78	30.00	0	.976	$\frac{(3.055)(29.87)(538)}{(3.148)(29.87+\frac{.01}{13.6})(535)}$ 5[illegible]
.03	4.724	4.912	75	89.5	68.5	79	30.00	0	.969	$\frac{(4.724)(29.87)(539)}{(4.912)(29.87+\frac{.03}{13.6})(538)}$ 77501
.05	5.974	6.271	76	93.5	68	81	30.00	0	.961	$\frac{(5.974)(29.87)(541)}{(6.271)(29.87+\frac{.05}{13.6})(536)}$ 1014
									Y = .969	

[a] If there is only one thermometer on the dry gas meter, record the temperature under t_d

V_w = Gas volume passing through the reference test meter, ft^3

V_d = Gas volume passing through the dry gas meter, ft^3

t_w = Temperature of the gas in the reference test meter, F°

t_{d_i} = Temperature of the inlet gas of the dry gas meter, °F

t_{d_o} = Temperature of the outlet gas of the dry gas meter, °F

t_d = Average temperature of the gas in the dry gas meter, obtained by the average of t_{d_i} and t_{d_o}, °F

ΔH = Pressure differential across orifice or dry gas meter, In H_2O

Y_i = Ratio of accuracy of reference test meter to dry gas meter for each run

Y = Average ratio of accuracy of reference test meter to dry gas meter for all three runs; tolerance = pretest Y ±0.05Y

P_b = Barometric pressure, In. Hg

θ = Time of calibration run, min

Post-Test Dry Gas Meter Calibration Data Form (English Units)

Date: 4-19-89

Technician: T. Palmer

DRY GAS METER CALIBRATION

Barometric Pressure (Initial) 29.87 in Hg

Barometric Pressure (Finish) 29.87 in Hg

Avg. Barometric Pressure 29.87 in Hg

H = .01 in H_2O

Elapse Time t = 30.00

Particulate Train Meter		Calibration Meter (Wet) ~~#26563~~	
ft^3_f	648.0	ft^3_f	99.10
ft^3_f	651.148	ft^3_f	102.155
ft^3	3.148	ft^3	3.055
T in_i	80	T in_i	74
T in_f	87	T in_f	75
T in avg.	83.5	T avg.	74.5
T out_i	74		
T out_f	69		
T out avg.	71.5		
T avg.	77.5		

Inches H_2O = .25"

CALCULATIONS:

Date: 4-19-89

Signature: T. Palmer

Date: 4-19-89

Technician: T. Palmer

DRY GAS METER CALIBRATION

Barometric Pressure (Initial) 29.87 in Hg

Barometric Pressure (Finish) 29.87 in Hg

Avg. Barometric Pressure 29.87 in Hg

H = 1.03 in H_2O

Elapse Time t = 30.00

Particulate Train Meter		Calibration Meter wet ~~#26563~~	
ft^3_f	651.148	ft^3_f	2.155
ft^3_f	656.060	ft^3_f	6.879
ft^3	4.912	ft^3	4.724
T in_i	87	T in_i	75
T in_f	92	T in_f	75
T in avg.	89.5	T avg.	75
T out_i	69		
T out_f	68		
T out avg.	68.5		
T avg.	79		

Inches H_2O = .25"

CALCULATIONS:

Date: 4-19-89 Signature: T. Palmer

Date: 4-19-89

Technician: T. Falconer

DRY GAS METER CALIBRATION

Barometric Pressure (Initial) 29.87 in Hg

Barometric Pressure (Finish) 29.87 in Hg

Avg. Barometric Pressure 29.87 in Hg

H = .05 in H_2O

Elapse Time t = 30.00

Particulate Train Meter		Calibration Meter ~~#26563~~ Wet
ft^3_f	656.060	6.879
ft^3_f	662.331	12.853
ft^3	6.271	5.974
T in_i	92	75
T in_f	95	76
T in avg.	93.5	T avg. 75.5
T out_i	68	
T out_f	68	
T out avg.	68	
T avg.	81	

Inches H_2O = .25"

CALCULATIONS:

Date: 4-19-89

Signature: T. Falconer

Test Numbers _____ Date 4-4-89 Wood Heater _____

Barometric Pressure, P_b = 30.22 In. Hg Dry Gas Meter Number #1 Pretest Y .970

Rotameter or Orifice Manometer Setting, (ΔH), In. H_2O	Gas Volume (Wet) Reference Test Meter (V_w), ft³	Gas Volume Dry Gas Meter (V_d), ft³	Temperature (Wet) Reference Test Meter (t_w), °F	Temperature Dry Gas Meter Inlet (t_{d_i}), °F	Temperature Dry Gas Meter Outlet (t_{d_o}), °F	Temperature Dry Gas Meter Average* (t_d), °F	Time (θ), min	Vacuum Setting, In. Hg	Y_i	$Y_i = \frac{V_w P_b (t_d + 460)}{V_d \left(P_b + \frac{\Delta H}{13.6}\right)(t_w + 460)}$
.01	2.818	2.901	62	70	63	67	30.00	0	.981	$\frac{(2.818)(30.22)(527)}{(2.901)(30.22+\frac{.01}{13.6})(522)}$ 45°26'
.03	4.598	4.775	63	76	59.5	68	30.00	0	.972	$\frac{(4.578)(30.22)(528)}{(4.775)(30.22+\frac{.03}{13.6})(523)}$ 75°
.05	5.845	6.122	63	79.5	57.5	69	30.00	0	.966	$\frac{(5.845)(30.22)(529)}{(6.122)(30.22+\frac{.05}{13.6})(523)}$ 96°77'
									Y = .973	

* If there is only one thermometer on the dry gas meter, record the temperature under t_d

V_w = Gas volume passing through the reference test meter, ft³

V_d = Gas volume passing through the dry gas meter, ft³

t_w = Temperature of the gas in the reference test meter, F°

t_{d_i} = Temperature of the inlet gas of the dry gas meter, °F

t_{d_o} = Temperature of the outlet gas of the dry gas meter, °F

t_d = Average temperature of the gas in the dry gas meter, obtained by the average of t_{d_i} and t_{d_o}, °F

ΔH = Pressure differential across orifice or dry gas meter, In H_2O

Y_i = Ratio of accuracy of reference test meter to dry gas meter for each run

Y = Average ratio of accuracy of reference test meter to dry gas meter for all three runs; tolerance = pretest Y ± 0.05Y

P_b = Barometric pressure, In. Hg

θ = Time of calibration run, min

Post-Test Dry Gas Meter Calibration Data Form (English Units)

Date: 4-4-89

Technician: T. Talmon

DRY GAS METER CALIBRATION

Barometric Pressure (Initial) 30.22 in Hg

Barometric Pressure (Finish) 30.22 in Hg

Avg. Barometric Pressure 30.22 in Hg

H = .01 in H_2O

Elapse Time t = 30.0

Particulate Train Meter		Calibration Meter #26563	
ft^3_f	395.80	ft^3_f	83.777
ft^3_f	398.701	ft^3_f	86.595
ft^3	2.901	ft^3	2.818
T in_i	66	T in_i	62
T in_f	74	T in_f	62
T in avg.	70	T avg.	62
T out_i	65		
T out_f	61		
T out avg.	63		
T avg.	66.5		

In H_2O .25"

CALCULATIONS:

Date: 4-4-89 Signature: T. Talmon

Date: 4-4-89

Technician: T. Palmer

DRY GAS METER CALIBRATION

Barometric Pressure (Initial) 30.22 in Hg

Barometric Pressure (Finish) 30.22 in Hg

Avg. Barometric Pressure 30.22 in Hg

H = .03 in H_2O

Elapse Time t = 30.00

	Particulate Train Meter	Calibration Meter #26563
ft^3_f	398.701	86.595
ft^3_f	403.476	91.193
ft^3	4.775	4.598
T in_i	74	63
T in_f	78	63
T in avg.	76	T avg. 63
T out_i	61	
T out_f	58	
T out avg.	59.5	
T avg.	68	

In H_2O .25"

CALCULATIONS:

Date: 4-4-89 Signature: T. Palmer

Date: 4-4-89

Technician: T Fahnestock

DRY GAS METER CALIBRATION

Barometric Pressure (Initial) 30.22 in Hg

Barometric Pressure (Finish) 30.22 in Hg

Avg. Barometric Pressure 30.22 in Hg

H = .05 in H_2O

Elapse Time t = 30.0

Particulate Train Meter		Calibration Meter #26563	
ft^3_f	403.476	ft^3_f	91.193
ft^3_f	409.598	ft^3_f	97.038
ft^3	6.122	ft^3	5.845
T in_i	78	T in_i	63
T in_f	81	T in_f	63
T in avg.	79.5	T avg.	63
T out_i	58		
T out_f	57		
T out avg.	57.5		
T avg.	68.5		

In H_2O .25"

CALCULATIONS:

Date: 4-4-89 Signature: T. Fahnestock

****
THIS PROGRAM CALCULATES THE AVERAGE Km AND DELTA H@
BY DAVID A. WINDSOR
****

:AFT SETTING	Qm	Km
**********	******	******
0.010	0.104	1.825
0.030	0.161	1.187
0.050	0.204	1.169
**********	******	******

IE AVERAGE Km IS 1.22682
ELTA H@ IS .6112599

Date: 4-19-89

Date. 2.9.87

Technician: T. Palmer

H @ CALIBRATION SHEET

H In H20	Vi_3 ft	Vf_3 ft	ø Min.	T_1 °F I	T_1 °F E	T_1 °F A	T_2 °F I	T_2 °F E	T_2 °F A	Qm ccm	$\bar{K}m$
.01	648.0	651.148	30.0	80	87	83.5	74	69	71.5		
.03	651.148	656.060	30.0	87	92	89.5	69	68	68.5		
.05	656.060	662.331	30.0	92	95	93.5	68	68	68		

H @ = .61

Date: 4-19-89

Signature: [signature]

****

THIS PROGRAM CALCULATES THE AVERAGE Km AND DELTA H@

BY DAVID A. WINDSOR

****

AFT SETTING	Qm	Km
0.010	0.096	1.248
0.030	0.157	1.175
0.050	0.200	1.163

E AVERAGE Km IS 1.19375

E DELTA H@ IS .6455966

Date: 4-4-89

Technician: T. Talmon

H @ CALIBRATION SHEET

H In H20	Vi_3 ft	Vf_3 ft	ø Min.	T_1 °F I	T_1 °F E	T_1 °F A	T_2 °F I	T_2 °F E	T_2 °F A	Qm ccm	$\overline{Km}$
.01	395.80	398.701	30.0	66	74	70	65	61	63		
.03	398.701	403.476	30.0	74	78	76	61	58	59.5		
.05	403.476	409.598	30.0	78	81	79.5	58	57	57.5		

H @ = _____

_____

Date: 4-4-89

Signature: T. Talmon

O2, CO, CO2, SO2 Error Check

The analyzer calibration error check is conducted prior to each certification test. After the flow rate measurement system and the tracer gas measurement system have been prepared for use, introduce zero gases and then the mid-level calibration gases for each analyzer. Set the analyzers' output responses to the appropriate levels. Then introduce the low-level and high-level calibration gases, one at a time, for each analyzer. Record the analyzer responses.

Date: 4-21-89
Technician: [illegible]

Barometric Pressure$_i$ 29.80 in Hg
Barometric Pressure$_f$ 29.80 in Hg
Barometric Pressure Avg. 29.80 in Hg

MULTI-POINT AUDIT

	CO2	CO	SO2	
Gas/ Concentration	14.98%	5.01%	512.5 ppm	
Zero	0.0	0.0	0.0	
Acutal	59.9	5.01	34.2	
Desired	59.9	5.01	34.2	
% Diff.	0.0%	0.0%	0.0%	

Gas/ Concentration	12.1%	1.38%	271 ppm	
Zero	0.0	0.0	0.0	
Acutal	49.9	1.41	18.2	
Desired	48.4	1.38	18.1	
% Diff.	3.1%	2.17%	0.29%	

Gas/ Concentration	2.89%	.397%	108 ppm	
Zero	0.0	0.0	0.0	
Acutal	12.1	.360	7.3	
Desired	11.6	.397	7.2	
% Diff.	4.3%	9.3%	1.3%	

Gas/ Concentration	14.98	5.01%	512.5 ppm	
Zero	0.0	0.0	0.0	
Acutal	59.9	5.01	34.2	
Desired	59.9	5.01	34.2	
% Diff.	0.0%	0.0%	34.2	

CALCULATIONS:

Date: 4-21-89 80 Signature: [signature]

Date: 4-7-89

Technician: T. Fahrner

Barometric Pressure$_i$ 30.27 in Hg

Barometric Pressure$_f$ 30.27 in Hg

Barometric Pressure Avg. 30.27 in Hg

MULTI-POINT AUDIT

	CO_2	CO	SO_2	
Gas/ Concentration	14.98%	5.01%	512 PPM	
Zero	0.0	0.0	0.0	
Acutal	59.9	5.01	34.2	
Desired	59.9	5.01	34.2	
% Diff.	0.0%	0.0%	0.0%	

Gas/ Concentration	12.1%	1.38%	271 PPM	
Zero	0.0	0.0	0.0	
Acutal	49.9	1.41	18.7	
Desired	48.4	1.37	18.1	
% Diff.	3.1%	2.17%	1.1%	

Gas/ Concentration	2.89%	.1397%	108 PPM	
Zero	0.0	0.0	0.0	
Acutal	12.1	.360	7.7	
Desired	11.4	.397	7.2	
% Diff.	4.7%	9.3%	-1.7%	

Gas/ Concentration	14.98%	5.01%	512 PPM	
Zero	0.0	0.0	0.0	
Acutal	59.9	5.01	34.2	
Desired	59.9	5.01	34.2	
% Diff.	0.0%	0.0%	0.0%	

CALCULATIONS:

Date: 4-7-89

81 Signature: T. Fahrner

Industrial Gases
Division of The BOC Group, Inc.
2009 Bellaire Avenue
Royal Oak
Michigan 48067
Telephone: 313-399-8020

ANALYTICAL REPORT

TO: Vancouver Welding Supply
800 Harney Street
Vancouver, WA 98660

LAST ANALYSIS DATE: 8/24/87
EXPIRATION DATE: 2/24/88
REFERENCE NUMBER: 805722
PURCHASE ORDER #: 1065/MEL

MATERIAL SUBMITTED - NOMINAL VALUE: 5% CO + 15.5% CO2 in N2

TEST CYLINDER NUMBER: CC-4145

METHOD OF ANALYSIS: Gas Chromatograph

INST. CALIB. DATE:
First: 8/17/87
Second: 8/24/87

NBS SRM's USED: (CRM 2642) 1675b

DATA

FIRST ANALYSIS DATE	SRM NO.	SRM CONC.	TEST CYL. CONCENTRATION
8/17/87	2642(CRM)	7.71% (CO)	5.00%
	1675b	14.00% (CO2)	15.16%

SECOND ANALYSIS DATE	SRM NO.	SRM CONC.	TEST CYL. CONCENTRATION
8/24/87	2642(CRM)	7.71% (CO)	5.01%
	1675b	14.00% (CO2)	15.21%

CYLINDER INVESTIGATION

CYLINDER NO.	COMPONENT	MEAN CONCENTRATION
CC-4145	Carbon Monoxide	5.00%
	Carbon Dioxide	15.19%
	Nitrogen	Balance

TRACEABLE TO NBS PER EPA PROTOCOL 2 JUNE 15, 1978

Michael E Kelley
PRINCIPAL GAS ANALYST
Michael E. Kelley

"This report states accurately the results of the investigation made upon the materials submitted to the analytical laboratory. Every effort has been made to determine objectively, the information requested, HOWEVER, in connection with its rendering of this report AIRCO shall have no liability in excess of its established charge for the service. Any use of this report or the information contained herein shall be at the sole risk of the user."

AIRCO Special Gases
An operating unit of The BOC Group, Inc.

Union Landing & River Roads
P.O. Drawer No. 272
Riverton
New Jersey 08077
Telephone: Marketing; 609-829-7878
Prod. & Admin.; 609-829-7914
International; 609-829-7917

847055

ANALYTICAL REPORT

To: Vancouver Welding Supply
800 Harney Street
Vancouver, WA 98660

Date Reported: 08-15-88
Test Number: 84344

Material Submitted: 21%Oxygen/Nitrogen

Specification Number:

Method of Analysis: Percent Oxygen Analyzer

Result of Investigation: Cylinder No. CC-383

Component	Specification	Concentration
Oxygen	21%	21.8 %
Nitrogen	Balance	Balance

By _____
Authorized Signature

AIRCO Industrial Gases
Division of Airco, Inc
660 North Baldwin Park Blvd.
P.O. Box 1290
City of Industry
California 91749
Telephone: (818) 369-2871

ANALYTICAL REPORT

To: Vancouver Welding Supply
800 Harney St.
Vancouver, WA 98660

Date Reported: 4-27-87

Reference: 309860
467-11846

Material Submitted: One size #152 cylinder containing 500 ppm Sulfur Dioxide, balance Air

Information Requested: Certification of Analysis

Method of Analysis: UV Photometric Analyzer

Result of Investigation:

Component	Cylinder	Specification	Concentration
SO2	CC3669	500 ppm	513 ppm

Balance Air (synthetic)

By _____
PRINCIPAL GAS ANALYST

"This report states accurately the results of the investigation made upon the materials submitted to the Analytical Laboratory. Every effort has been made to determine objectively, the information requested; HOWEVER, in connection with its rendering of this report, AIRCO shall have no liability in excess of its established charge for the service. Any use of this report or the information contained herein shall be at the sole risk of the user."

GA 3099 E - 6/77
PRTD. IN USA

METHOD 5H EQUIPMENT CLAIBRATION

O2, CO, CO2, SO2 Response Check

The analyzer response check is performed on a semi-annual basis. Zero gas is introduced at the calibration gas valve into the flow rate measurement system and the tracer gas measurement system until all readings are stable. Then, quickly switch to introduce the mid-level calibration gas at the calibration valve until a stable value is obtained. Record the response time and repeat the procedure three times.

ANALYZER RESPONSE CHECK

Test Facility: N.W. Testing Labs, Inc. Date: 3-7-89

Technician: T. Palmer Barometric Pressure: 28.83

Analyzer	Timings (sec.) 1	2	3	Response Time Specification	Stability
SO2	19.1	17.4	15.0	2.0 min	Came to Stability
CO2	14.9	12.9	12.9		& remained
CO	14.6	11.8	12.4		
O2	28.5	29.4	27.1		

EXAMPLE CALCULATIONS

DRY BURN RATE, (BR)

Equation Used

$$BR = \left[\frac{60 W_{wd}}{\Theta}\right]\left[\frac{100 - \%M_w}{100}\right]$$

Nomenclature

BR = Dry wood burn rate, kg/hr (lb/hr)

W_{wd} = Total mass of wood burned (wet basis) during the test run, kg (lb)

Θ = Total time of test run, minutes

$\%M_w$ = Average moisture in test fuel charge, wet basis, percent

NOTE: To convert from dry basis to wet basis:

(100) (percent dry reading) ÷ (100 + percent dry reading) = percent moisture wet basis

Sample Calculation

$$BR = \left(\frac{60 \text{ min/hr } (6.62 \text{ kg})}{120 \text{ minutes}}\right)\left(\frac{100\ \% - 18.6\ \%}{100\ \%}\right)$$

BR = 2.69 kg/hr (dry basis)

VOLUME OF GAS SAMPLE CORRECTED TO DRY STANDARD CONDITIONS

$\left(V_{m(std)}\right)$

Equation Used

$$V_{m(std)} = K_1 V_m Y \left(\frac{P_{bar} + \left(\frac{\Delta H}{13.6}\right)}{T_m} \right)$$

Nomenclature

$V_{m(std)}$ = Volume of gas sample measured by the dry gas meter, corrected to standard conditions, $dscm^3$ (dscf)

K_1 = 0.3858 $^oK/mm$ Hg for metric units

= 17.64 $^oR/in.$ Hg for English units

V_m = Volume of gas sample as measured by the dry gas meter, dm^3 (dcf)

Y = Dry gas meter calibration factor

P_{bar} = Barometric pressure at the sampling site, mm Hg (in. Hg)

ΔH = Average pressure differential across the orifice meter (if used), mm H_2O (in. H_2O)

T_m = Absolute average dry gas meter temperature, ^oK (^oR)

Sample Calculation

$$V_{m(std)} = (17.64\,^oR/in.\ Hg) \times (61.588\ dcf) \times (1.003) \times \frac{\left(29.23\ in.\ Hg + \frac{2.31\ in.\ H_2O}{13.6\left(\frac{in.\ H_2O}{in.\ Hg}\right)}\right)}{542\,^oR}$$

$V_{m(std)}$ = 59.11 dscf

TOTAL AMOUNT OF PARTICULATE MATTER COLLECTED (5G-2 and 5H)

(m_n)

Equation Used

$$m_n = F_1 + F_2 + R + I_{ex} + I_w - \left(\frac{m_a V_{aw}}{V_a}\right) - \left(\frac{m_{dcm} V_{dcmw}}{V_{dcm}}\right) - \left(\frac{m_w V_{iw}}{V_w}\right)$$

Nomenclature

m_n = Total amount of particulate matter collected, mg

F_1 = Particulate matter collected on front filter, mg

F_2 = Particulate matter collected on second filter, mg

R = Residue from evaporated probe and filter holder rinses, mg

I_{ex} = Weight of residue from evaporated impinger water extract, mg

I_w = Weight of residue from evaporated impinger water, mg

m_a = Mass of residue of acetone solvent blank after evaporation, mg

V_{aw} = Volume of acetone used in probe and filter holder rinses, ml

V_a = Volume of acetone blank, ml

m_{dcm} = Mass of residue in dichloromethane solvent blank after evaporation, mg

V_{dcmw} = Volume of dichloromethane used in impinger rinses and impinger extractions, ml

V_{dcm} = Volume of dichloromethane blank, ml

m_w = Mass of residue in water blank after evaporation, mg

V_{iw} = Volume of water placed in train impingers, ml

V_w = Volume of water blank, ml

Sample Calculation

$$m_n = 75.1\ mg + 13.2\ mg + 56.4\ mg + 35\ mg + 23\ mg - \left(\frac{(0.2\ mg)(250\ ml)}{(50\ ml)}\right) - \left(\frac{(0.1)(100\ ml)}{(75\ ml)}\right) - \left(\frac{(0.1\ mg)(200\ ml)}{(200\ ml)}\right)$$

$$m_n = 201.47\ mg$$

PARTICULATE CONCENTRATION (C_s)

Equation Used

$$C_s = (0.001 \text{ g/mg}) \times (m_n/V_{m(std)})$$

Nomenclature

C_s = Concentration of particulate matter in stack gas or dilution tunnel, dry basis, corrected to standard conditions g/dsm^3 (g/dscf)

m_n = Total amount of particulate matter collected in the sampling train, mg

$V_{m(std)}$ = Volume of gas sample measured corrected to dry standard conditions, dsm^3 (dscf)

Sample Calculation

$$C_s = (0.001 \text{ g/mg}) \times \frac{52.4 \text{ mg}}{12.23 \text{ dscf}}$$

$$C_s = 0.00428 \text{ g/dscf}$$

TOTAL DRY MOLES OF STACK EXHAUST GAS (N_T)

METHOD 5H CARBON BALANCE

Equation Used

$$N_T = \frac{42.5}{(Y_{CO_2} + Y_{CO} + Y_{HC})}$$

Nomenclature

N_T = Total dry moles of exhaust gas per kg of dry wood burned, g-moles/kg (lb-moles/1000 lb)

42.5 = gram moles of carbon per kilogram of dry fuel (lb/lb)

Y_{CO} = Measured mole fraction of CO (dry), average g/g-mole, (lb/lb-mole)

Y_{CO_2} = Measured mole fraction of CO_2 (dry) average g/g-mole, (lb/lb-mole)

Y_{HC} = Assumed mole fraction of HC (dry), average g/g-mole, (lb/lb-mole)

= 0.0088 for catalytic wood heaters

= 0.0132 for non catalytic wood heaters

= 0.0080 for pellet-fired wood heaters.

Sample Calculation

$$N_T = \frac{42.5 \text{ g-atoms of carbon/kg}}{(0.1128) + (0.0126) + (0.0132)(\text{g-carbon/mole stack gas})}$$

N_T = 306.64 moles of stack gas/kg

TOTAL STACK GAS FLOW RATE (Q_{sd})

METHOD 5H CARBON BALANCE

Equation Used

$$Q_{sd} = K_4 N_T BR$$

Nomenclature

Q_{sd} = Total stack gas flow rate corrected to dry standard conditions, dsm^3/hr (dscf/hr)

K_4 = 0.02406 dsm^3/g-mole for metric units
= 384.8 dscf/lb-mole for English units

N_T = Total dry moles of exhaust gas per kg of dry wood burned, g-moles/kg (lb-moles/1000 lbs)

BR = Dry burn rate, kg/hr (lb/hr)

Sample Calculation

$$Q_{sd} = 0.02406 \frac{dsm^3}{g\text{-mole}} \times 306.64 \frac{g\text{-mole}}{kg} \times 4.65 \frac{kg}{hr}$$

$$Q_{sd} = 34.307 \frac{dsm^3}{hr}$$

ORIFICE PRESSURE DIFFERENTIAL, (H@)

Equation Used

$$\Delta H@ = \frac{0.0317\ \Delta H}{Pb\ (To + 460)} \left[\frac{(Tw + 460)\ \theta}{Vw}\right]^2$$

Nomenclature

ΔH = Oifice manometer setting, in. H_2O.

Pb = Barometric pressure, in. Hg.

To = Volume meter inlet temperature, °F.

Tw = Wet test meter temperature, °F.

θ = Time, min.

Vw = Wet test meter gas volume, ft^3.

Sample Calculation

$$H@ = \frac{(0.0317)(0.10\ \text{in. } H_2O)}{(30.11\ \text{in. Hg})(71°F + 460)} \left[\frac{(68°F + 460)(15\ \text{min})}{(3.053\ \text{cu. ft.})}\right]^2$$

$$= (1.98 \times 10^{-7})(2594.2)^2$$

$$= 1.334$$

ANALYZER ERROR CHECKS

Equation Used

$$AE\ (\%) = \frac{\Delta C}{span} \times 100$$

Nomenclature

AE = Analyzer error in measuring low level and high level calibration gases, expressed as percent relative to the instrument range, (%)

span = The upper limit of the instrument range, ppmv or (%)

C = The absolute difference between analyzer response and known calibration gas concentrations, ppmv or (%)

Sample Calculation

CO_2 Analyzer Range (span): 0 - 25% vol

Low level calibration gas concentration: 6.25% vol

Analyzer response to low level calibration gas: 6.42% vol

High Level calibration gas concentration: 22.10% vol

Analyzer response to high level calibration gas: 22.62% vol

$$\text{Low level AE} = \frac{6.42 - 6.25\%\ \text{vol}}{25.00\%\ \text{vol}} \times 100 = 0.68\%$$

$$\text{High level AE} = \frac{22.62 - 22.10\%\ \text{vol}}{25.00\%\ \text{vol}} \times 100 = 2.08\%$$

PERCENT OF PROPORTIONAL SAMPLING RATE (PR)

Equation Used

$$PR = \left(\frac{\Theta \, S_i \, V_{mi(std)}}{10 \sum_{i=1}^{n} (S_i \, V_{mi(std)})} \right) \times 100$$

Nomenclature

PR = Percent of proportional sampling rate (%).

Θ = Total sampling time, min.

S_i = Concentration measured at the He analyzer for the "i^{th}" 10-minute interval, ppm.

$V_{mi(std)}$ = Volume of gas sample measured by the dry gas meter during the i^{th} 10-minute interval, dsm^3 (dscf).

Sample Data

i	(min.)	(ppm)	$V_{mi(std)}$	PR_i (%)
1	0	2400	1.9439	100
2	10	2750	1.6085	97.3
3	20	2650	1.7228	100.3
4	30	2650	1.6881	98.7
5	40	2550	1.8090	101.4

Sample Calculation

When i = 1:

$$PR = \left[\frac{10 \text{ min. } (2400 \text{ ppm}) \ (1.9439 \text{ dscf})}{10 \text{ min. } (2400 \text{ ppm}) \ (1.9439 \text{ dscf})} \right] \times 100 = 100\%$$

When i = 2:

$$PR = \left[\frac{20 \text{ min. } (2750 \text{ ppm}) \ (1.6085 \text{ dscf})}{10 \text{ min. } [(2400 \text{ ppm}) \ (1.9439 \text{ dscf}) + 2750 \text{ ppm}) \ (1.6085 \text{ dscf})]} \right] \times 100$$

$$= 97.3\%$$

When i = 3:

$$PR = \left[\frac{30\ (2650)\ (1.7228)}{10\ (2400)\ (1.9439) + (2750)\ (1.6085) + (2650)\ (1.7228)} \right] \times 100$$

$$= 100.3\%$$

When i = 4:

$$PR = \left[\frac{40\ (2650)\ (1.6881)}{10 \left[(2400)\ (1.9439) + 2750\ (1.6085) + (2650)\ (1.7228) \right] + (2650)\ (1.6881)} \right] \times 100$$

$$= 98.7\%$$

When i = 5:

$$PR = \left[\frac{50\ (2550)\ (1.8090)}{10 \left[(2400)\ (1.9439) + 2750\ (1.6085) + 2650\ (1.7228) \right] + (2650)\ (1.6881) + (2550)\ (1.8090)} \right] \times 100$$

$$= 101.4\%$$

ANALYZER DRIFT CHECKS

Equation Used

$$\text{Drift} = \frac{\Delta R}{\text{span}} \times 100$$

Nomenclature

Drift = the change in analyzer response to calibration gas over the duration of the test run relative to the instrument range, (%)

ΔR = the difference between the analyzer response at the end of the test run and the known calibration gas value, ppmv or (%)

span = the upper limit of the instrument range, ppmv or (%)

Sample Calculation

CO_2 Analyzer Range: 0 - 25% vol

Calibration Gas: 0.00, 12.50% vol

Post-test Run Instrument Response: 0.32, 11.95% vol

Zero Drift = [(0.32-0.00% vol)/25% vol] x 100

= 1.28%

Midlevel Drift = [(12.50-11.95% vol)/25% vol] x 100

= 2.2%

PARTICULATE EMISSION RATE, (E)

Equation Used

$$E = C_s Q_{sd}$$

Nomenclature

E = Particulate emission rate, g/hr

C_s = Concentration of particulate matter in stack gas or dilution tunnel gas, dry basis corrected to standard conditions, g/dscm^3, (g/dscf)

Q_{sd} = Total gas flow rate, dry basis corrected to standard conditions, dsm^3/hr (dscf/hr)

Sample Calculation

E = (0.1770 g/dscf) (19.77 dscf/hr)

E = 3.50 g/hr

CORRECTION TO DRY GAS METER

Equation Used

Correction to meter readings = [(A - B)/B] x 100

Nomenclature

A = Small water-sealed rotating-drum meter reading, where A = Final reading - Initial reading.

B = Dry gas meter reading, where B = Final reading - Initial reading.

Sample Calculation

A = 4.713 - 1.660

= 3.053 cu. ft.

B = 717.755 - 714.600

= 3.155 cu. ft.

Correction to meter readings = [(3.053 - 3.155)/3.155] x 100

= -3.23%.

WEIGHTED EMISSION RATE, (E_w)

Equation Used

$$E_w = \frac{\sum_{i=1}^{n} (K_i E_i)}{\sum_{i=1}^{n} K_i}$$

Nomenclature

E_w = Weighted average emission rate, g/hr

E_i = Emission rate for test run, i, adjusted to Method 5H equivalent, g/hr

K_i = Test run weighting factor = $P_{i+1} - P_{i-1}$

n = Total number of test runs

P_i = Probability for burn rate during test run, i

Sample Calculation

$$E_w = \frac{(5.00 \text{ g/hr})\ (0.300) + (4.70 \text{ g/hr})\ (0.259) + (5.30 \text{ g/hr})\ (0.422) + (3.80 \text{ g/hr})\ (0.532) + (5.10 \text{ g/hr})\ (0.278)}{(0.300) + (0.259) + (0.422) + (0.532) + (0.278)}$$

$$E_w = \frac{8.40 \text{ g/hr}}{1.791}$$

E_w = 4.69 g/hr

CALCULATION OF OXYGEN VALUE, (% by volume)

Equation Used

Oxygen (O_2) = 20.9 - ((1.06 x CO_2) + (0.61 x CO)

Nomenclature

Oxygen (O_2) = The percentage of oxygen by volume in the flue gas.

CO_2 = The percentage of carbon dioxide by volume in the flue gas.

CO = The percentage of carbon monoxide by volume in the flue gas.

20.9 = Percent of oxygen by volume in ambient air.

Sample Calculation

Oxygen (O_2) = 20.9 - ((1.06 x 10.30% by volume) + (0.61 x 0.65% by volume))

= 9.59% by volume.

PARTICULATE SAMPLING RATE FOR ISOKINETIC/PROPORTIONAL FLOW

EQUATION USED

$$\underset{Set}{\Delta H} = \frac{H@\ Dn^4\ Q_{ti}^2\ P_{ti}}{3.86E\text{-}06\ A_s^2\ Ps\ C't\ Tti^2}$$

NOMENCLATURE

C't = Downstream tracer concentration, ppm
Tm = Average meter temperature R
Ps = Stack pressure, in. Hg = $\left(Pb + \frac{draft}{13.6}\right)$
Tti = Tracer gas injection temperature, R
Pti = Tracer gas injection pressure, in. Hg= $\left(Pb + \frac{in\ H2O}{13.6}\right)$
Qti = Tracer gas injection rate, ft3/hr.
ΔH@ = Orifice calibration factor, in H2O
Dn = Diameter of nozzle, inches
As = Stack area, ft2
Pb = Barometric pressure, in. Hg

SAMPLE CALCULATION

$$\Delta H = \frac{(1.55)(.62)^4\ (533.5)(.15)^2\left(\frac{.12}{29.99 + 13.6}\right)^2}{(3.86E\text{-}06)(.1963)^2\left(\frac{.10}{29.99 + 13.6}\right)^2\ (645)^2\ (531)^2}$$

$$= \frac{(1.55)(.148)(533.5)(.0225)(899.93)}{(3.86E\text{-}06)(.0385)(299.997)(416025)(2819961)}$$

$$= \frac{2474.1376}{523382.63}$$

$$= 4.7272E\text{-}03 \text{ in H2O.}$$

FUEL FACTOR
Fo

Equation Used

$$Fo = \left(\frac{20.9 - \%O2}{\%CO2} \right)$$

Nomenclature

%O2 = Percent O2 by volume (dry basis).

%CO2 = Percent CO2 by volume (dry basis).

20.9 = Percent O2 by volume in ambient air.

NOTE : If CO is measureable, O2 and CO2 are adjusted using the following equations.

$\%CO2(adj) = \%CO2 + \%CO$

$\%O2(adj) = \%O2 - 0.5\ \%CO$

%CO = Percent CO by volume (dry basis).

Sample Calculation

$\%CO2(adj) = 11.25 + .15$

$= 11.40$

$\%O2(adj) = 9.0 - (0.5)(.15)$

$= 8.925$

$$Fo = \left(\frac{20.9 - 8.925}{11.4} \right)$$

$= 1.05.$

DRY GAS VOLUME CORRECTED TO STANDARD CONDITIONS

Equation Used

$$Vm\ std = 17.65\ Vm \left(\frac{Pbar + \frac{\Delta H}{13.6}}{Tm} \right)$$

Nomenclature

Vm std = Volume of gas sample measured by the dry gas meter to standard conditions, dscf.

Vm = Volume of gas sample as measured by the dry gas meter, dcf.

Tm = Absolute average dry gas meter temperature, R.

Pbar = Barometric pressure at the sampling site, in. Hg.

ΔH = Average pressure differential across the orifice meter, in H2O.

Sample Calculation

$$Vm\ std = (17.65)(23.0\ dcf) \left(\frac{30.29\ in.\ Hg + \frac{0.03\ in\ H2O}{13.6}}{526 \cdot R} \right)$$

$$= (405.95)(0.0576)$$

$$= 23.379\ dscf$$

SOLVENT BLANKS FOR SAMPLE EXTRACTION

Deionized Water

0.0019 gm/200 ml

Dichloromethane

0.0009 gm/150 ml

Acetone

0.0018 gm/200 ml

RAW TEST DATA

SAMPLE EXTRACTION DATA

Stove Mfg.: Marks Custom Stoves Test: 1

Stove Model: K-400 FS Test Cycle: High

Date: 4-6-89 Stove I.D. No.: 184

Technician: D. Windsor

V_V

CONDENSED WATER VOLUME, GMS

	Modified Temp. 100 ml H20	Standard Imp 100 ml Hz	Modified Imp. Dry	Modified Imp. 200 Gms Silica Gel
Gross Weight	586.9	607.4	487.3	749.6
Initial Weight	564.0	606.3	487.3	748.3
Net Weight	22.9	1.1	0.0	1.3

TOTAL 25.3 GMS

W .8188 PARTICULATE CATCH, GMS .7627 4-10 13:30

	OVEN FILTER(S)				TRAIN FILTER(S)	
Gross Weight	.8189				.7580	
Initial Weight	.7631				.7582	
Net Weight	0.0558				0.000	TOTA

TOTAL 0.0558 GMS

#8	Front Catch Probe	Rear Catch Impingers	DCM	H20	
Beaker, ml	90	150	150	250	
Gross, Weight	99.3802	100.0442	102.6929	100.1972	
Initial Weight	99.3425	100.0092	102.6722	100.1870	
Net Weight	0.0377	0.0350	0.0207	0.0102	
Evaporation	0.0008	0.0014	0.0009	0.0024	
Residue Weight	0.0369	0.0336	0.0198	0.0078	TOTA

TOTAL 0.0981 GMS 0.0705

0.0276

Total Particulate = 0.1539 gm

= 153.9 mg

ANALYSIS CONTROL LOG

DATE	CLIENT	TEST I.D.	SAMPLE WEIGHTS						TIME 24 HR.
			OVEN FILTER	TRAIN FILTER	PROBE	ACETONE	DCM	H20	
4-10	Marks Custom K-400FS	184-1	.8188	.7627					18:30
4-11			.8189	.7582					11:30
4-11				.7580					13:30
4-12					99.3797	100.0432	102.6930	100.1973	07:30
4-12					99.3802	100.0453	102.6938	100.1994	09:30
4-12						100.0437	102.6920	100.1971	11:30
4-12						100.0442	102.6927	100.1972	13:30
4-13							102.6934		07:30
4-13							102.6929		09:30

METHOD 5H FLOW RATE (STACK) CALCULATIONS

(Put general info in col B, data info in col H.)

Lab name: NORTHWEST TESTING LABS, INC.
Stv manu: MARKS CUSTOM STOVES
Model no: K-400 FREESTANDING
Tst Date: APRIL 10, 1989

Yhc 1=cat,2=ncat : 1
Wc (if supplied) :
Burn rate (kg/hr): 6.81
Run Number : 1

run time (min)	O2 (%)	CO2 (%)	CO (%)	Fo (1.-1.12)	Stack Gas Flow Rate (dscfh)	(dscfm)	(dsm3/hr)
0	3.20	16.60	0.11	1.06	1363.88	22.73	38.66
10	0.20	18.40	2.03	1.06			
20	0.10	18.40	2.32	1.06			
30	0.10	18.50	2.45	1.05			
40	0.60	18.30	1.53	1.06			
50	3.30	16.50	0.20	1.06			
60	6.80	13.30	0.01	1.06			
70	7.40	12.80	0.01	1.05			
74	7.60	12.50	0.02	1.06			

Method 5H Proportionality Rate and Sample Volume Calculation
(put general info in col. C; Pb,Y,& unit info in col. G)

Lab name: NORTHWEST TESTING LAB., INC.
Stv manu: MARKS CUSTOM STOVES
Model no: K-400 FREESTANDING
Tst date: APRIL 10, 1989
Run no : 1.0

Units 1=metric, 2=English: 2.0
Y, DGM: 0.971
Pb (mm,in. Hg): 30.0

NOTE: Input raw data below, use F9 for CALC.

run time (min)	tracer conc (ppm,%)	DGM rdg (m3,ft3)	DGM temp (C,F)	DGM dH (mm H2O) (in.H2O)	dDGM vol std (m3,ft3)	PR (%)	Sample vol std (m3,ft3)
0	157.5	435.646	72	0.011			
10	195.0	436.650	75	0.007	0.968	107.3	6.215
20	172.5	437.430	77	0.009	0.748	102.6	
30	195.0	438.300	77	0.007	0.831	100.9	
40	165.0	439.030	78	0.010	0.697	95.7	
50	165.0	439.950	80	0.010	0.877	101.8	
60	150.0	440.860	79	0.012	0.865	100.4	
70	157.5	441.780	80	0.011	0.876	92.4	
74	157.5	442.150	80	0.011	0.352	97.4	

NORTHWEST TESTING LABORATORIES
Woodstove Emmission Testing

PAGE 1 - STOVE INFORMATION AND PRE-TEST DATA

Stove Manufacturer: Marks Custom Stoves
Stove Model: K-300 FS
Stove I.D. Number: 184
Run Number: 1
Date: 4-10-89
Expected Burn Rate: High

STOVE

Weight: 502.1 lb.
Platform Scale Audit?: yes -ok
Primary Air Control Setting: 100% open
Blower: On ___ Off ___ Auto. ___ N/A ✓
Flue Pipe Gauge: 24
Flue Pipe Diameter in.: 8 in.
Pictures: Yes ✓ No ___
Operating Instructions:
Stove Manual ___ Verbal ___ Other ✓ written Letter
Stack Cleaned: Yes ✓ No ___

CATALYST Yes ✓ No ___

Catalyst Brand: Applied Ceramics
Catalyst I.D.: Firecat 2½ x 7½ x 3, 16 cell
Catalyst Age: 50+ hrs.
Catalyst Provided: Marks Custom Stoves

AMBIENT

Dry Bulb Reading 77 °F
Wet Bulb Reading 61 °F
Relative Humidity 39 %
Baro. 29.93 in Hg.

% Moisture 1.3 % Volume ___

CONTINUOUS ANALYZERS

Audited by: D. Windsor
Leak Tested by: D. Windor

PARTICULATE TRAIN

Probe Length & Type 6" Pyrex
Nozzle Size 0.62 in.
ΔH @ 0.65
ΔH Magnehelic Range, 0→1 in H_2O
Leakage Rate: 0.009 $Ft.^3$/min.

TRACER GAS

Gas Used: SO_2
Rotameter No.: 601
Rotameter Rdg.: 60 mm
Ball Read: Stainless Steel
CC/Min.: 70.62
$Ft.^3$/hr. 0.15
(cc/min. ÷ 472 = Ft^3/hr.)
Injection System Rate
Checked: Yes: ✓ No: ___

SIGNED BY: David Windsor

DATE: April 10, 1989

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 2 - FUEL DATA

Stove Manufacturer: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. Number: 184
Technician: D. Windsor

Run Number: 1
Expected Burn Rate: High
Calculated Charge Wt.: 24.8
Coal Bed Wt. Lbs.: 4.6
HHV Sample: Yes ✓ No
(Saw Dust Catch & Block)

I. Fuel Moisture Content, % (Dry Basis):

1.	19.2	19.2	19.2	11.	19.8	19.2	19.2
2.	19.2	19.2	19.2	12.	19.2	19.2	19.8
3.	19.2	19.2	19.2	13.	19.2	19.2	19.2
4.	19.2	19.2	19.2	14.			
5.	19.2	19.8	19.2	15.			
6.	19.2	19.8	19.8	16.			
7.	19.8	19.2	19.2	17.			
8.	19.2	19.8	19.2	18.			
9.	19.8	19.2	19.2	19.			
10.	19.8	19.2	19.2	20.			
				21.			
				22.			
				23.			
				24.			
				25.			
				26.			
				27.	24.8	23.7	24.3
				28.	24.8	24.8	24.3
				29.	24.3	24.3	24.8
				30.	23.7	24.8	24.3

II. Test Fuel:

1. No. of 2 x 4's: 0
2. No. of 4 x 4's: 4
3. Total No. of Fuel Pieces: # 27-30
4. Weight, Lbs.: 23.0
5. Species: DF
6. Moisture Content, % Ave. (Dry Basis): 24.41
7. Length, In.: 20.0

III. Pre-Burn Fuel:

1. No. of 2 x 4's: 13
2. No. of 4 x 4's: 0
3. Total No. of Fuel Pieces: # 1-13
4. Weight, Lbs.: 24.9
5. Species: DF
6. Moisture Content, % Ave. (Dry Basis): 19.35
7. Length, In.: 21 ÷ 3 = 7.0

IV. Kindling Fuel:

1. No. of 2 x 4's: 0
2. No. of 4 x 4's: 1
3. Total No. of Fuel Pieces: 1
4. Weight, Lbs.: 4.2
5. Species: DF
6. Moisture Content, % Ave. (Dry Basis): 19.0
7. Length, In.: 20.0

Date: 4-13-89

Attention: Mike Cave

Subject: Analysis on one (1) wood fuel sample received 4-10-89.

Item: Wood Fuel

Reference: Mark's Custom Stoves
Model K-400 FS
184-1
high cycle

REPORT:

Analysis:

Moisture, %, as received	12.1
Moisture, %, dry basis	13.8
Density, g/cm^3, dry basis	0.48
Higher Heat of Combustion, BTU/lb., dry basis	8397.6

J.M. Toll

Report Number: 321591

Charges: $70

WOOD/FUEL
(ON NTL STOVE DISK)

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 3 - STOVE OPERATION LOG

Stove Mfg.: Marks Custom Stoves Date: 4-10-89

Stove Model: K-400 FS Technician: D. Windsor

Stove I.D. Number: 184

Run Number: 1

24 Hr. Time	OPERATION
09:43	Ignited 4.2 lbs kindling, Door ajar, By-pass open, Drafts 100% open
09:50	Added 24.9 lbs Preburn, Door ajar, By-pass open Drafts 100%
09:55	Door closed, By-pass closed. Draft 100% open
10:00	Started Preburn Readings
10:42	Stoked and Added 3.8 lbs Preburn
10:57	Stoked and Added 6.2 lbs Preburn

NORTHWEST TESTING LABORATORIES
Woodstove Emission Testing

PAGE 4 - PREBURN DATA

Stove Mfg.: Marks Custom Stoves
Run Number: 1
Stove Model: K-400 FS
Date: 4-10-89
Stove I.D. No.: 184
Air Control Setting: 100% open

Data Set No.		Elapsed 24/Hr. Time	TEMPERATURES						Fuel Wt/lb	Prim. Temp. (7)	Cat. Temp. (8)	Cat. Temp. (16)
			Amb.(1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)				
1	5	10:00	62	464	128	286	354	408	21.6	622	1238	N/A
2	10	10:05	63	760	176	340	417	524	19.1	764	1353	
3	15	10:10	65	896	227	395	480	609	16.7	810	1386	
4	20	10:15	66	992	162	459	544	667	14.1	966	1405	
5	25	10:20	67	1050	175	525	604	740	11.7	1140	1333	
6	30	10:25	68	1080	180	602	667	803	9.6	1057	1281	
7	35	10:30	70	1096	193	655	712	855	8.0	1148	1424	
8	40	10:35	70	1066		695	781	887	6.7	1162	1361	
9	45	10:40	70	1027		723	869	901	5.6	1169	1385	
10	50	10:45	72	1013		776	875	893	7.8	1042	1274	
11	55	10:50	74	1079		787	951	933	5.9	1243	1404	
12	60	10:55	74	1092		824	983	957	4.6	1265	1394	
13	65	11:00	77	1024		850	937	961	8.6	1177	1261	
14	70	11:05	74	1107		788	899	899	6.8	1179	1322	
15	75	11:10	78	1133		789	915	926	5.4	1176	1398	
						Test	Fuel	Added	at 4.6 lbs,			

Range 4.6 to 5.8 lb

< 3.8 lbs added at 5.0 lbs

< Add 6.2 lbs Preburn

SIGNED: David Windsor
DATE: April 10, 1989

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 1
Date: 4-10-89

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES Amb. (1)	Stove Surfaces F(2)	B(3)	942 R(4)	RS(5)	LS(6)	Primry Comb. (7)	Catl. or Secondry Comb.(8)	Catl. or Secondary Comb.(16)	Flue db (9)	Flue wb (10)	Dry Gas In (11)	Dry Gas Out (12)	Oven Temp °F (13)	Imp. Temp. °F (14)	Tracer Temp. °F (15)
1	0	11:13	23.0	75	1136		795	915	922	1140	1407		633	165	70	73	248	32	71
2	10	11:23	18.8	76	1148		669	767	739	803	1329		588	168	75	74	246	32	72
3	20	11:33	15.4	79	1097		642	793	720	925	1435		681	174	80	73	248	32	73
4	30	11:43	11.2	77	1150		748	986	852	1369	1436		604	169	83	71	241	32	74
5	40	11:53	7.5	78	1141		840	1042	951	1325	1468		617	174	85	70	248	32	75
6	50	12:03	4.5	78	1062		987	1037	972	1246	1375		596	165	89	70	244	32	76
7	60	12:13	2.4	80	1015		999	985	977	1274	1273		557	151	88	69	230	32	76
8	70	12:23	0.5	78	962		965	948	973	1210	1227		540	156	90	69	232	32	77
9	74	12:27		78	957		953	943	971	1178	1276		546	154	91	69	229	32	77
							956												
			avg	78	1074		844	935	897	1163	1358		596		83	71			75
															77				

SIGNED BY: David A Wundson DATE: April 10, 1989

ΔT = + 14.0
Avg Skin = 938° F

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 6 - PARTICULATE TRAIN OPERATION

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 1

Date: 4-10-89
Expected Burn Rate: High
Oven Temp. Setting: 548°F
Tracer Rota, mm: 60
Tracer Pressure in H_2O: 0.12

Proportional:

Data Point	24 hr. Time	Elap. Time Δt	SO2 Scale	SO2 ppm	CO2 Scale	CO %	O2 %	Orifice Δ H In H20	Dry Gas Meter ft 3	Vacuum in Hg	Stove Static Pressure In H20	Comments
1	11:13	0	10.5	157.5	66.5	.11	3.2	0.011	435.646	<.5		
2	11:23	10	13	195	73.5	2.03	0.18	0.007	436.65	<.5		
3	11:33	20	11.5	172.5	73.5	2.32	0.07	0.009	437.43	<.5		
4	11:43	30	13	195	74	2.45	0.10	0.007	438.30	<.5		
5	11:53	40	11	165	73	1.53	.62	0.010	439.03	<.5		
6	12:03	50	11	165	66	0.20	3.29	0.010	439.95	<.5		
7	12:13	60	10	150	53	0.01	6.85	0.012	440.86	<.5		
8	12:23	70	10.5	157.5	51	0.01	7.38	0.011	441.78	<.5		
9	12:27	74	10.5	157.5	50	0.02	7.64	0.011	442.150	<.5		
10												
11												
12					64.5	0.96		0.010	6.504			
13			avg		16.13							
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												

SIGNED: David Windsor DATE: April 10, 1989

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 1
Date: 4-10-89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:		Pre - Tes		
ZERO GAS:	0.0	0.00	N/A	0.0
AUDIT GAS:	59.9	5.01		34.2
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.0%	0.0%		0.0%
TIME (24 HOUR):	10:17	10:17	↓	10:17

SIGNED: David Wurdack
DATE: April 10, 1989

NORTHWEST TESTING LABORATORIES
Woodstove Emmission Testing

PAGE 7 - POST TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184

Run No.: 1
Date: 4-10-89
Time: 12145

Analyzer Audit

	Scale Readings			
	CO_2	O_2	CO	SO_2
Zero Gas	0.0	N/A	0.00	0.2
Audit Gas	60.0		5.03	34.0
Desired	59.9		5.01	34.2
% Difference	0.2%		0.4%	1.2%
% Drift Check:				
Zero Drift	0.0%		0.0%	0.2%
Mid Level Drift	0.1%		0.2%	0.2%
Leak Test Results	passed		passed	passed

Particulate Train

Leakage Rate: 0.007 ft^3/min.

Extra Filters Used: N/A

Ambient

Tdb 79 °F
Twb 64 °F
Pbaro 29.98 in Hg. 29.955
Moisture 1.5 % By Volume 1.4
Relative Humidity, % 44

SIGNED: David Windsor DATED: April 10, 1989

SAMPLE EXTRACTION DATA

Stove Mfg.: Marks Custom Stoves Test: 2

Stove Model: K-400 FS Test Cycle: High

Date: 4-10-89 Stove I.D. No.: 184

Technician: D. Windsor

V_V

CONDENSED WATER VOLUME, GMS

	Modified Temp. 100 ml H20	Standard Imp 100 ml Hz	Modified Imp. Dry	Modified Imp. 200 Gms Silica Gel
Gross Weight	620.9	610.0	487.1	711.6
Initial Weight	563.2	607.8	487.1	704.8
Net Weight	57.7	2.2	0.0	6.8

TOTAL 66.7 GMS

W

PARTICULATE CATCH, GMS

	OVEN FILTER(S)				TRAIN FILTER(S)	
Gross Weight	.7934				.7718	
Initial Weight	.7612				.7666	
Net Weight	0.0322			—	0.0052	TOTA

TOTAL 0.0374 GMS

	Front Catch Probe	Rear Catch Impingers	DCM	H20	
Beaker, ml	45 ml	145 ml	150 ml	200 ml	55
Gross, Weight	94.1006	97.0210	98.7689	95.2346	
Initial Weight	94.0797	96.9716	98.7338	95.2096	
Net Weight	0.0209	0.0494	0.0351	0.0250	
Evaporation	0.0004	0.0013	0.0009	0.0024	
Residue Weight	0.0205	0.0481	0.0342	0.0226	TOTA

TOTAL 0.1254 GMS 0.0686 0.0568

Particulate Total = 0.1628 gm

= 162.8 mg

ANALYSIS CONTROL LOG

DATE	CLIENT	TEST I.D.	SAMPLE WEIGHTS						TIME 24 HR.
			OVEN FILTER	TRAIN FILTER	PROBE	ACETONE	DCM	H20	
4-11	Marks Custom K-400FS	184-2	.9838	.7760					14:00
4-12			.8642	.7733					13' 30
4-13			.8322	.7719	94.0992	97.0225	98.7684		07:30
4-13			.8036	.7718	94.1009	97.0237	98.7689		09:30
4-13			.7932		94.1006	97.0229			11:30
4-13			.7934			97.0222		95.2361	13:30
4/14						97.0207		95.2345	09:00
						97.0210		95.2346	12:45

METHOD 5H FLOW RATE (STACK) CALCULATIONS
(Put general info in col B, data info in col H.)

Lab name: NORTHWEST TESTING LABS, INC.
Stv manu: MARKS CUSTOM STOVES
Model no: K-400 FREESTANDING
Tst Date: APRIL 11, 1989

Yhc 1=cat,2=ncat : 1
Wc (if supplied) :
Burn rate (kg/hr): 2.57
Run Number : 2

run time (min).	O2 (%)	CO2 (%)	CO (%)	Fo (1.-1.12)	Stack Gas Flow Rate (dscfh)	(dscfm)	(dsm3/hr)
0	5.00	15.00	0.05	1.06	667.47	11.12	18.92
10	4.40	15.50	0.13	1.06			
20	8.90	11.30	0.13	1.06			
30	10.60	9.60	0.10	1.07			
40	12.10	8.30	0.05	1.06			
50	10.90	9.40	0.08	1.06			
60	5.40	14.30	0.60	1.06			
70	1.40	17.40	1.84	1.06			
80	1.90	17.80	0.26	1.06			
90	3.10	16.80	0.15	1.05			
100	4.70	15.30	0.04	1.06			
110	6.80	13.30	0.04	1.06			
120	5.30	14.80	0.02	1.05			
130	6.40	13.60	0.04	1.06			
140	7.40	12.80	0.05	1.05			
150	6.20	13.90	0.06	1.06			
160	7.90	12.30	0.08	1.05			
170	10.40	9.90	0.02	1.06			
180	10.70	9.60	0.03	1.06			
190	11.70	8.60	0.03	1.07			
200	10.80	9.50	0.03	1.06			

Method 5H Proportionality Rate and Sample Volume Calculation
(put general info in col. C; Pb,Y,& unit info in col. G)

Lab name: NORTHWEST TESTING LAB., INC.
Stv manu: MARKS CUSTOM STOVES
Model no: K-400 FREESTANDING
Tst date: APRIL 11, 1989
Run no : 2.0

Units 1=metric, 2=Englsh: 2.0
Y, DGM: 0.971
Pb (mm,in. Hg): 30.1

NOTE: Input raw data below, use F9 for CALC.

run time (min)	tracer conc (ppm,%)	DGM rdg (m3,ft3)	DGM temp (C,F)	DGM dH (mm H2O) (in.H2O)	dDGM vol std (m3,ft3)	PR (%)	Sample vol std (m3,ft3)
0	255.0	442.221	70	0.013			
10	255.0	443.350	74	0.013	1.098	108.9	22.167
20	240.0	444.460	77	0.014	1.072	106.3	
30	247.0	445.590	78	0.013	1.085	101.3	
40	240.0	446.690	79	0.014	1.054	101.3	
50	232.0	447.800	78	0.015	1.062	99.1	
60	225.0	448.940	77	0.016	1.093	98.6	
70	247.5	450.100	76	0.014	1.114	97.5	
80	240.0	451.245	76	0.014	1.102	106.0	
90	232.5	452.390	76	0.015	1.102	102.8	
100	217.5	453.525	76	0.017	1.092	98.7	
110	225.0	454.700	76	0.016	1.130	95.6	
120	217.5	455.870	76	0.017	1.126	98.5	
130	210.0	457.050	76	0.019	1.135	96.0	
140	217.0	458.340	76	0.017	1.241	101.3	
150	225.0	459.520	76	0.016	1.135	95.8	
160	225.0	460.660	76	0.016	1.097	95.9	
170	232.0	461.810	76	0.015	1.106	96.8	
180	232.0	462.960	77	0.015	1.106	99.8	
190	232.0	464.110	77	0.015	1.104	99.6	
200	232.0	465.268	77	0.015	1.112	100.3	

NORTHWEST TESTING LABORATORIES
Woodstove Emmission Testing

PAGE 1 - STOVE INFORMATION AND PRE-TEST DATA

Stove Manufacturer: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. Number: 184
Run Number: 2
Date: 4-11-89
Expected Burn Rate: Med. High

STOVE

Weight: 502.1 lb.
Platform Scale Audit?: OK
Primary Air Control Setting: 7/8" open
Blower: On ___ Off ___ Auto. ___ N/A ___
Flue Pipe Gauge: 24
Flue Pipe Diameter in.: 8 in.
Pictures: Yes X No ___
Operating Instructions:
Stove Manual ___ Verbal ___ Other X written
Stack Cleaned: Yes X No ___

CATALYST Yes X No ___

Catalyst Brand: Applied Ceramics
Catalyst I.D.: Firecat, 12½ x 7½ x 3, 16 cell
Catalyst Age: 50+ hrs
Catalyst Provided: Marks Custom Stoves

AMBIENT

Dry Bulb Reading 72 °F
Wet Bulb Reading 61 °F
Relative Humidity 53 %
Baro. 30.11 in Hg.

% Moisture 1.4 % Volume ___

CONTINUOUS ANALYZERS

Audited by: T. Palmer
Leak Tested by: T. Palmer

PARTICULATE TRAIN

Probe Length & Type 6" Pyrex
Nozzle Size .62 in.
ΔH @ .65
ΔH Magnehelic Range, 0-1 in H_2O
Leakage Rate: .001 $Ft.^3$/min.

TRACER GAS

Gas Used: SO2
Rotameter No.: 601
Rotameter Rdg.: 60
Ball Read: 55
CC/Min.: 70.62
$ft.^3$/hr. 1.5
(cc/min. ÷ 472 = ft^3/hr.)
Injection System Rate
Checked: Yes: X No: ___

SIGNED BY: [signature]

DATE: 4-11-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 2 - FUEL DATA

Stove Manufacturer: Monti Custom Stoves
Stove Model: K-400 FS
Stove I.D. Number: 184
Technician: T. Patmer

Run Number: 2
Expected Burn Rate: Med. High
Calculated Charge Wt.: 24.8
Coal Bed Wt. Lbs.: 4.6
HHV Sample: Yes X No
(Saw Dust Catch & Block)

I. Fuel Moisture Content, % (Dry Basis):

1.	19.2	19.2	19.2	11.	19.2	19.2	19.2	21.			
2.	14.2	19.2	14.2	12.	19.2	19.2	19.2	22.			
3.	19.8	19.8	14.8	13.	19.2	19.2	19.2	23.			
4.	19.8	19.8	19.8	14.	19.2	19.2		24.			
5.	19.8	19.2	14.8	15.				25.			
6.	19.8	14.8	20.3	16.				26.			
7.	21	19.8	21	17.				27.	21.5	22.0	23.1
8.	19.8	21	21	18.				28.	21.5	23.1	23.1
9.	22	19.2	19.2	19.				29.	21.5	22.6	19.8
10.	19.2	19.2	19.2	20.				30.	22.6	23.1	24.3

II. Test Fuel:

1. No. of 2 x 4's: 0
2. No. of 4 x 4's: 4
3. Total No. of Fuel Pieces: #27 → #30
4. Weight, Lbs.: 23.1
5. Species: D.F.
6. Moisture Content, % Ave. (Dry Basis): 22.35
7. Length, In.: 20"

III. Pre-Burn Fuel:

1. No. of 2 x 4's: 14
2. No. of 4 x 4's: 0
3. Total No. of Fuel Pieces: #1 → 14
4. Weight, Lbs.: 26.4
5. Species: D.F.
6. Moisture Content, % Ave. (Dry Basis): 19.65
7. Length, In.: 21" ÷ 3 = 7"

IV. Kindling Fuel:

1. No. of 2 x 4's: 0
2. No. of 4 x 4's: 1
3. Total No. of Fuel Pieces: 1
4. Weight, Lbs.: 4.4
5. Species: D.F.
6. Moisture Content, % Ave. (Dry Basis): 20%
7. Length, In.: 20"

Date: 4-20-89

Attention: Mike Cave

Subject: Analysis on one (1) wood fuel sample received 4-11-89.

Item: Wood Fuel

Reference: Mark's Custom Stoves
Model K-400 FS
184-2

REPORT:

Analysis:

Moisture, %, as received	20.3
Moisture, %, dry basis	25.5
Density, g/cm^3, dry basis	0.55
Higher Heat of Combustion, BTU/lb., dry basis	8,028

9M2

Report Number: 321591

WOOD/FUEL
(ON NTL STOVE DISK)

Charge: $70

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 3 - STOVE OPERATION LOG

Stove Mfg.: Marks Custom Stoves Date: 4-11-89

Stove Model: K-400 FS Technician: D. Windsor

Stove I.D. Number: 184

Run Number: 2

24 Hr. Time	OPERATION
08:37	Ignited 4.4 lbs kindling Door ajar, By-pass open, Drafts 100% open
08:45	Added # 1 Pre-Burn, 26.4 lbs, Shut Dampers, Set Air at 7/8" open on both sides
08:50	Started Pre-Burn Readings
09:32	Stoked Fire
09:52	Stoked Fire
10:05	Added 23.1 lbs Test Fuel, Drafts 100% open By-pass open
10:10	closed Door and By-pass, Drafts set at 7/8"

NORTHWEST TESTING LABORATORIES
Woodstove Emission Testing

PAGE 4 - PREBURN DATA

Stove Mfg.: Marks Custom Stoves Run Number: 2

Stove Model: K-400 FS Date: 4-11-89

Stove I.D. No.: 184 Air Control Setting: 7/8" open on Both Sides

4.6 → 5.8

Data Set No.	Elapsed 24/Hr. Time	TEMPERATURES						Fuel Wt/lb	Prim. Temp. (7)	Cat. Temp. (8)	Cat. Temp. (16)	
		Amb. (1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)					
1 5	08:50	63	428	141	393	280	447	23.2	527	1155		
2 10	08:55	63	558	173	395	307	472	21.5	560	1188		
3 15	09:00	63	767	214	407	371	510	19.2	624	1187		
4 20	09:05	64	850	272	391	452	530	17.2	647	1227		
5 25	09:10	66	891	324	403	494	542	15.7	658	1244		
6 30	09:15	67	934	370	425	539	568	14.1	712	1218		
7 35	09:20	68	952	407	451	611	598	12.9	738	1210		
8 40	09:25	68	980	421	473	670	616	11.7	751	1250		
9 45	09:30	69	943	432	498	699	639	10.8	781	1225		← STOKED
10 50	09:35	69	965	453	562	700	671	9.1	822	1141		
11 55	09:40	69	969	488	583	713	701	8.4	855	1164		
12 60	09:45	68	950	538	608	730	724	7.6	884	1142		
13 65	09:50	70	910	575	616	740	717	7.1	866	1106		← STOKED
14 70	09:55	71	895	608	648	728	716	5.7	876	1130		
15 75	10:00	72	923	631	645	722	709	5.1	876	1190		
					Added test fuel →			4.6				

SIGNED: J. Tatum DATE: 4-11-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

+ 271 = 1.9
− 412 = 1.25

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: C-400 FS
Stove I.D. No.: 184
Run No.: 2
Date: 4-11-89

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES Amb. (1)	Stove Surfaces F(2)	B(3)	R(4)	RS(5)	LS(6)	Primry Comb. (7)	Catl. or Secondry Comb. (8)	Catl. or Secondary Comb. (16)	Flue db (9)	wb (10)	Dry Gas In (11)	Out (12)	Oven Temp °F (13)	Imp. Temp. °F (14)	Tracer Temp. °F (15)
1	0	10:05	23.1	71	933	641	643	713	709	871	1170		727	143	69	71	247	32	70
2	10	10:15	20.9	71	816	657	556	564	600	617	1138		543	157	75	72	245	32	71
3	20	10:25	19.6	72	779	647	488	520	587	570	1142		315	150	81	72	225	32	73
4	30	10:35	18.6	74	713	611	455	490	492	530	1062		299	146	84	71	224	32	74
5	40	10:45	17.7	73	661	572	437	463	477	581	987		281	145	87	70	227	32	75
6	50	10:55	16.8	73	624	536	422	455	477	590	1019		279	145	85	70	241	32	73
7	60	11:05	15.2	72	634	494	427	473	532	714	1192		318	164	81	72	241	32	71
8	70	11:15	13.0	72	827	467	477	514	642	918	1203		357	162	80	72	248	32	71
9	80	11:25	11.0	73	926	456	525	619	733	924	1233		328	161	80	71	248	32	72
10	90	11:35	9.2	74	949	457	561	667	757	895	1215		318	158	81	70	248	32	72
11	100	11:45	7.6	73	954	460	588	696	828	1315	1206		316	155	81	70	248	32	72
12	110	11:55	6.4	74	877	453	596	688	812	908	1145		303	155	81	70	248	32	73
13	120	12:05	5.2	75	862	451	588	690	775	941	1117		280	153	82	70	248	32	73
14	130	12:15	4.1	76	886	464	581	701	735	881	1125		273	147	81	70	248	32	73
15	140	12:25	3.3	77	793	500	594	692	706	848	1075		265	145	81	70	248	32	73
16	150	12:35	2.3	77	793	561	581	673	705	838	1112		276	147	82	70	248	32	74
17	160	12:45	1.5	76	779	582	598	669	687	806	1099		273	141	82	70	248	32	74
18	170	12:55	1.1	77	717	588	592	644	658	773	1010		259	134	82	70	248	32	75
19	180	13:05	.7	77	677	573	568	621	636	845	969		257	132	81	71	248	32	75
20	190	13:15	.4	77	648	553	555	607	612	728	920		255	129	85	71	247	32	76

SIGNED BY: T. J. Johnson DATE: 4-11-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 2
Date: 4-11-89

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES Amb. (1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Primry Comb. (7)	Catl. or Secondry Comb.(8)	Catl. or Secondary Comb.(16)	Flue db (9)	Flue wb (10)	Dry Gas In (11)	Dry Gas Out (12)	Oven Temp °F (13)	Imp. Temp. °F (14)	Tracer Temp. °F (15)
21	200	15:25	.0	77	624	535	545	605	597	708	901		259	127	82	72	246	55	74
								581.2											
			avg	74	784	536	542	608	652	1802	1098		293		81	71			73
																76			

SIGNED BY: _____ DATE: _____

ΔT = -146.6°F
Avg Skin = 624.4°F

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 6 - PARTICULATE TRAIN OPERATION

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 2

Date: 4-11-89
Expected Burn Rate: Med. High
Oven Temp. Setting: 248°F
Tracer Rota, mm: 60
Tracer Pressure in H_2O: .12

PC = 3

Data Point	24 hr. Time	Elap. Time Δt	SO2 Scale	SO2 ppm	CO2 Scale	CO %	O2 %	Orifice Δ H In H2O	Dry Gas Meter ft 3	Vacuum in Hg	Stove Static Pressure In H2O	Comments
1	10:05	0	17.5	255	60	.05	4.97	.013	442.221	<.5	.075	
2	10:15	10	17	255	62	.13	4.39	.013	443.335	<.5	.080	
3	10:25	20	16	240	45	.13	8.9	.014	444.46	<.5	.075	
4	10:35	30	16.5	247	38.5	.10	10.64	.013	445.59	<.5	.075	
5	10:45	40	16	240	33	.05	12.12	.014	446.69	<.5	.070	
6	10:55	50	15.5	232	37.5	.08	10.91	.015	447.80	<.5	.070	
7	11:05	60	15	225	57	.60	5.43	.016	448.94	<.5	.075	
8	11:15	70	16.5	247.5	69.5	1.84	1.36	.014	450.10	<.5	.080	
9	11:25	80	16	240	71	0.26	1.93	.014	451.245	<.5	.080	
10	11:35	90	15.5	232.5	67	.15	3.05	.015	452.39	<.5	.075	
11	11:45	100	14.5	217.5	61	.04	4.71	.017	453.525	<.5	.075	
12	11:55	110	15	225	53	.04	6.83	.016	454.70	<.5	.070	
13	12:05	120	14.5	217.5	59	.02	5.25	.017	455.87	<.5	.070	
14	12:15	130	14	210	54.5	.04	6.43	.019	457.05	<.5	.070	
15	12:25	140	14.5	217	51	.05	7.35	.017	458.34	<.5	.070	
16	12:35	150	15	225	55.5	.06	6.16	.016	459.52	5.5	.065	
17	12:45	160	15	225	49	.08	7.87	.016	460.66	<.5	.065	
18	12:55	170	15.5	232	39.5	.02	10.42	.015	461.81	<.5	.065	
19	13:05	180	15.5	232	38.5	.03	10.68	.015	462.96	<.5	.060	
20	13:15	190	15.5	232	34.5	.03	11.74	.015	464.11	<.5	.060	
21	13:25	200	15.5	232	38	.03	10.81	.015	465.268	<.5	.055	
22	13:35	210										
23	13:45	220			51.14	0.18		0.015	23.047		0.070	
24	13:55	230			12.79							
25	14:05	240										

SIGNED: [signature]

DATE: 4-11-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Marks Custom Stoves
Stove Model: IC-400 FS
Stove I.D. No.: 184
Run No.: 2
Date: 4-11-89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:		PRE-Test Calibration		
ZERO GAS:	0.0	0.0	NA	0.0
AUDIT GAS:	59.9	5.01		34.2
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.0%	0.0%		0.0%
TIME (24 HOUR):	09:30	09:30		09:30

SIGNED: [signature]
DATE: 4-11-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 2
Date: 4-11-89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:		120 min		
ZERO GAS:	0.0	0.00	N/A	.5
AUDIT GAS:	60.0	5.02		35.5
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.2%	0.2%		2.9%
TIME (24 HOUR):	12:10	12:10		12:10

SIGNED: Daniel Windsor
DATE: April 11, 1989

NORTHWEST TESTING LABORATORIES
Woodstove Emmission Testing

PAGE 7 - POST TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184

Run No.: 2
Date: 4-11-89
Time: 13:46

Analyzer Audit

	Scale Readings			
	CO_2	O_2	CO	SO_2
Zero Gas	0.0	N/A	0.0	0.5
Audit Gas	59.9		5.01	35.0
Desired	59.9		5.01	34.2
% Difference	0.0%		0.0%	1.8%
% Drift Check:				
Zero Drift	0.0%		0.0%	0.5%
Mid Level Drift	0.0%		0.0%	0.8%
Leak Test Results	OK			

Particulate Train

Leakage Rate: 1001 ft^3/min.
Extra Filters Used: N/A

Ambient

Tdb 77 °F 30.105
Twb 64 °F
Pbaro 30.10 in Hg. 1.45
Moisture 1.45 % By Volume
Relative Humidity, % 49

SIGNED: S. Talmon DATED: 4-11-89

SAMPLE EXTRACTION DATA

Stove Mfg.: Marks Custom Stoves Test: 3

Stove Model: K-400 FS Test Cycle: Low

Date: 4-11-89 Stove I.D. No.: 184

Technician: D Windsor

V_V

CONDENSED WATER VOLUME, GMS

	Modified Temp. 100 ml H20	Standard Imp 100 ml Hz	Modified Imp. Dry	Modified Imp. 200 Gms Silica Gel
Gross Weight	675.9	609.5	488.0	719.6
Initial Weight	563.3	607.0	486.8	711.9
Net Weight	112.6	2.5	1.2	7.7

TOTAL 124.0 GMS

W .8012 PARTICULATE CATCH, GMS .7588 4-13-89 08:04

	OVEN FILTER(S)				TRAIN FILTER(S)	
Gross Weight	.7960				.7585	
Initial Weight	.7602				.7545	
Net Weight	0.0358				0.0040	TOTA

TOTAL 0.0398 GMS

	Front Catch Probe	Rear Catch Impingers	DCM	H20	
Beaker, ml	75	160	150	200+140	
Gross, Weight	102.6355	104.7922	95.4052	101.3562	
Initial Weight	102.5950	104.7458	95.3330	101.2889	
Net Weight	0.0405	0.0464	0.0722	0.0673	
Evaporation	0.0007	0.0014	0.0009	0.0032	
Residue Weight	0.0398	0.0450	0.0713	0.0641	TOTA

TOTAL 0.2202 GMS 0.0848 0.1354

Total Particulate = 0.2600 gm

= 260.0 mg

ANALYSIS CONTROL LOG

DATE	CLIENT	TEST I.D.	SAMPLE WEIGHTS						TIME 24 HR.
			OVEN FILTER	TRAIN FILTER	PROBE	ACETONE	DCM	H20	
4-13	Marks Custom K-400	184-3	.8012	.7588					08:04
4/14			.7999	.7585 ✓					09:00
4/14			.7964						12:50
4/15			.7960 ✓		102.6356	104.7930	95.4054	101.3560	09100
4/15					102.6355 ✓	104.7922	95.4052 ✓	101.3562 ✓	11:35
4/17						104.7922 ✓			07:30

METHOD 5H FLOW RATE (STACK) CALCULATIONS
(Put general info in col B; data info in col H.)

Lab name: NORTHWEST TESTING LABS, INC.
Stv manu: MARKS CUSTOM STOVES
Model no: K-400 FREESTANDING
Tst Date: APRIL 12, 1989

Yhc 1=cat,2=ncat : 1
Wc (if supplied) :
Burn rate (kg/hr): 0.98
Run Number : 3

run time (min)	O2 (%)	CO2 (%)	CO (%)	Fo (1.-1.12)	Stack Gas Flow Rate (dscfh)	(dscfm)	(dsm3/hr)
0	4.50	14.90	1.06	1.06	267.59	4.46	7.58
10	10.40	9.90	0.02	1.06			
20	9.20	11.00	0.02	1.06			
30	7.90	12.30	0.01	1.06			
40	9.60	10.60	0.01	1.07			
50	9.80	10.50	0.01	1.06			
60	9.40	10.90	0.01	1.05			
70	8.80	11.40	0.01	1.06			
80	9.00	11.30	0.02	1.05			
90	9.80	10.50	0.02	1.06			
100	9.90	10.40	0.02	1.06			
110	10.40	9.90	0.02	1.06			
120	10.20	10.10	0.02	1.06			
130	9.20	11.00	0.02	1.06			
140	7.80	12.40	0.02	1.06			
150	6.40	13.60	0.02	1.07			
160	5.90	14.10	0.02	1.06			
170	6.40	13.60	0.02	1.07			
180	9.10	11.10	0.02	1.06			
190	8.40	11.80	0.02	1.06			
200	7.00	13.10	0.02	1.06			
210	5.90	13.90	0.45	1.06			
220	3.90	15.00	1.75	1.07			
230	4.10	14.90	1.65	1.06			
240	3.10	15.30	2.60	1.07			
250	4.00	15.10	1.45	1.06			
260	4.60	14.60	1.25	1.07			
270	4.50	14.60	1.40	1.07			
280	4.60	14.90	0.90	1.06			
290	6.30	13.80	0.08	1.05			
300	6.70	13.40	0.02	1.06			
310	6.40	13.60	0.02	1.07			
320	6.30	13.82	0.02	1.06			
330	6.70	13.40	0.03	1.06			
340	6.40	13.60	0.03	1.06			
350	7.20	12.90	0.02	1.06			
360	6.80	13.30	0.02	1.06			
370	7.00	13.10	0.02	1.06			
380	7.80	12.40	0.02	1.06			
390	8.30	11.90	0.02	1.06			
400	8.80	11.40	0.02	1.06			
410	9.90	10.40	0.02	1.06			
420	10.60	9.80	0.02	1.05			
430	10.40	9.90	0.02	1.06			
440	10.40	9.90	0.02	1.06			
450	9.90	10.40	0.02	1.06			
460	9.80	10.50	0.02	1.06			

470	9.60	10.60	0.02	1.06
480	9.10	11.10	0.02	1.06
490	8.60	11.60	0.02	1.06
500	9.10	11.10	0.02	1.06
510	8.60	11.60	0.02	1.06
520	9.10	11.10	0.02	1.06
530	9.60	10.60	0.02	1.06
540	9.40	10.90	0.02	1.05
550	9.50	10.80	0.02	1.05
560	8.80	11.40	0.02	1.06
570	9.10	11.10	0.02	1.06
580	9.40	10.90	0.02	1.05

Method 5H Proportionality Rate and Sample Volume Calculation
(put general info in col. C; Pb,Y,& unit info in col. G)

Lab name: NORTHWEST TESTING LAB., INC.
Stv manu: MARKS CUSTOM STOVES
Model no: K-400 FREESTANDING
Tst date: APRIL 12, 1989
Run no : 3.0

Units 1=metric, 2=English: 2.0
Y, DGM: 0.971
Pb (mm,in. Hg): 29.9

NOTE: Input raw data below, use F9 for CALC.

run time (min)	tracer conc (ppm,%)	DGM rdg (m3,ft3)	DGM temp (C,F)	DGM dH (mm H2O) (in.H2O)	dDGM vol std (m3,ft3)	PR (%)	Sample vol std (m3,ft3)
0	592.5	465.375	73	0.004			
10	390.0	466.060	76	0.009	0.659	108.8	43.311
20	427.5	466.960	79	0.007	0.861	93.5	
30	382.5	467.770	78	0.009	0.770	91.8	
40	390.0	468.690	77	0.009	0.877	93.4	
50	390.0	469.640	76	0.009	0.907	98.6	
60	420.0	470.600	75	0.008	0.918	99.8	
70	420.0	471.540	74	0.008	0.901	105.4	
80	427.0	472.470	73	0.007	0.893	104.5	
90	427.0	473.270	74	0.007	0.769	91.6	
100	427.0	474.080	74	0.007	0.778	92.5	
110	442.0	474.880	74	0.007	0.768	91.4	
120	457.0	475.660	75	0.006	0.749	92.2	
130	427.0	476.410	75	0.007	0.719	91.5	
140	412.0	477.220	76	0.008	0.776	92.4	
150	412.0	478.150	76	0.008	0.889	102.1	
160	397.0	479.080	76	0.009	0.889	102.1	
170	382.0	480.030	77	0.009	0.908	100.5	
180	405.0	480.970	78	0.008	0.897	95.5	
190	427.0	481.830	78	0.007	0.819	92.5	
200	435.0	482.640	78	0.007	0.772	91.8	
210	435.0	483.440	79	0.007	0.762	92.4	
220	412.0	484.230	79	0.008	0.751	91.1	
230	412.0	485.080	79	0.008	0.808	92.8	
240	405.0	485.930	80	0.008	0.808	92.8	
250	397.0	486.800	80	0.009	0.826	93.2	
260	427.0	487.680	81	0.007	0.835	92.4	
270	442.0	488.490	81	0.007	0.767	91.3	
280	472.0	489.270	81	0.006	0.739	91.0	
290	495.0	490.000	81	0.005	0.692	91.0	
300	487.0	490.700	81	0.006	0.663	91.5	
310	502.0	491.410	81	0.005	0.673	91.3	
320	495.0	492.110	81	0.005	0.663	92.8	
330	510.0	492.830	81	0.005	0.682	94.1	
340	510.0	493.530	81	0.005	0.663	94.3	
350	495.0	494.230	81	0.005	0.663	94.3	
360	487.0	494.940	80	0.006	0.673	92.8	
370	487.0	495.670	80	0.006	0.693	94.0	
380	495.0	496.390	80	0.005	0.683	92.8	
390	517.0	497.150	80	0.005	0.721	99.5	
400	517.0	497.950	80	0.005	0.759	109.4	
410	547.0	498.750	80	0.004	0.759	109.4	
420	562.0	499.510	79	0.004	0.721	110.0	

430	570.0	500.240	79	0.004	0.694	108.7
440	570.0	500.960	79	0.004	0.685	108.8
450	592.0	501.680	78	0.004	0.685	108.8
460	577.0	502.380	78	0.004	0.667	110.0
470	592.0	503.090	78	0.004	0.676	108.8
480	600.0	503.790	78	0.004	0.667	110.0
490	592.0	504.480	78	0.004	0.657	109.9
500	600.0	505.180	77	0.004	0.667	110.0
510	615.0	505.860	78	0.004	0.649	108.5
520	607.0	506.530	77	0.004	0.638	109.4
530	600.0	507.210	78	0.004	0.649	109.8
540	600.0	507.930	77	0.004	0.686	114.7
550	592.0	508.660	77	0.004	0.697	116.5
560	585.0	509.380	76	0.004	0.687	113.4
570	592.0	510.100	76	0.004	0.689	112.3
580	615.0	510.824	76	0.004	0.692	114.2

NORTHWEST TESTING LABORATORIES
Woodstove Emmission Testing

PAGE 1 - STOVE INFORMATION AND PRE-TEST DATA

Stove Manufacturer: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. Number: 184
Run Number: 3
Date: 4-12-89
Expected Burn Rate: Low

STOVE

Weight: 502.1 lb.
Platform Scale Audit?: yes - ok
Primary Air Control Setting: 1/8"
Blower: On ___ Off ___ Auto. ___ N/A ✓
Flue Pipe Gauge: 24
Flue Pipe Diameter in.: 8 in.
Pictures: Yes ✓ No ___
Operating Instructions:
Stove Manual ___ Verbal ___ Other ✓ Written Letter
Stack Cleaned: Yes ✓ No ___

CATALYST Yes ✓ No ___

Catalyst Brand: Applied Ceramics
Catalyst I.D.: Firecat, 2½ x 7½ x 3, 16 cells
Catalyst Age: 50 + hrs
Catalyst Provided: Marks Custom Stoves

AMBIENT

Dry Bulb Reading 72 °F
Wet Bulb Reading 59 °F
Relative Humidity 46 %
Baro. 29.98 in Hg.

% Moisture 1.3 % Volume ___

CONTINUOUS ANALYZERS

Audited by: D. Windsor
Leak Tested by: D Windsor

PARTICULATE TRAIN

Probe Length & Type 6" Pyrex
Nozzle Size 0.62 in.
H @ 0.65
H Magnehelic Range, 0 - 1 in H_2O
Leakage Rate: 0.000 $Ft.^3$/min.

TRACER GAS

Gas Used: SO_2
Rotameter No.: 601
Rotameter Rdg.: 60 mm
Ball Read: Stainless Steel
CC/Min.: 70.62
$ft.^3$/hr. 0.15
(cc/min. ÷ 472 = Ft^3/hr.)
Injection System Rate
Checked: Yes: ✓ No: ___

SIGNED BY: David Windsor

DATE: April 12, 1989

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 2 - FUEL DATA

Stove Manufacturer: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. Number: 184
Technician: D. Windsor

Run Number: 3
Expected Burn Rate: Low
Calculated Charge Wt.: 24.8
Coal Bed Wt. Lbs.: 5.2
HHV Sample: Yes ✓ No
(Saw Dust Catch & Block)

I. Fuel Moisture Content, % (Dry Basis):

1.	19.2	19.2	19.2	11.	19.2	19.2	19.2	21.			
2.	19.8	19.2	19.2	12.	19.2	19.2	19.2	22.			
3.	19.2	19.8	19.8	13.				23.			
4.	19.2	19.2	19.2	14.				24.			
5.	19.2	19.8	19.2	15.				25.			
6.	20.3	19.8	19.2	16.				26.	24.8	24.8	24.8
7.	19.2	20.3	19.2	17.				27.	24.3	24.3	24.8
8.	19.2	19.8	19.8	18.				28.	21.5	24.3	24.8
9.	19.2	19.2	19.8	19.				29.	19.2	22.6	20.3
10.	19.8	20.3	19.8	20.				30.	21.5	22.6	21.5

II. Test Fuel:

1. No. of 2 x 4's: Ø
2. No. of 4 x 4's: 5
3. Total No. of Fuel Pieces: #26 → 30
4. Weight, Lbs.: 25.6
5. Species: DF
6. Moisture Content, % Ave. (Dry Basis): 23.07
7. Length, In.: 20.0

III. Pre-Burn Fuel:

1. No. of 2 x 4's: 12
2. No. of 4 x 4's: Ø
3. Total No. of Fuel Pieces: #1 → 12
4. Weight, Lbs.: 15.5
5. Species: DF
6. Moisture Content, % Ave. (Dry Basis): 19.46
7. Length, In.: 21 ÷ 3 = 7

IV. Kindling Fuel:

1. No. of 2 x 4's: Ø
2. No. of 4 x 4's: 1
3. Total No. of Fuel Pieces: 1
4. Weight, Lbs.: 4.8
5. Species: DF
6. Moisture Content, % Ave. (Dry Basis): 20.0
7. Length, In.: 21.0

Date: 4-20-89

Attention: Mike Cave

Subject: Analysis on one (1) wood fuel sample received 4-12-89.

Item: Wood Fuel

Reference: Mark's Custom Stoves
Model: K-400 F.S.
184-3
Low cycle

REPORT:

Analysis:

Moisture, %, as received	21.5
Moisture, %, dry basis	27.3
Density, g/cm^3, dry basis	0.47
Higher Heat of Combustion, BTU/lb., dry basis	8,304

JMT

Report Number: 321591

WOOD/FUEL
(ON NTL STOVE DISK)

Charges: $70

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 3 - STOVE OPERATION LOG

Stove Mfg.: Marks Custom Stoves Date: 4-12-89

Stove Model: K-400 FS Technician: D. Windsor

Stove I.D. Number: 184

Run Number: 3

24 Hr. Time	OPERATION
08:53	Ignited 4.8 lbs of Kindling, Door ajar, By-pass open, Drafts 100% open
09:03	Added 25.5 lbs of Preburn, Door ajar, By-pass open, Drafts 100% open
09:08	Door and By-pass closed
09:30	set Drafts at 1/8" open
09:35	Started Preburn Readings
10:03	Stoked the Fire
10:35	Test Fuel added, By-pass open, Drafts 100% open
10:39	Door and By-pass Closed
10:40	Drafts set at 1/8"

NORTHWEST TESTING LABORATORIES
Woodstove Emission Testing

PAGE 4 - PREBURN DATA

Stove Mfg.: Marks Custom stoves Run Number: 3

Stove Model: K-400 FS Date: 4-12-89

Stove I.D. No.: 184 Air Control Setting: 1/8"

Data Set No.		Elapsed 24/Hr. Time	TEMPERATURES						Fuel Wt/lb	Prim. Temp. (7)	Cat. Temp. (8)	Cat. Temp. (16)
				Stove Surfaces								
			Amb.(1)	T(2)	B(3)	R(4)	RS(5)	LS(6)				
1	5	9:35	69	932	448	563	599	666	10.7	751	1044	N/A
2	10	9:40	68	911	473	542	589	618	10.1	707	1036	
3	15	9:45	68	857	481	523	586	584	9.6	685	1039	
4	20	9:50	69	816	481	508	589	560	9.0	670	1018	
5	25	9:55	69	778	480	497	591	539	8.7	646	1019	
6	30	10:00	70	742	471	489	593	523	8.4	630	1012	
7	35	10:05	71	693	461	488	616	506	7.6	604	779	
8	40	10:10	70	718	464	478	581	502	7.0	619	870	
9	45	10:15	70	737	468	464	559	495	6.5	609	901	
10	50	10:20	70	737	469	454	544	489	6.2	602	948	
11	55	10:25	70	731	464	449	534	487	5.9	602	963	
12	60	10:30	70	732	459	444	528	485	5.6	595	962	
						Test	Fuel	Added	At 5.2	lbs.		

Range 5.1 to 6.4

← stoked

SIGNED: David Windisch DATE: April 12, 1989

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

+454 = 1.25
+567 = 1.0

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 3
Date: 4-12-89

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES Amb. (1)	528.0 Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Primry Comb. (7)	Catl. or Secondry Comb.(8)	Catl. or Secondary Comb.(16)	Flue db (9)	Flue wb (10)	Dry Gas In (11)	Dry Gas Out (12)	Oven Temp °F (13)	Imp. Temp. °F (14)	Tracer Temp. °F (15)
1	0	10:35	25.6	70	730	457	443	527	483	593	956		179	127	72	74	247	32	73
2	10	10:45	23.9	71	640	456	409	459	461	468	924		233	143	77	75	248	32	75
3	20	10:55	23.2	70	575	473	351	405	399	416	908		181	136	83	75	248	32	76
4	30	11:05	22.5	70	565	452	328	395	375	420	928		182	138	80	75	248	32	71
5	40	11:15	21.9	71	552	438	318	406	362	413	868		171	134	78	76	248	32	69
6	50	11:25	21.4	71	536	422	310	405	352	406	851		170	133	77	74	248	33	68
7	60	11:35	20.8	72	532	409	304	391	345	404	897		167	133	77	72	248	34	69
8	70	11:45	20.2	71	541	397	306	385	346	414	926		170	135	78	69	248	34	70
9	80	11:55	19.6	72	550	384	307	385	347	414	931		168	134	78	68	247	34	71
10	90	12:05	19.1	72	552	376	306	383	347	414	917		167	133	79	68	247	33	72
11	100	12:15	18.6	71	550	365	305	378	348	417	906		166	131	79	68	248	33	72
12	110	12:25	18.1	71	543	357	304	378	349	414	887		164	129	80	68	248	34	73
13	120	12:35	17.6	72	539	352	302	380	348	421	902		166	129	80	69	248	34	73
14	130	12:45	17.0	72	542	347	302	387	345	423	921		167	131	81	69	248	35	74
15	140	12:55	16.4	72	560	341	302	389	347	432	977		173	134	81	70	248	36	74
16	150	13:05	15.7	72	596	335	308	398	356	445	1026		180	137	82	70	248	36	75
17	160	13:15	15.0	72	629	330	317	412	370	463	1046		182	137	82	70	247	35	75
18	170	13:25	14.1	73	651	330	327	433	393	517	1015		187	138	83	71	240	36	76
19	180	13:35	13.5	74	616	342	327	426	402	494	905		175	130	82	72	240	36	76
20	190	13:45	13.1	73	587	349	333	420	391	480	895		169	128	83	72	239	37	77
			1452	11586	7712	6508	8138	7466	8868	18584			3517		1593	1425			1459

SIGNED BY: D. Pahman
DATE: 4-12-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: C-400 FS
Stove I.D. No.: 184
Run No.: 3
Date: 4-12-89

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES Amb. (1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Primry Comb. (7)	Catl. or Secondry Comb. (8)	Catl. or Secondary Comb. (16)	Flue db (9)	wb (10)	Dry In (11)	Gas Out (12)	Oven Temp °F (13)	Imp. Temp. °F (14)	Tracer Temp. °F (15)
21	200	13:55	12.6	74	583	355	335	423	386	475	927		172	129	83	71	239	39	77
22	210	14:05	12.0	74	595	358	340	429	388	486	969		172	130	84	71	240	41	77
23	220	14:15	11.3	74	633	361	356	446	404	517	977		176	135	84	74	244	44	77
24	230	14:25	10.5	74	644	361	377	469	422	543	986		181	137	84	74	242	43	78
25	240	14:35	9.6	75	652	365	393	495	432	547	964		182	138	86	74	244	48	79
26	250	14:45	8.9	76	671	365	400	527	441	557	964		185	138	86	74	244	52	79
27	260	14:55	8.1	76	682	370	395	576	453	580	958		182	134	86	75	247	55	79
28	270	15:05	7.5	76	674	381	398	520	459	582	950		180	132	85	76	246	58	79
29	280	15:15	6.9	75	661	390	398	522	464	594	947		174	128	85	76	245	62	79
30	290	15:25	6.5	76	646	397	397	522	464	593	904		170	122	85	77	246	64	79
31	300	15:35	6.1	77	612	403	395	574	456	577	860		163	119	84	77	251	32	78
32	310	15:45	5.8	77	599	406	396	579	453	578	863		163	119	84	77	250	72	78
33	320	15:55	5.4	77	585	408	396	523	446	570	849		161	117	84	77	226	72	78
34	330	16:05	5.1	78	576	410	396	516	442	567	843		159	117	84	77	225	73	78
35	340	16:15	4.8	78	570	411	394	570	438	560	849		160	117	84	77	227	73	78
36	350	16:25	4.4	78	565	411	388	497	436	563	857		160	117	84	77	227	73	78
37	360	16:35	4.0	77	561	410	385	481	440	567	857		161	118	83	76	227	74	77
38	370	16:45	3.7	77	563	404	382	478	442	566	869		161	118	83	76	229	74	77
39	380	16:55	3.4	77	564	401	378	475	443	570	862		160	115	83	76	228	74	77
40	390	17:05	3.1	77	555	396	372	471	442	564	854		157	112	83	76	222	75	77
				1523	12131	7764	7671	9856	8751	11156	18087		3379		1684	1512			1560

SIGNED BY: JC Tahmus
DATE: 4-12-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 3
Date: 4-12-89

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES Amb. (1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Primry Comb. (7)	Catl. or Secondry Comb. (8)	Catl. or Secondary Comb. (16)	Flue db (9)	wb (10)	Dry In (11)	Gas Out (12)	Oven Temp °F (13)	Imp. Temp. °F (14)	Tracer Temp. °F (15)
41	400	17:15	2.9	76	538	386	372	467	438	556	796		152	107	83	76	228	36	77
42	410	17:25	2.7	77	523	379	367	460	432	551	760		147	104	83	76	228	37	76
43	420	17:35	2.6	77	502	369	364	447	422	537	751		143	100	82	75	229	39	76
44	430	17:45	2.4	76	484	360	359	434	417	534	710		141	100	82	75	225	41	76
45	440	17:55	2.3	77	473	349	358	427	412	529	704		140	100	82	75	226	44	75
46	450	18:05	2.1	77	467	339	356	421	410	526	703		138	100	81	74	225	45	75
47	460	18:15	2.0	77	464	332	354	419	406	521	705		138	100	82	74	224	46	75
48	470	18:25	1.9	77	463	325	353	420	402	520	704		139	100	81	74	223	47	75
49	480	18:35	1.7	77	464	319	356	423	397	514	713		138	100	82	73	226	47	75
50	490	18:45	1.5	77	470	312	361	427	393	511	728		141	102	82	73	225	51	75
51	500	18:55	1.4	78	475	306	365	428	391	507	724		140	102	82	72	224	54	75
52	510	19:05	1.2	77	474	299	367	424	386	502	720		141	102	83	72	226	56	75
53	520	19:15	1.0	78	471	291	368	418	388	505	714		141	100	82	72	226	57	75
54	530	19:25	.9	78	466	285	366	414	390	501	709		137	99	82	73	225	58	74
55	540	19:35	.7	77	461	282	370	410	389	500	699		137	98	81	73	225	59	73
56	550	19:45	.5	77	457	279	377	405	384	490	703		137	98	81	72	226	60	73
57	560	19:55	.3	77	463	276	384	405	381	494	740		137	102	80	72	224	61	73
58	570	19:05	.2	77	469	274	392	408	380	495	749		140	104	80	71	223	63	72
59	580	19:15	.0	76	469	272	398	409	379	492	731		138	100	80	71	225	65	73
			avg	75	555	365	359	432	404	505	854		162		82	73			75

385.4

78

SIGNED BY: [signature]
DATE: 4-12-89

ΔT = -142.6°F
Avg Skin = 423°F

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 6 - PARTICULATE TRAIN OPERATION

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 3

Date: 4-12-89
Expected Burn Rate: Low
Oven Temp. Setting: 248°F
Tracer Rota, mm: 60
Tracer Pressure in H_2O: 0.12

Proportional: 5

Data Point	24 hr. Time	Elap. Time Δt	SO2 Scale	SO2 ppm	CO2 Scale	CO %	O2 %	Orifice Δ H In H2O	Dry Gas Meter ft 3	Vacuum in Hg	Stove Static Pressure In H20	Comments
1	10:35	0	39.5	592.5	59.5	1.06	4.49	0.004	465.375	<.5	0.045	
2	10:45	10	26	390	39.5	0.02	10.42	0.009	466.06	<.5	0.050	
3	10:55	20	28.5	427.5	44	0.02	9.22	0.007	466.96	<.5	0.050	
4	11:05	30	25.5	382.5	49	0.01	7.91	0.009	467.77	<.5	0.045	
5	11:15	40	26	390	42.5	0.01	9.63	0.009	468.69	<.5	0.045	
6	11:25	50	26	390	42	0.01	9.76	0.009	469.64	<.5	0.045	
7	11:35	60	28	420	43.5	0.01	9.37	0.008	470.60	<.5	0.045	
8	11:45	70	28	420	45.5	0.01	8.84	0.008	471.54	<.5	0.045	
9	11:55	80	28.5	427	45	0.02	8.96	0.007	472.47	<.5	0.045	
10	12:05	90	28.5	427	42	0.02	9.76	0.007	473.27	<.5	0.040	
11	12:15	100	28.5	427	41.5	0.02	9.89	0.007	474.08	<.5	0.040	
12	12:25	110	29.5	442	39.5	0.02	10.42	0.007	474.88	<.5	0.040	
13	12:35	120	30.5	457	40.5	0.02	10.16	0.006	475.66	<.5	0.040	
14	12:45	130	28.5	427	44	0.02	9.23	0.007	476.41	<.5	0.040	
15	12:55	140	27.5	412	49.5	0.02	7.77	0.008	477.22	<.5	0.045	
16	13:05	150	27.5	412	54.5	0.02	6.45	0.008	478.15	<.5	0.045	
17	13:15	160	26.5	397	56.5	0.02	5.92	0.009	479.08	<.5	0.045	
18	13:25	170	25.5	382	54.5	0.02	6.45	0.009	480.03	<.5	0.045	
19	13:35	180	27	405	44.5	0.02	9.1	0.008	480.97	<.5	0.040	
20	13:45	190	28.5	427	47	0.02	8.43	0.007	481.83	<.5	0.040	
21	13:55	200	29	435	52.5	0.02	6.98	0.007	482.64	<.5	0.035	
22	14:05	210	29	435	55.5	0.45	5.92	0.007	483.44	<.5	0.040	
23	14:15	220	27.5	412	60	1.75	3.95	0.008	484.23	<.5	0.040	
24	14:25	230	27.5	412	59.5	1.65	4.13	0.008	485.08	<.5	0.040	
25	14:35	240	27	405	61	2.6	3.15	0.008	485.93	<.5	0.040	
					1213	7.84		.191			1.07	

SIGNED: J. Palmer

DATE: 4-12-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 6 - PARTICULATE TRAIN OPERATION

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 3

Date: 4-12-89
Expected Burn Rate: Low
Oven Temp. Setting: 248°F
Tracer Rota, mm: 60
Tracer Pressure in H_2O: .12

Data Point	24 hr. Time	Elap. Time Δt	SO2 Scale	SO2 ppm	CO2 Scale	CO %	O2 %	Orifice Δ H In H2O	Dry Gas Meter ft 3	Vacuum in Hg	Stove Static Pressure In H2O	Comments
1	14:45	250	26.5	397	60.5	1.45	3.98	.009	486.80	<.5	.040	
2	14:55	260	28.5	427	58.5	1.25	4.64	.007	487.68	<.5	.040	
3	15:05	270	29.5	442	58.5	1.40	4.54	.007	488.49	<.5	.040	
4	15:15	280	31.5	472	59.5	.90	4.58	.006	489.27	<.5	.040	
5	15:25	290	33	495	55	.08	6.28	.005	490.00	<.5	.035	
6	15:35	300	32.5	487	53.5	.02	6.71	.006	490.70	<.5	.030	
7	15:45	310	33.5	502	54.5	.02	6.45	.005	491.41	<.5	.030	
8	15:55	320	33	495	55	.02	6.81	.005	492.11	<.5	.030	
9	16:05	330	34	510	53.5	.03	6.7	.005	492.83	<.5	.030	
10	16:15	340	34	510	54.5	.03	6.44	.005	493.53	<.5	.030	
11	16:25	350	33	495	51.5	.02	7.24	.005	494.23	<.5	.030	
12	16:35	360	32.5	487	53	.02	6.84	.006	494.94	<.5	.030	
13	16:45	370	32.5	487	52.5	.02	6.98	.006	495.67	<.5	.030	
14	16:55	380	33	495	49.5	.02	7.77	.005	496.39	<.5	.030	
15	17:05	390	34.5	517	47.5	.02	8.3	.005	497.15	<.5	.025	
16	17:15	400	34.5	517	45.5	.02	8.83	.005	497.95	<.5	.025	
17	17:25	410	36.5	547	41.5	.02	9.89	.004	498.75	<.5	.025	
18	17:35	420	37.5	562	39	.02	10.55	.004	499.51	<.5	.025	
19	17:45	430	38	570	39.5	.02	10.42	.004	500.24	<.5	.020	
20	17:55	440	38	570	39.5	.02	10.42	.004	500.96	<.5	.020	
21	18:05	450	39.5	592	41.5	.02	9.89	.004	501.68	<.5	.020	
22	18:15	460	38.5	577	42	.02	9.76	.004	502.38	<.5	.020	
23	18:25	470	39.5	592	42.5	.02	9.63	.004	503.09	<.5	.020	
24	18:35	480	40	600	44.5	.02	9.10	.004	503.79	<.5	.020	
25	18:45	490	39.5	592	46.5	.02	8.57	.004	504.48	<.5	.020	
					1239			1.28			.705	

SIGNED: [signature]

DATE: 4-12-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 6 - PARTICULATE TRAIN OPERATION

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 84
Run No.: 3

Date: 4-12-89
Expected Burn Rate: Low
Oven Temp. Setting: 248°F
Tracer Rota, mm: 60
Tracer Pressure in H_2O: .12

Data Point	24 hr. Time	Elap. Time Δt	SO2 Scale	SO2 ppm	CO2 Scale	CO %	O2 %	Orifice Δ H In H20	Dry Gas Meter ft 3	Vacuum in Hg	Stove Static Pressure In H20	Comments
1	18:55	500	40	600	44.5	.02	9.10	.004	505.18	<.5	.020	
2	19:05	570	41	615	46.5	.02	8.57	.004	505.86	<.5	.020	
3	19:15	520	40.5	607	44.5	.02	9.10	.004	506.55	<.5	.020	
4	19:25	530	40	600	42.5	.02	9.63	.004	506.21	<.5	.020	
5	19:35	540	40	600	43.5	.02	9.36	.004	507.93	<.5	.020	
6	19:45	550	39	572	43	.02	9.49	.004	508.66	<.5	.020	
7	19:55	560	38.5	585	45.5	.02	8.83	.004	509.38	<.5	.020	
8	20:05	570	39	590	44.5	.02	9.10	.004	510.10	<.5	.020	
9	20:15	580	41	615	45.5	.02	9.36	.004	570.824	<.5	.020	
10					398							
11												
12												
13			avg		48.31	0.23		0.006	45.449		-0.033	
14					12.08							
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												

SIGNED: [signature] DATE: 4-12-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Marks Custom Stoves
Stove Model: K - 400 FS
Stove I.D. No.: 184
Run No.: 3
Date: 4-12-89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:		Pre-Test		
ZERO GAS:	0.0	0 00	N/A	0.0
AUDIT GAS:	59.9	5.01		34.2
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.0%	0.0%		0.0%
TIME (24 HOUR):	0915	0915		0915

SIGNED: David Windsor
DATE: April 12, 1989

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 ES
Stove I.D. No.: 184
Run No.: 3
Date: 4-12-89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:		120 min.		
ZERO GAS:	0.0	0.0	N/A	0.5
AUDIT GAS:	60.1	5.03	↓	34.8
DESIRED:	59.9	5.01	↓	34.2
PERCENT DIFFERENCE:	0.33%	0.4%	↓	3.2%
TIME (24 HOUR):	12:35	12:35		12:35

SIGNED: [signature]

DATE: 4-12-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Mark's Custom Stoves
Stove Model: K-400FS
Stove I.D. No.: 184
Run No.: 3
Date: 4-12-89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:		240	min.	
ZERO GAS:	0.0	0.0	N/A	0.5
AUDIT GAS:	60.1	5.03		34.8
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.33%	0.4%		1.2%
TIME (24 HOUR):	14:35	14:35		14:35

SIGNED: [signature]
DATE: 4-12-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Mark's Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 7
Date: 4-12-89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:		360 min		
ZERO GAS:	0.0	0.0	NA	05
AUDIT GAS:	60.1	5.03		34.8
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.33%	0.4%		3.2%
TIME (24 HOUR):	16:35	16:35		16:35

SIGNED: T. Pahman

DATE: 4-12-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Mark's Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 3
Date: 4-12-89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:		480 min		
ZERO GAS:	0.0	0.0	N/A	0.5
AUDIT GAS:	60.1	5.03		34.8
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.33%	0.4%	↓	3.2%
TIME (24 HOUR):	18:35	18:35		18:35

SIGNED: [signature]

DATE: 4-12-89

NORTHWEST TESTING LABORATORIES
Woodstove Emmission Testing

PAGE 7 - POST TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184

Run No.: 3
Date: 4-12-89
Time: 20:30

Analyzer Audit

	Scale Readings			
	CO_2	O_2	CO	SO_2
Zero Gas	0.0	N/A	0.0	0.5
Audit Gas	60.1		5.03	34.8
Desired	59.9		5.01	34.2
% Difference	0.33%		0.4%	1.2%
% Drift Check:				
Zero Drift	0.0%		0.0%	0.5%
Mid Level Drift	0.2%		0.2%	0.6%
Leak Test Results	OK			

Particulate Train

Leakage Rate: .001 ft^3/min.

Extra Filters Used: N/A

Ambient

Tdb 78 °F
Twb 63 °F
Pbaro 29.87 in Hg.
Moisture 1.4 % By Volume
Relative Humidity, % 43

29.925
1.35

SIGNED: [signature]

DATED: 4-12-89

SAMPLE EXTRACTION DATA

Stove Mfg.: Marks Custom Stoves Test: 4

Stove Model: K-400 FS Test Cycle: Medium Low

Date: 4-13-89 Stove I.D. No.: 184

Technician: O. Windsor

V_V

CONDENSED WATER VOLUME, GMS

	Modified Temp. 100 ml H20	Standard Imp 100 ml Hz	Modified Imp. Dry	Modified Imp. 200 Gms Silica Gel
Gross Weight	683.8	610.2	487.1	728.0
Initial Weight	563.9	607.9	487.0	719.1
Net Weight	119.9	2.3	0.1	8.9

TOTAL 131.2 GMS

W 08:20 .8354 .7616

PARTICULATE CATCH, GMS

	OVEN FILTER(S)				TRAIN FILTER(S)	
Gross Weight	.7945				.7602	
Initial Weight	.7634				.7583	
Net Weight	0.0311				0.0019	TOTA

TOTAL 0.0330 GMS

Beaker #3

	Front Catch Probe	Rear Catch Impingers	DCM	H20	
Beaker, ml	75 ml	160	150	200 + 130	
Gross, Weight	99.4839	92.4401	97.0400	98.3263	
Initial Weight	99.4555	92.3884	96.9969	98.2808	
Net Weight	0.0284	0.0517	0.0431	0.0455	
Evaporation	0.0007	0.0014	0.0009	0.0031	
Residue Weight	0.0277	0.0503	0.0422	0.0424	TOTA

TOTAL 0.1626 GMS 0.0780 0.0846

Total Particulate = 0.1956 gm

= 195.6 mg

ANALYSIS CONTROL LOG

DATE	CLIENT	TEST I.D.	SAMPLE WEIGHTS						TIME 24 HR.
			OVEN FILTER	TRAIN FILTER	PROBE	ACETONE	DCM	H20	
4/14	marks Custom Stoves K-400 FS	184-4	.8354	.7583					08.20
4/15			.8055	.7604					09:00
4/15			.7946	.7602 ✓					11:40
4/17			.7945 ✓		99.4818	92.4370	97.0388		07:30
4/17					99.4837	92.4400	97.0403		09:30
4/17					99.4843	92.4401 ✓	97.0410	98.3257	11:30
4/17					99.4839 ✓		97.0402	98.3251	13:30
4/17							97.0400 ✓	98.3259	15:30
4/18								98.3263 ✓	07:30

METHOD 5H FLOW RATE (STACK) CALCULATIONS
(Put general info in col B, data info in col H.)

Lab name: NORTHWEST TESTING LABS, INC.
Stv manu: MARKS CUSTOM STOVES
Model no: K-400 FREESTANDING
Tst Date: APRIL 13, 1989

Yhc 1=cat,2=ncat : 1
Wc (if supplied) :
Burn rate (kg/hr): 0.88
Run Number : 4

run time (min)	O2 (%)	CO2 (%)	CO (%)	Fo (1.-1.12)	Stack Gas Flow Rate (dscfh)	(dscfm)	(dsm3/hr)
0	6.60	13.50	0.01	1.06	243.64	4.06	6.91
10	12.70	7.80	0.01	1.05			
20	13.10	7.40	0.01	1.05			
30	9.90	10.40	0.01	1.06			
40	9.10	11.10	0.01	1.06			
50	12.40	8.00	0.01	1.06			
60	11.40	9.00	0.01	1.05			
70	11.00	9.40	0.01	1.05			
80	8.40	11.80	0.01	1.06			
90	7.50	12.60	0.01	1.06			
100	6.30	13.80	0.01	1.06			
110	8.20	12.00	0.01	1.06			
120	7.90	12.30	0.01	1.06			
130	7.40	12.80	0.01	1.05			
140	6.60	13.50	0.01	1.06			
150	6.80	13.30	0.02	1.06			
160	6.30	13.80	0.02	1.06			
170	5.70	14.40	0.02	1.05			
180	5.10	14.90	0.02	1.06			
190	5.00	15.00	0.02	1.06			
200	4.30	15.60	0.02	1.06			
210	3.00	16.80	0.20	1.06			
220	0.80	17.10	3.15	1.07			
230	1.80	17.40	1.15	1.06			
240	1.80	17.50	0.91	1.06			
250	2.10	17.30	0.87	1.06			
260	2.20	17.40	0.47	1.06			
270	2.10	17.00	1.20	1.07			
280	5.00	15.00	0.02	1.06			
290	6.50	13.60	0.01	1.06			
300	6.60	13.50	0.01	1.06			
310	6.30	13.80	0.01	1.06			
320	7.10	13.00	0.01	1.06			
330	7.10	13.00	0.01	1.06			
340	6.80	13.30	0.02	1.06			
350	6.70	13.40	0.01	1.06			
360	7.10	13.00	0.01	1.06			
370	7.40	12.80	0.02	1.05			
380	7.20	12.90	0.01	1.06			
390	7.40	12.80	0.02	1.05			
400	7.90	12.30	0.01	1.06			
410	9.20	11.00	0.01	1.06			
420	9.50	10.80	0.02	1.05			
430	9.50	10.80	0.01	1.06			
440	9.90	10.40	0.02	1.06			
450	10.30	10.00	0.02	1.06			
460	10.20	10.10	0.01	1.06			

470	10.30	10.00	0.01	1.06
480	10.30	10.00	0.01	1.06
490	11.10	9.30	0.01	1.05
500	10.80	9.50	0.01	1.06
510	10.80	9.50	0.01	1.06
520	10.80	9.50	0.02	1.06
530	11.00	9.40	0.01	1.05
540	11.40	9.00	0.01	1.05
550	11.40	9.00	0.01	1.05
560	11.90	8.50	0.01	1.06
570	11.00	9.40	0.01	1.05
580	11.90	8.50	0.01	1.06
590	12.10	8.30	0.01	1.06
600	12.70	7.80	0.01	1.05
610	12.90	7.50	0.01	1.07

Method 5H Proportionality Rate and Sample Volume Calculation
(put general info in col. C; Pb,Y,& unit info in col. G)

Lab name: NORTHWEST TESTING LAB., INC.
Stv manu: MARKS CUSTOM STOVES
Model no: K-400 FREESTANDING
Tst date: APRIL 13, 1989
Run no : 4.0

Units 1=metric,
2=English: 2.0
Y, DGM: 0.971
Pb (mm,in. Hg): 29.8

NOTE: Input raw data below, use F9 for CALC.

run time (min)	tracer conc (ppm,%)	DGM rdg (m3,ft3)	DGM temp (C,F)	DGM dH (mm H2O) (in.H2O)	dDGM vol std (m3,ft3)	PR (%)	Sample vol std (m3,ft3)
0	465.0	510.959	77	0.006			
10	412.0	511.830	80	0.008	0.829	98.2	51.453
20	435.0	512.830	81	0.007	0.946	99.4	
30	487.0	513.710	80	0.006	0.831	92.2	
40	450.0	514.560	79	0.007	0.804	99.8	
50	450.0	515.500	78	0.007	0.891	102.2	
60	502.0	516.440	78	0.005	0.893	102.4	
70	495.0	517.270	77	0.005	0.788	100.9	
80	502.0	518.100	77	0.005	0.790	99.6	
90	480.0	518.950	77	0.006	0.809	103.5	
100	465.0	519.810	77	0.006	0.818	100.1	
110	412.0	520.630	77	0.008	0.780	92.5	
120	450.0	521.540	76	0.007	0.866	90.9	
130	450.0	522.410	76	0.007	0.829	95.1	
140	480.0	523.280	76	0.006	0.829	95.1	
150	450.0	524.150	76	0.007	0.829	101.5	
160	442.0	525.010	76	0.007	0.820	94.0	
170	442.0	525.880	76	0.007	0.829	93.4	
180	420.0	526.770	77	0.008	0.848	95.6	
190	442.0	527.660	77	0.007	0.847	90.7	
200	457.0	528.540	79	0.006	0.837	94.3	
210	427.0	529.430	79	0.007	0.844	98.3	
220	427.0	530.320	80	0.007	0.844	91.8	
230	427.0	531.210	80	0.007	0.842	91.7	
240	435.0	532.100	80	0.008	0.842	91.7	
250	435.0	532.980	80	0.007	0.833	92.3	
260	435.0	533.850	79	0.007	0.823	91.3	
270	405.0	534.720	79	0.008	0.825	91.4	
280	420.0	535.640	79	0.008	0.872	90.0	
290	435.0	536.530	79	0.007	0.844	90.3	
300	435.0	537.420	78	0.007	0.844	93.5	
310	450.0	538.300	79	0.007	0.836	92.7	
320	450.0	539.190	78	0.007	0.844	96.8	
330	465.0	540.080	78	0.006	0.845	97.0	
340	465.0	540.970	77	0.006	0.845	100.2	
350	465.0	541.850	77	0.006	0.837	99.2	
360	472.5	542.760	76	0.006	0.866	102.6	
370	465.0	543.640	76	0.006	0.839	101.0	
380	465.0	544.520	76	0.006	0.839	99.4	
390	472.5	545.410	75	0.006	0.848	100.6	
400	465.0	546.290	75	0.006	0.840	101.2	
410	450.0	547.180	74	0.007	0.850	100.7	
420	465.0	548.070	75	0.006	0.852	97.7	

430	480.0	548.960	74	0.006	0.850	100.7
440	480.0	549.850	73	0.006	0.852	104.2
450	495.0	550.740	73	0.005	0.853	104.4
460	495.0	551.630	73	0.005	0.853	107.6
470	510.0	552.520	73	0.005	0.853	107.6
480	510.0	553.410	72	0.005	0.853	110.9
490	510.0	554.290	72	0.005	0.845	109.9
500	525.0	555.190	72	0.005	0.864	112.4
510	525.0	556.080	71	0.005	0.855	114.4
520	510.0	556.970	71	0.005	0.856	114.6
530	510.0	557.860	71	0.005	0.856	111.3
540	495.0	558.750	73	0.005	0.856	111.3
550	495.0	559.630	74	0.005	0.844	106.4
560	495.0	560.520	75	0.005	0.852	107.4
570	487.5	561.400	76	0.005	0.840	106.0
580	480.0	562.320	75	0.005	0.877	109.0
590	480.0	563.180	74	0.005	0.821	100.5
600	480.0	564.060	74	0.005	0.842	103.0
610	495.0	564.960	74	0.005	0.861	105.4

NORTHWEST TESTING LABORATORIES
Woodstove Emmission Testing

PAGE 1 - STOVE INFORMATION AND PRE-TEST DATA

Stove Manufacturer: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. Number: 184
Run Number: 4
Date: 4-13-89
Expected Burn Rate: Med. Low

STOVE

Weight: 502.1 lb.
Platform Scale Audit?: OK
Primary Air Control Setting: 3/16" open Both Sides
Blower: On ___ Off ___ Auto. ___ N/A X
Flue Pipe Gauge: 24
Flue Pipe Diameter in.: 8 in.
Pictures: Yes X No ___
Operating Instructions:
Stove Manual ___ Verbal ___ Other X written
Stack Cleaned: Yes X No ___

CATALYST Yes X No ___

Catalyst Brand: Applied Ceramics
Catalyst I.D.: Firecat, 2½x7½x3, 16 cell
Catalyst Age: 50+ hrs.
Catalyst Provided: Marks Custom Stoves

AMBIENT

Dry Bulb Reading 74 °F
Wet Bulb Reading 62 °F
Relative Humidity 51 %
Baro. 29.84 in Hg.

% Moisture 1.4 % Volume ___

CONTINUOUS ANALYZERS

Audited by: T. Palmer
Leak Tested by: T. Palmer

PARTICULATE TRAIN

Probe Length & Type 6" Pyrex
Nozzle Size .62 in.
ΔH @ .65
ΔH Magnehelic Range, 0-1 in H_2O
Leakage Rate: 0.012 $Ft.^3$/min.

TRACER GAS

Gas Used: SO_2
Rotameter No.: 601
Rotameter Rdg.: 60
Ball Read: 55
CC/Min.: 70.62
$Ft.^3$/hr. 1.5
(cc/min. ÷ 472 = Ft^3/hr.)
Injection System Rate
Checked: Yes: X No: ___

SIGNED BY: T. Tarleton

DATE: 4-13-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 2 - FUEL DATA

Stove Manufacturer: Mantis Custom Stove
Stove Model: K-400 FS
Stove I.D. Number: 184
Technician: T. Palmer

Run Number: 4
Expected Burn Rate: Med. Low
Calculated Charge Wt.: 24.8
Coal Bed Wt. Lbs.: 5.4
HHV Sample: Yes X No
(Saw Dust Catch & Block)

I. Fuel Moisture Content, % (Dry Basis):

1. 19.2, 19.2, 19.2	11. 19.2, 19.8, 19.8	21.	
2. 19.2, 19.2, 20.9	12. 21.5, 21.5, 20.9	22.	
3. 20.2, 20.9, 20.9	13. 19.8, 19.8, 21.5	23.	
4. 21.5, 21.5, 20.2	14. 20.3, 20.3, 20.3	24.	
5. 20.9, 20.9, 20.9	15.	25.	
6. 21.5, 19.2, 19.2	16.	26. 24.8, 24.8, 24.8	
7. 19.2, 19.8, 19.8	17.	27. 24.8, 24.8, 24.8	
8. 19.2, 19.2, 19.2	18.	28. 24.8, 24.8, 24.8	
9. 20.9, 20.9, 19.8	19.	29. 24.8, 24.8, 24.8	
10. 19.2, 19.2, 19.2	20.	30. 24.8, 24.8, 24.8	

II. Test Fuel:

1. No. of 2 x 4's: 0
2. No. of 4 x 4's: 5
3. Total No. of Fuel Pieces: #26 → #30
4. Weight, Lbs.: 24.5
5. Species: D.F.
6. Moisture Content, % Ave. (Dry Basis): 24.8
7. Length, In.: 20"

III. Pre-Burn Fuel:

1. No. of 2 x 4's: 11
2. No. of 4 x 4's: 0
3. Total No. of Fuel Pieces: #1 → #11
4. Weight, Lbs.: 25.0
5. Species: D.F.
6. Moisture Content, % Ave. (Dry Basis): 20.68
7. Length, In.: 21" ÷ 3 = 7"

IV. Kindling Fuel:

1. No. of 2 x 4's: 0
2. No. of 4 x 4's: 1
3. Total No. of Fuel Pieces:
4. Weight, Lbs.: 4.1
5. Species: D.F.
6. Moisture Content, % Ave. (Dry Basis): 20.0
7. Length, In.: 18"

Date: 4-20-89

Attention: Mike Cave

Subject: Analysis on one (1) wood fuel sample received 4-13-89.

Item: Wood Fuel

Reference: Mark's Custom Stoves
Model: K-400 F.S.
184-4
Medium Low

REPORT:

Analysis:

Moisture, %, as received	18.5
Moisture, %, dry basis	22.7
Density, g/cm^3, dry basis	0.49
Higher Heat of Combustion, BTU/lb., dry basis	9677

JMT /RWH

Report Number: 321591

WOOD/FUEL
(ON NTL STOVE DISK)

D800 Charges $170

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 3 - STOVE OPERATION LOG

Stove Mfg.: Mark's Custom Stoves Date: 4-13-89

Stove Model: K-400 FS Technician: T. Palmer

Stove I.D. Number: 184

Run Number: 4

24 Hr. Time	OPERATION
08:45	Lit 4.1 lbs of Kindling, Door Ajar
	Air controls 100% open
08:50	Shut Door
8:55	Added #1 Fire - Burn 25.0 lbs
09:00	Shut Dampers
09:15	Set Air Controls at 3/16" air gap
09:20	Started Fire - Burn Reactivity
09:37	Stoked Fire
09:52	Stoked Fire
10:17	Stoked Fire
11:10	Added Test Fuel 24.5 lbs
	Air + By-Pass 100% open
11:02	Shut Door
11:03	Closed By-Pass + set air 3/16" open

NOR..WEST TESTING LABORATORIES
Woodstove Emission Testing

PAGE 4 - PREBURN DATA

Stove Mfg.: Marks Custom Stoves Run Number: 4

Stove Model: K-400 ES Date: 4-13-89

Stove I.D. No.: 184 Air Control Setting: 3/16" open

4.9 → 6.1

Data Set No.	Elapsed 24/Hr. Time	TEMPERATURES Amb.(1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Fuel Wt/lb	Prim. Temp. (7)	Cat. Temp. (8)	Cat. Temp. (16)	
1 5	09:20	68	870	348	472	588	522	15.8	629	1105		
2 10	09:25	69	854	373	468	578	505	15.2	608	1084		
3 15	09:30	70	773	384	462	572	483	14.8	557	1034		
4 20	09:35	69	719	382	453	591	466	14.4	543	1021		
5 25	09:40	70	687	371	462	593	451	13.6	581	884		← STOKED
6 30	09:45	70	707	370	455	562	449	13.1	560	954		
7 35	09:50	70	714	374	449	540	446	12.6	566	1039		
8 40	09:55	70	713	380	440	520	446	12.2	551	1022		← STOKED
9 45	10:00	71	684	382	494	544	496	10.8	634	850		
10 50	10:05	71	670	392	481	550	491	10.1	627	894		
11 55	10:10	71	687	396	473	551	485	9.7	608	918		
12 60	10:15	71	695	391	470	553	481	9.3	612	983		← STOKED
13 65	10:20	72	679	384	483	546	528	8.2	661	829		
14 70	10:25	71	696	391	480	545	572	7.7	622	874		
15 75	10:30	71	710	400	473	544	499	7.3	615	911		
16 80	10:35	72	725	406	467	537	492	6.9	609	919		
17 85	10:40	72	734	406	462	531	491	6.5	607	936		
18 90	10:45	71	730	406	460	524	490	6.2	610	1002		
19 95	10:50	72	711	402	455	514	485	6.0	582	963		
20 100	10:55	72	676	399	447	500	475	5.9	577	943		
21 105	11:00	72	654	399	440	490	466	5.8	572	925		
22 110	11:05	71	632	401	433	482	458	5.6	568	907		
						Test Fuel Added at 5.4 lbs.						

SIGNED: T. Tacheron DATE: 4-13-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 PS
Stove I.D. No.: 184
Run No.: 4
Date: 4-13-89

BT = 479 °F
ET = °F
-T =

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES Amb. (1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Primry Comb. (7)	Catl. or Secondry Comb.(8)	Catl. or Secondary Comb.(16)	Flue db (9)	Flue wb (10)	Dry Gas In (11)	Dry Gas Out (12)	Oven Temp °F (13)	Imp. Temp. °F (14)	Tracer Temp. °F (15)
1	0	11:10	24.5	71	627	401	431	479	456	565	909		137	119	76	78	248	32	76
2	10	11:20	23.7	72	573	415	365	404	388	405	816		151	131	81	78	248	33	77
3	20	11:30	23.4	72	491	421	327	358	346	376	687		133	124	83	78	246	34	77
4	30	11:40	23.1	72	449	407	304	332	325	361	699		132	127	80	79	247	35	74
5	40	11:50	22.7	72	433	394	292	322	315	365	716		129	128	79	79	248	35	73
6	50	12:00	22.3	73	424	386	285	319	308	358	685		128	125	79	77	247	36	73
7	60	12:10	21.9	72	405	378	275	312	301	354	629		126	122	79	76	248	36	73
8	70	12:20	21.6	73	401	370	268	307	298	352	672		126	122	79	75	248	37	73
9	80	12:30	21.2	73	417	365	266	304	297	346	746		130	128	79	74	248	37	73
10	90	12:40	20.7	74	446	360	270	308	300	376	813		139	133	80	73	248	37	75
11	100	12:50	20.0	74	479	358	279	321	306	394	892		146	133	80	73	239	39	73
12	110	13:00	19.4	75	488	361	292	346	318	393	838		149	133	80	73	240	39	73
13	120	13:10	18.8	74	498	364	303	367	324	408	834		147	132	80	72	240	34	72
14	130	13:20	18.2	75	515	366	310	373	330	416	873		149	136	80	72	240	34	73
15	140	13:30	17.7	75	528	369	316	378	334	418	872		150	137	80	71	249	35	73
16	150	13:40	17.1	76	574	369	322	381	339	425	892		149	135	80	71	238	35	73
17	160	13:50	16.5	76	615	363	326	384	346	457	927		155	138	81	70	236	35	75
18	170	14:00	15.9	75	630	361	329	394	353	449	925		158	139	81	70	240	37	76
19	180	14:10	15.2	75	632	358	327	416	360	460	941		160	140	82	70	225	34	77
20	190	14:20	14.6	76	639	356	324	437	369	486	959		162	141	83	71	224	36	78
				1475	10264	7522	6241	7242	6713	8159	16323		2858		1603	1480			1487

SIGNED BY: [signature]
DATE: 4-13-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: IC-400F3
Stove I.D. No.: 184
Run No.: 4
Date: 4-13-89

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES									Flue		Dry Gas		Oven Temp °F	Imp. Temp. °F	Tracer Temp. °F
				Amb.	Stove Surfaces					Primry Comb.	Catl. or Secondry Comb.	Catl. or Secondary Comb.	db	wb	In	Out			
				(1)	T(2)	B(3)	R(4)	RS(5)	LS(6)	(7)	(8)	(16)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
21	200	14:30	13.9	76	642	353	347	442	376	468	1017		166	138	85	72	224	36	79
22	210	14:40	13.0	77	674	353	353	450	393	509	1040		173	143	85	72	222	36	79
23	220	14:50	11.9	78	740	362	376	502	419	542	921		174	149	86	73	227	36	78
24	230	15:00	11.1	79	734	376	387	512	430	548	963		172	146	85	75	230	38	77
25	240	15:10	10.2	78	718	391	395	518	444	570	963		171	144	84	75	239	40	77
26	250	15:20	9.4	79	713	400	397	518	456	585	980		170	137	84	75	244	41	77
27	260	15:30	8.7	80	719	410	400	525	463	591	961		167	138	83	75	246	43	76
28	270	15:40	8.1	79	725	418	404	529	479	631	969		169	138	83	75	242	44	76
29	280	15:50	7.5	78	723	430	408	525	495	620	961		167	133	83	74	239	44	77
30	290	16:00	7.2	78	671	435	405	513	489	611	914		160	125	84	73	239	44	77
31	300	16:10	6.8	80	630	437	396	503	478	589	881		156	124	82	74	240	32	76
32	310	16:20	6.5	79	611	436	391	500	469	575	863		154	123	82	75	242	32	76
33	320	16:30	6.2	79	590	442	384	496	458	562	824		150	119	81	74	242	32	75
34	330	16:40	5.9	78	578	443	378	488	451	557	817		150	116	81	74	245	32	74
35	340	16:50	5.6	79	572	441	374	482	445	550	834		150	119	81	73	244	33	74
36	350	17:00	5.3	79	571	439	372	480	443	548	847		149	118	80	73	246	34	73
37	360	17:10	4.9	79	573	437	371	477	440	546	854		150	119	80	72	247	36	73
38	370	17:20	4.6	79	569	437	370	464	438	545	844		150	116	79	72	246	35	73
39	380	17:30	4.4	79	567	435	370	460	435	545	846		149	116	79	72	247	37	72
40	390	17:40	4.1	78	566	429	370	457	433	543	859		149	116	79	71	246	38	72
				1571	12886	8304	7148	9736	8934	11235	18158		3196		1616	1469			1511

SIGNED BY: Michael Cain DATE: 4/13/89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 4
Date: 4/13/89

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES									Flue		Dry Gas		Oven Temp °F	Imp. Temp. °F	Tracer Temp. °F	
				Amb. (1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Primry Comb. (7)	Catl. or Secondry Comb.(8)	Catl. or Secondary Comb.(16)	db (9)	wb (10)	In (11)	Out (12)	(13)	(14)	(15)	
41	400	17:50	3.8	79	563	422	370	453	431	541	854		149	115	79	70	239	40	72	
42	410	18:00	3.6	78	538	420	367	444	435	550	804		146	115	78	70	242	40	71	
43	420	18:10	3.4	78	518	423	363	435	430	540	777		144	111	79	70	240	40	72	
44	430	18:20	3.3	79	505	425	358	425	424	533	763		142	109	78	70	241	40	71	LTC
45	440	19:30	3.1	79	494	421	353	418	417	524	747		141	108	77	69	241	32	71	
46	450	18:40	2.9	78	488	419	349	412	410	515	744		140	107	77	69	240	32	70	
47	460	18:50	2.7	78	481	412	346	404	402	503	740		139	107	77	69	242	33	69	
48	470	19:00	2.5	78	477	409	344	396	395	498	744		139	109	77	68	240	34	70	
49	480	19:10	2.3	78	474	406	344	393	392	497	743		139	110	76	68	240	35	70	
50	490	19:20	2.2	78	470	400	344	388	388	489	730		139	110	75	68	240	35	69	
51	500	19:30	2.0	79	464	394	347	388	386	492	721		138	109	75	68	240	35	68	
52	510	19:40	1.8	79	461	386	350	387	388	499	722		137	104	75	67	239	36	69	
53	520	19:50	1.6	78	459	379	353	384	387	497	728		137	104	75	67	240	37	68	
54	530	20:00	1.5	79	456	367	362	384	383	489	737		138	105	75	67	239	39	68	
55	540	20:10	1.3	77	452	353	369	383	376	479	735		138	105	81	64	239	40	72	
56	550	20:20	1.1	78	445	341	372	381	369	473	726		138	105	85	62	235	40	75	
57	560	20:30	.9	77	435	327	371	380	361	459	716		138	104	88	61	240	40	74	
58	570	20:40	.7	77	428	317	374	382	356	451	716		140	106	89	62	241	41	74	
59	580	20:50	.5	76	425	303	386	399	353	445	716		138	107	83	66	241	41	71	TEST
60	590	21:00	.3	76	423	292	387	399	349	438	701		136	103	79	69	240	32	69	
				1559	9456	7616	7201	8035	7832	9912	14864		2796		1578	1344			1417	

SIGNED BY: Michael Cain DATE: 4/13/89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Mark's Custom Stoves
Stove Model: K-400FS
Stove I.D. No.: 184
Run No.: 4
Date: 4/13/89

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES									Flue		Dry Gas		Oven Temp °F (13)	Imp. Temp. °F (14)	Tracer Temp. °F (15)
				Amb. (1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Primry Comb. (7)	Catl. or Secondry Comb.(8)	Catl. or Secondary Comb.(16)	db (9)	wb (10)	In (11)	Out (12)			
61	600	21:10	.1	76	417	279	382	391	343	429	684		134	102	77	70	241	32	68
62	610	21:20	0	76	411	271	381	379	336	423	684		132	103	79	69	240	33	71
								355.6											
				152	828	550	763	770	679	852	1368				156	138	481	65	139
				4757	33434	23992	21859	25883	24158	30158	50713				4983	4431			4555
				77	539	387	353	417	390	1186	818		147		80	71			73
															76				

SIGNED BY: [signature] DATE: 4/13/89

ΔT = -123.2°F
Avg Skin = 417.2°F

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 6 - PARTICULATE TRAIN OPERATION

Stove Mfg.: Marks Custom Stoves
Stove Model: IC-400ES
Stove I.D. No.: 184
Run No.: 4

Date: 4-13-89
Expected Burn Rate: Med. Low
Oven Temp. Setting: 248°F
Tracer Rota, mm: 60
Tracer Pressure in H_2O: 1.2

Proportional rate = 5

Data Point	24 hr. Time	Elap. Time Δt	SO2 ✓ Scale	SO2 ✓ ppm	CO2 ✓ Scale	CO ✓ %	O2 ✓ %	Orifice Δ H ✓ In H2O	Dry Gas Meter ft 3	Vacuum in Hg	Stove Static ✓ Pressure In H20	Comments
1	11:10	0	31	465	54	0.01	6.58	0.006	510.959	<.5	0.030	
2	11:20	10	27.5	412	51	0.01	12.68	0.008	511.85	<.5	0.040	
3	11:30	20	29	435	29.5	0.01	13.08	0.007	512.83	<.5	0.035	
4	11:40	30	32.5	487	41.5	0.01	9.9	0.006	513.71	<.5	0.035	
5	11:50	40	30	450	44.5	0.01	9.1	0.007	514.56	<.5	0.030	
6	12:00	50	30	450	32	0.01	12.41	0.007	515.50	<.5	0.030	
7	12:10	60	33.5	502	36	0.01	11.35	0.005	516.44	<.5	0.030	
8	12:20	70	33	495	37.5	0.01	10.96	0.005	517.27	<.5	0.030	
9	12:30	80	33.5	502	47	0.01	8.44	0.005	518.10	<.5	0.030	
10	12:40	90	32	480	50.5	0.01	7.57	0.006	518.95	<.5	0.035	
11	12:50	100	31	465	55	.01	6.32	.006	519.81	.5	.040	
12	13:00	110	27.5	413	48	.01	8.17	.008	520.63	.5	.040	
13	13:10	120	30	450	49	.01	7.91	.007	521.54	.5	.035	
14	13:20	130	30	450	51	.01	7.38	.007	522.41	.5	.040	
15	13:30	140	32	480	54	.01	6.58	.006	523.28	.5	.040	
16	13:40	150	30	450	53	.02	6.84	.007	524.15	.5	.040	
17	13:50	160	29.5	442	55	.02	6.31	.007	525.01	.5	.040	
18	14:00	170	29.5	442	57.5	.02	5.65	.007	525.88	.5	.040	
19	14:10	180	28	420	59.5	.02	5.12	.008	526.77	.5	.040	
20	14:20	190	29.5	442	60	.02	4.99	.007	527.66	.5	.040	
21	14:30	200	30.5	457	62.5	.02	4.33	.006	528.57	.5	.040	
22	14:40	210	28.5	427	67	.20	3.02	.007	529.45	.5	.045	
23	14:50	220	28.5	427	68.5	3.15	0.83	.007	530.32	.5	.045	
24	15:00	230	28.5	427	69.5	1.15	1.78	.007	531.21	.5	.040	
25	15:10	240	29	435	70	.91	1.79	.008	532.10	.5	.040	
				11,304	1283	5.68	179.09	.167			.93	

SIGNED: Michael Cain
DATE: April 13, 1989

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 6 - PARTICULATE TRAIN OPERATION

Stove Mfg.: Marks Custom Stove
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 4

Date: 4/13/89
Expected Burn Rate: med/low
Oven Temp. Setting: 248
Tracer Rota, mm: 60
Tracer Pressure in H_2O: 0 12

Data Point	24 hr. Time	Elap. Time Δt	SO2 Scale	SO2 ppm	CO2 Scale	CO %	O2 %	Orifice Δ H In H20	Dry Gas Meter ft 3	Vacuum in Hg	Stove Static Pressure In H20	Comments
26 1	15:20	250	29	435	69	.87	2.08	.007	532.98	.5	.045	
27 2	15:30	260	29	435	69.5	.47	2.20	.007	533.85	.5	.040	
28 3	15:40	270	27	405	68	1.20	2.15	.008	534.72	.5	.045	
29 4	15:50	280	28	420	60	.02	4.98	.008	535.64	.5	.040	
30 5	16:00	290	29	435	54.5	.01	6.45	.007	536.53	.5	.035	
31 6	16:10	300	29	435	54	.01	6.58	.007	537.42	.5	.035	
32 7	16:20	310	30	450	55	.01	6.32	.007	538.30	.5	.035	
33 8	16:30	320	30	450	52	.01	7.11	.007	539.19	.5	.030	
34 9	16:40	330	31	465	52	.01	7.11	.006	540.08	.5	.030	
35 10	16:50	340	31	465	53	.02	6.84	.006	540.97	.5	.030	
36 11	17:00	350	31	465	53.5	.01	6.72	.006	541.85	.5	.030	
37 12	17:10	360	31.5	472.5	52	.01	7.11	.006	542.76	.5	.030	
38 13	17:20	370	31	465	51	.02	7.37	.006	543.64	.5	.030	
39 14	17:30	380	31	465	51.5	.01	7.25	.006	544.52	.5	.030	
40 15	17:40	390	31.5	472.5	51	.02	7.37	.006	545.41	.5	.030	
41 16	17:50	400	31	465	49	.01	7.90	.006	546.29	.5	.030	
42 17	18:00	410	30	450	44	.01	9.20	.007	547.18	.5	.030	
43 18	18:10	420	31	465	43	.02	9.49	.006	548.07	.5	.030	
44 19	18:20	430	32	480	43	.01	9.50	.006	548.96	.5	.030	
45 20	18:30	440	32	480	41.5	.02	9.89	.006	549.85	.5	.030	
46 21	18:40	450	33	495	40	.02	10.29	.007	550.74	.5	.030	
47 22	18:50	460	33	495	40.5	.01	10.16	.005	551.63	.5	.030	
48 23	19:00	470	34	510	40	.01	10.29	.005	552.52	.5	.030	
49 24	19:10	480	34	510	40	.01	10.29	.005	553.41	.5	.030	
50 25	19:20	490	34	510	37	.01	11.08	.005	554.29	.5	.030	
				11595	1264	2.83	185.73	.156			.815	

SIGNED: Michael Cain
DATE: 4/13/89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 6 - PARTICULATE TRAIN OPERATION

Stove Mfg.: Marks Custom Stove
Stove Model: K-400 ES
Stove I.D. No.: 164
Run No.: 4

Date: 4/13/89
Expected Burn Rate: Med/Low
Oven Temp. Setting: 24t
Tracer Rota, mm: 60
Tracer Pressure in H_2O: .12

Data Point	24 hr. Time	Elap. Time Δt	SO2 Scale	SO2 ppm	CO2 Scale	CO %	O2 %	Orifice Δ H In H2O	Dry Gas Meter ft 3	Vacuum in Hg	Stove Static Pressure In H20	Comments
1	19:30	500	35	525	38	.01	10.82	.005	555.19	.5	.030	
2	19:40	510	35	525	38	.01	10.82	.005	556.08	.5	.030	
3	19:50	520	34	510	38	.02	10.82	.005	556.97	.5	.030	
4	20:00	530	34	510	37.5	.01	10.95	.005	557.86	.5	.030	
5	20:10	540	33	495	36	.01	11.35	.005	558.75	.5	.030	
6	20:20	550	33	495	36	.01	11.35	.005	559.63	.5	.030	
7	20:30	560	33	495	34	.01	11.88	.005	560.52	.5	.030	
8	20:40	570	32.5	487.5	37.5	.01	10.96	.005	561.40	.5	.030	
9	20:50	580	32	480	34	.01	11.88	.005	562.29	.5	.030	
10	21:00	590	32	480	33	.01	12.15	.005	563.18	.5	.030	
11	21:10	600	32	480	31	.01	12.68	.005	564.06	.5	.030	
12	21:20	610	33	495	30	.01	12.94	.005	564.960	.5	.030	
13	21:30	620										
14	21:40	630										
15												
16				5977.5	423	-13	138.6	.06			.36	
17												
18				28876.5	2970	8.64	503.42	.383			2.105	
19									//			
20				465.75	47.903	.1393	8.1196	.00617	54.001		.09395	
21					11.98							
22												
23												
24												
25												

SIGNED: Michael Cain DATE: 4/13/89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Mark's Custom Stoves
Stove Model: K-400FS
Stove I.D. No.: 184
Run No.: 4
Date: 4-13-89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:		PRE-Test Calibration		
ZERO GAS:	0.0	0.0	N/A	0.0
AUDIT GAS:	59.9	5.01		34.2
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.0%	0.0%		0.0%
TIME (24 HOUR):	09:30	09:30		09:30

SIGNED: [signature]
DATE: 4-13-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 4
Date: 4/13/89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:	120 minute	audit →		
ZERO GAS:	0.0	0.0		0.4
AUDIT GAS:	59.8	5.03		34.0
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.2%	0.4%		1.8%
TIME (24 HOUR):	13:20 →			

SIGNED: Michael Cain

DATE: 4/13/89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 4
Date: 4/13/89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:	240 minute			
ZERO GAS:	0.0	0.0		0.2
AUDIT GAS:	59.9	5.00		34.2
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.0%	0.2%		1.2%
TIME (24 HOUR):	15:20			

SIGNED: Michael Cain

DATE: 4/13/89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400FS
Stove I.D. No.: 184
Run No.: 4
Date: 4/13/89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:	360 minute audit →			
ZERO GAS:	0.0	0.0		0.2
AUDIT GAS:	59.9	5.00		34.2
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.0%	0.2%		0.6%
TIME (24 HOUR):	17:20 →			

SIGNED: Michael Cain

DATE: 4/13/89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 4
Date: 4/13/89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:	480 minute audit →			
ZERO GAS:	0.0	0.0		0.3
AUDIT GAS:	60.0	5.01		34.3
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.2%	0.0%		1.5%
TIME (24 HOUR):	19:00 →			

SIGNED: Michael Cena

DATE: 4/13/89

NORTHWEST TESTING LABORATORIES
Woodstove Emmission Testing

PAGE 7 - POST TEST DATA

Stove Mfg.: Mark's Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184

Run No.: 4
Date: 4/13/89
Time: 21:35

Analyzer Audit

	Scale Readings			
	CO_2	O_2	CO	SO_2
Zero Gas	0.0		0.0	0.2
Audit Gas	60.1		5.62	34.4
Desired	59.9		5.01	34.2
% Difference	0.3%		0.2%	0.6%
% Drift Check:				
Zero Drift	0.0%		0.0%	0.2%
Mid Level Drift	0.2%		0.1%	0.2%
Leak Test Results	Pass		Pass	

Particulate Train

Leakage Rate: 0.008 ft^3/min.

Extra Filters Used: N/A

Ambient

Tdb 77 °F
Twb 64 °F
Pbaro 29.82 in Hg. 29.83
Moisture 1.5 % By Volume
Relative Humidity, % 49%

SIGNED: Michael Cenk DATED: 4/13/89

SAMPLE EXTRACTION DATA

Stove Mfg.: Marks Custom Stoves Test: 5

Stove Model: K-400ES Test Cycle: med / High

Date: 4/14/89 Stove I.D. No.: 184

Technician: M Cave

V_V

CONDENSED WATER VOLUME, GMS

	Modified Temp. 100 ml H20	Standard Imp 100 ml Hz	Modified Imp. Dry	Modified Imp. 200 Gms Silica Gel
Gross Weight	641.3	612.5	487.1	733.3
Initial Weight	563.6	607.6	487.0	728.0
Net Weight	77.7	4.9	0.1	5.3

TOTAL 88.0 GMS

W 10.00 1.0401 .7908

PARTICULATE CATCH, GMS

	OVEN FILTER(S)				TRAIN FILTER(S)	
Gross Weight	.8347				.7842	
Initial Weight	.7594				.7586	
Net Weight	0.0753				0.0256	TOTA

TOTAL 0.1009 GMS

	Front Catch Probe	Rear Catch Impingers	DCM	H20	
Beaker, ml	70ml	175ml	150ml	200ml + 100	
Gross Weight	102.4607	100.5800	102.3051	101.3905	
Initial Weight	102.4167	100.4681	102.2099	101.3468	
Net Weight	0.0440	0.1119	0.0952	-0.0437	
Evaporation	0.0006	0.0016	0.0009	0.0029	
Residue Weight	0.0434	0.1103	0.0943	0.0408	TOTA

TOTAL 0.2888 GMS 0.1537 0.1351

Total Particulate = 0.3897 gm

= 389.7 mg

ANALYSIS CONTROL LOG

DATE	CLIENT	TEST I.D.	SAMPLE WEIGHTS						TIME 24 HR.
			OVEN FILTER	TRAIN FILTER	PROBE	ACETONE	DCM	H20	
4/15	Mark's Custom Stoves K-400 FS	184-5	1.0401	.7908					10:00
4/17			.8770	.7838					07:30
4/17			.8627	.7842					09:30
4/17			.8672						11:30
4/17			.8582						13:30
4/17			.8569						15:30
4/18			.8509		102.4602	100.5797	102.3052		07:30
4/18			.8454		102.4611	100.5800	102.3051		09:30
4/18			.8351		102.4607				11:30
4/18	"		.8347					101.3702	13:30
4/18								101.3905	15:30

METHOD 5H FLOW RATE (STACK) CALCULATIONS
(Put general info in col B, data info in col H.)

Lab name: NORTHWEST TESTING LABS, INC.
Stv manu: MARKS CUSTOM STOVES
Model no: K-400 FREESTANDING
Tst Date: APRIL 14, 1989

Yhc 1=cat,2=ncat : 1
Wc (if supplied) :
Burn rate (kg/hr): 2.34
Run Number : 5

run time (min)	O2 (%)	CO2 (%)	CO (%)	Fo (1.-1.12)	Stack Gas Flow Rate (dscfh)	(dscfm)	(dsm3/hr)
0	5.60	14.40	0.08	1.06	517.61	8.63	14.67
10	8.10	12.00	0.05	1.06			
20	10.40	9.90	0.03	1.06			
30	10.70	9.60	0.02	1.06			
40	10.30	10.00	0.03	1.06			
50	2.10	17.30	0.90	1.06			
60	0.30	17.60	3.10	1.07			
70	0.10	17.30	4.85	1.05			
80	0.10	17.10	5.60	1.04			
90	0.50	17.60	2.75	1.07			
100	0.50	17.80	2.60	1.06			
110	0.60	17.90	2.25	1.06			
120	1.10	17.10	2.65	1.07			
130	2.10	16.60	1.95	1.07			
140	3.60	16.10	0.40	1.06			
150	6.00	14.00	0.02	1.06			
160	6.70	13.40	0.02	1.06			
170	7.60	12.50	0.01	1.06			
180	8.20	12.00	0.01	1.06			
190	8.20	12.00	0.01	1.06			
200	7.90	12.30	0.01	1.06			
210	8.70	11.50	0.02	1.06			
220	9.20	11.00	0.01	1.06			

Method 5H Proportionality Rate and Sample Volume Calculation
(put general info in col. C; Pb,Y,& unit info in col. G)

Lab name: NORTHWEST TESTING LAB., INC.
Stv manu: MARKS CUSTOM STOVES
Model no: K-400 FREESTANDING
Tst date: APRIL 14, 1989
Run no : 5.0

Units 1=metric, 2=English: 2.0
Y, DGM: 0.971
Pb (mm,in. Hg): 29.9

NOTE: Input raw data below, use F9 for CALC.

run time (min)	tracer conc (ppm,%)	DGM rdg (m3,ft3)	DGM temp (C,F)	DGM dH (mm H2O) (in.H2O)	dDGM vol std (m3,ft3)	PR (%)	Sample vol std (m3,ft3)
0	330.0	564.961	66	0.013			
10	345.0	566.080	68	0.011	1.090	110.3	23.849
20	300.0	567.070	68	0.015	0.961	101.6	
30	292.0	568.210	69	0.016	1.107	101.7	
40	285.0	569.350	70	0.017	1.104	98.8	
50	292.0	570.520	70	0.016	1.131	98.8	
60	277.0	571.660	69	0.018	1.102	98.7	
70	262.0	572.910	70	0.020	1.211	102.8	
80	247.0	574.170	70	0.023	1.218	97.8	
90	240.0	575.550	70	0.024	1.334	101.0	
100	255.0	577.000	70	0.021	1.402	103.1	
110	270.0	578.300	69	0.019	1.257	98.3	
120	255.0	579.560	70	0.021	1.221	101.0	
130	277.0	580.850	71	0.018	1.247	97.5	
140	285.0	582.040	71	0.017	1.149	97.5	
150	285.0	583.150	73	0.017	1.071	93.6	
160	330.0	584.270	72	0.012	1.077	94.1	
170	315.0	585.300	73	0.014	0.992	100.4	
180	315.0	586.400	74	0.013	1.058	102.1	
190	315.0	587.500	75	0.013	1.056	101.9	
200	315.0	588.520	75	0.014	0.977	94.3	
210	285.0	589.650	75	0.017	1.082	104.5	

NORTHWEST TESTING LABORATORIES
Woodstove Emmission Testing

PAGE 1 - STOVE INFORMATION AND PRE-TEST DATA

Stove Manufacturer: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. Number: 184
Run Number: 5
Date: 4-14-89
Expected Burn Rate: Med. High

STOVE

Weight: 502.1 lb.
Platform Scale Audit?: OK
Primary Air Control Setting: 1/2" open both sides
Blower: On ___ Off ___ Auto. ___ N/A X
Flue Pipe Gauge: 24
Flue Pipe Diameter in.: 8 in.
Pictures: Yes X No ___
Operating Instructions:
Stove Manual ___ Verbal ___ Other X written
Stack Cleaned: Yes X No ___

CATALYST Yes X No ___

Catalyst Brand: Applied Ceramics
Catalyst I.D.: Firecat, 2½x7½x3, 16 cell
Catalyst Age: 50+ hrs.
Catalyst Provided: Marks Custom Stoves

AMBIENT

Dry Bulb Reading 75 °F
Wet Bulb Reading 62 °F
Relative Humidity 48 %
Baro. 29.91 in Hg.

% Moisture 1.4 % Volume ___

CONTINUOUS ANALYZERS

Audited by: T. Palmer
Leak Tested by: T. Palmer

PARTICULATE TRAIN

Probe Length & Type 6" Pyrex
Nozzle Size .162 in.
ΔH @ .65
ΔH Magnehelic Range, 0-1 in H_2O
Leakage Rate: .001 $Ft.^3/min.$

TRACER GAS

Gas Used: SO_2
Rotameter No.: 601
Rotameter Rdg.: 60
Ball Read: 55
CC/Min.: 70.62
$Ft.^3/hr.$ 1.15
(cc/min. ÷ 472 = $Ft^3/hr.$)
Injection System Rate
Checked: Yes: X No: ___

SIGNED BY: T. Palmer

DATE: 4-14-89

Date: 4-21-89

Attention: Mike Cave

Subject: Analysis on one (1) wood fuel sample received 4-14-89.

Item: Wood Fuel

Reference: Mark's Custom Stoves
Model: K-400 F.S.
184-5
Medium high

REPORT:

Analysis:

Moisture, %, as received	15.4
Moisture, %, dry basis	18.2
Density, g/cm^3, dry basis	0.51
Higher Heat of Combustion, BTU/lb., dry basis	8745

JMT / RWH

Report Number: 321591

WOOD/FUEL
(ON NTL STOVE DISK)

0800 charges $70

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 3 - STOVE OPERATION LOG

Stove Mfg.: Marks Custom Stoves Date: 4-14-89

Stove Model: K-400 FS Technician: T Fahmer

Stove I.D. Number: 154

Run Number: 5

24 Hr. Time	OPERATION
09:50	Lit 4.0 lbs of Kindling Door Ajar
	Air controls 100% open, By-Pass open
09:55	Shut Door
10:00	Added #1 Pre-Burn
10:02	Shut By-Pass
10:05	Set Air controls at 1/2" open
10:10	Started Pre-Burn Readings
10:42	Stoked Fire
10:57	Stoked Fire
11:15	Added 22.7 lbs of Test Fuel
	By-Pass open, Air controls 100% open
11:16 + 30sec	Shut Door + By-Pass
11:20	Set Air controls at 1/2" open

NOR.AWEST TESTING LABORATORIES
Woodstove Emission Testing

+ 271 = 1.9
- 412 = 1.25

PAGE 4 - PREBURN DATA

Stove Mfg.: Marks Custom Stoves Run Number: 5

Stove Model: K-400 FS Date: 4-14-89

Stove I.D. No.: 184 Air Control Setting: Med. High

4.5 ↓
5.7

Data Set No.	Elapsed 24/Hr. Time	TEMPERATURES						Fuel Wt/lb	Prim. Temp. (7)	Cat. Temp. (8)	Cat. Temp. (16)	
		Amb. (1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)					
1 5	10:10	69	527	166	379	435	437	19.3	520	1204		
2 10	10:15	68	579	214	415	502	451	17.9	587	1150		
3 15	10:20	69	621	246	474	585	459	16.5	614	1075		
4 20	10:25	69	654	275	527	715	497	14.9	688	1007		
5 25	10:30	69	673	286	532	717	508	13.5	727	994		
6 30	10:35	70	726	312	528	678	525	12.1	686	1028		
7 35	10:40	71	756	344	550	670	556	10.9	755	1029		← STOKED
8 40	10:45	71	795	385	572	658	579	8.9	707	1027		
9 45	10:50	72	828	416	557	628	567	8.1	703	1069		
10 50	10:55	72	851	438	542	613	570	7.5	720	1067		← STOKED
11 55	11:00	73	862	469	590	650	607	6.0	760	1053		
12 60	11:05	74	850	482	586	654	610	5.4	762	1110		
13 65	11:10	73	854	490	577	639	615	5.0	757	1101		
	11:15			Added test fuel →				4.6				

SIGNED: [signature] DATE: 4-14-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Hawks Custom Stoves
Stove Model: K-400FS
Stove I.D. No.: 184
Run No.: 5
Date: 4-14-89

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES Amb. (1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Primry Comb. (7)	Catl. or Secondry Comb.(8)	Catl. or Secondary Comb.(16)	Flue db (9)	wb (10)	Dry Gas In (11)	Out (12)	Oven Temp °F (13)	Imp. Temp. °F (14)	Tracer Temp. °F (15)
1	0	11:15	22.7	74	847	493	573	631	617	748	1080		240	140	64	68	241	J2	65
2	10	11:25	21.4	73	789	575	492	499	576	459	1053		270	150	67	68	245	J2	66
3	20	11:35	20.6	74	681	515	448	449	468	438	942		271	143	69	67	234	J2	66
4	30	11:45	19.8	74	615	498	421	441	441	432	885		220	142	71	67	234	J2	67
5	40	11:55	19.0	73	577	477	404	447	427	432	918		217	141	73	67	240	J2	67
6	50	12:05	17.7	75	621	458	408	478	439	480	1167		217	154	73	67	245	J2	66
7	60	12:15	15.8	74	799	444	437	503	467	577	1124		264	160	72	66	243	J2	66
8	70	12:25	13.3	74	828	474	504	673	499	560	1156		269	161	73	66	246	J2	66
9	80	12:35	11.1	76	802	426	592	787	528	621	1151		282	161	73	66	238	J2	66
10	90	12:45	9.2	76	817	420	643	796	570	672	1130		273	158	74	66	233	J3	66
11	100	12:55	7.6	77	878	419	662	728	603	720	1117		265	156	74	66	230	J3	67
12	110	13:05	6.0	77	895	427	662	709	611	726	1101		260	154	73	65	230	J3	66
13	120	13:15	4.7	77	913	434	655	714	622	739	1085		258	151	75	65	233	J4	68
14	130	13:25	3.6	78	875	446	623	686	639	752	1099		251	146	78	64	239	J4	71
15	140	13:35	2.7	78	859	463	625	690	704	908	1081		236	138	78	63	241	J4	71
16	150	13:45	2.1	78	785	473	631	680	693	873	1008		233	129	80	65	240	J3	72
17	160	13:55	1.8	79	730	477	604	656	668	879	952		231	124	78	66	240	J3	71
18	170	14:05	1.5	78	690	481	589	633	647	782	930		220	122	81	67	241	J4	73
19	180	14:15	1.2	78	660	481	572	611	624	773	890		214	122	80	67	241	J4	73
20	190	14:25	1.0	78	635	489	557	593	607	730	871		210	117	81	68	241	J4	74
				1521	15,272	9,274	11,092	12,404	11,320		20,740		4871		1,483	1324			1366

SIGNED BY: J. Tahmin DATE: 4-17-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-4001-S
Stove I.D. No.: 184
Run No.: 5
Date: 4-14-89

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES									Flue		Dry Gas		Oven Temp °F (13)	Imp. Temp. °F (14)	Tracer Temp. °F (15)
				Amb. (1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Primry Comb. (7)	Catl. or Secondry Comb.(8)	Catl. or Secondary Comb.(16)	db (9)	wb (10)	In (11)	Out (12)			
21	200	14:35	0.6	78	618	490	545	582	593	721	861		204	115	80	69	248	31	72
22	210	14:45	0.3	78	616	486	532	568	581	741	853		200	111	79	70	247	86	72
23	220	14:55	0.1	79	592	480	517	549	583	762	822		199	114	79	71	248	36	71
				235	1620	1462	1594	1699	1761	2224	2540				238	210			215
								544.2											
			Avg	76	743	467	552	613	572	669	577		238		75	67			69
															71				

SIGNED BY: [signature]

DATE: 4-14-89

ΔT = -87.2°F

Avg Skin = 589.4°F

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 6 - PARTICULATE TRAIN OPERATION

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400FS
Stove I.D. No.: 184
Run No.: 5

Date: 4-14-89
Expected Burn Rate: Med. High
Oven Temp. Setting: 248°F
Tracer Rota, mm: 60
Tracer Pressure in H_2O: .12

Data Point	24 hr. Time	Elap. Time Δt	SO2 Scale	SO2 ppm	CO2 Scale	CO %	O2 %	Orifice ΔH In H20	Dry Gas Meter ft 3	Vacuum in Hg	Stove Static Pressure In H20	Comments
1	11:15	0	22	330	57.5	.08	5.61	.013	564.961	<.5	.065	
2	11:25	10	23	345	48	.05	8.15	.011	566.08	<.5	.070	
3	11:35	20	20	300	39.5	.03	10.41	.015	567.07	<.5	.065	
4	11:45	30	19.5	292	38.5	.02	10.69	.016	568.21	<.5	.065	
5	11:55	40	19	285	40	.03	10.28	.017	569.35	<.5	.065	
6	12:05	50	19.5	292	69	.90	2.07	.016	570.52	<.5	.070	
7	12:15	60	18.5	277	70.5	3.10	.33	.018	571.66	<.5	.075	
8	12:25	70	17.5	262	69	4.85	0.0	.020	572.91	<.5	.075	
9	12:35	80	16.5	247	68.5	5.60	0.0	.027	574.17	<.5	.075	
10	12:45	90	16	240	70.5	2.75	.54	.024	575.55	<.5	.070	
11	12:55	100	17	255	71	2.6	.50	.021	577.00	<.5	.070	
12	13:05	110	18	270	71.5	2.25	.58	.019	578.30	<.5	.070	
13	13:15	120	17	255	68.5	2.65	1.13	.021	579.56	<.5	.070	
14	13:25	130	18.5	277	66.5	1.95	2.09	.018	580.8	<.5	.065	
15	13:35	140	19	285	64.5	.40	3.56	.017	582.04	<.5	.060	
16	13:45	150	19	285	56	.08	6.05	.017	583.15	<.5	.055	
17	13:55	160	22	330	53.5	.02	6.71	.012	584.27	<.5	.055	
18	14:05	170	21	315	52	.01	7.64	.014	585.30	<.5	.050	
19	14:15	180	21	315	48	.01	8.17	.013	586.40	<.5	.050	
20	14:25	190	21	315	48	.01	8.17	.013	587.50	<.5	.050	
21	14:35	200	21	315	49	.01	7.90	.014	588.52	<.5	.050	
22	14:45	210	19	285	46	.02	8.69	.017	589.65	<.5	.050	
23	14:55	220	19	285	44	.01	9.23	.016	590.757	<.5	.050	
24				6654	~~665.5~~	27.37	132.51	~~.385~~			490	
25			Avg		1307.5	1.19	5.98	0.385	25.796		-0.065	

56.85
14.21
0.017

SIGNED: [signature] DATE: 4-17-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Hawks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 5
Date: 4-14-89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:		PRE-Test Calibration		
ZERO GAS:	0.0	0.0	N/A	0.0
AUDIT GAS:	59.9	5.01		34.2
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.0%	0.0%		0.0%
TIME (24 HOUR):	10:30	10:30		10:30

SIGNED: J. Palmer

DATE: 4-14-89

NORTHWEST TESTING LABORATORIES
Woodstove Emmission Testing

PAGE 7 - POST TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184

Run No.: 5
Date: 4/14/89
Time: 15:16

Analyzer Audit

	Scale Readings			
	CO_2	O_2	CO	SO_2
Zero Gas	0.0		0.0	0.2
Audit Gas	59.9		5.00	34.4
Desired	59.9		5.01	34.2
% Difference	0.0%		0.2%	0.6%
% Drift Check:				
Zero Drift	0.0%		0.0%	0.2%
Mid Level Drift	0.0%		0.1%	0.2%
Leak Test Results	PASS			

Particulate Train

Leakage Rate: 0.00% ft^3/min.

Extra Filters Used: N/A

Ambient

Tdb 78 °F
Twb 64 °F
Pbaro 29.93 in Hg. 29.92
Moisture 1.6 % By Volume
Relative Humidity, % 46

SIGNED: [signature] DATED: 4/14/89

SAMPLE EXTRACTION DATA

Stove Mfg.: Marks Custom Stoves Test: 6

Stove Model: K-400FS Test Cycle: Med. High

Date: 4-17-89 Stove I.D. No.: 184

Technician: T. Palmer

V_V

CONDENSED WATER VOLUME, GMS

	Modified Temp. 100 ml H20	Standard Imp 100 ml Hz	Modified Imp. Dry	Modified Imp. 200 Gms Silica Gel
Gross Weight	678.3	610.8	464.5	738.8
Initial Weight	586.5	606.0	463.8	737.1
Net Weight	91.8	4.8	0.7	5.7

TOTAL 103.0 GMS

W .7916

PARTICULATE CATCH, GMS .7664 4/18 0800

	OVEN FILTER(S)				TRAIN FILTER(S)
Gross Weight	.7864				.7645
Initial Weight	.7569				.7605
Net Weight	0.0295				-0.0040

TOTA

TOTAL 0.0335 GMS

# 8	Front Catch Probe	Rear Catch Impingers	DCM	H20	
Beaker, ml	75	150	150	200+ 115	
Gross, Weight	99.3704	100.0591	102.7165	100.2239	
Initial Weight	99.3437	100.0104	102.6723	100.1883	
Net Weight	0.0267	0.0487	0.0442	-0.0356	
Evaporation	0.0007	0.0014	0.0009	0.0030	
Residue Weight	0.0266	0.0473	0.0433	0.0326	TOTA

TOTAL 0.1492 GMS 0.0733 0.0759

Total Particulate = 0.1827 g

= 182.7 mg

ANALYSIS CONTROL LOG

DATE	CLIENT	TEST I.D.	SAMPLE WEIGHTS						TIME 24 HR.
			OVEN FILTER	TRAIN FILTER	PROBE	ACETONE	DCM	H20	
4-18	Marks Custom K-40FS	184-6	.7916	.7664					08:00
4-19			.7896	.7647	99.3704				07:30
4-19			.7871	.7645	99.3717				09:30
4-19			.7863		99.3709				11:30
4-19			.7855		99.3704				13:30
4-19			.7868						15:30
4-20			.7861			100.0591	102.7155	100.2225	07:30
4-20			.7864			100.0596	102.7167	100.2240	09:30
4-20							102.7165	100.2229	12:00
4-20								100.2240	14:15
4-21								100.2234	07:15
4-21								100.2239	09:15

METHOD 5H FLOW RATE (STACK) CALCULATIONS
(Put general info in col B, data info in col H.)

Lab name: NORTHWEST TESTING LABS, INC.
Stv manu: MARKS CUSTOM STOVES
Model no: K-400 FREESTANDING
Tst Date: APRIL 17, 1989

Yhc 1=cat,2=ncat : 1
Wc (if supplied) :
Burn rate (kg/hr): 1.39
Run Number : 6

run time (min)	O2 (%)	CO2 (%)	CO (%)	Fo (1.-1.12)	Stack Gas Flow Rate (dscfh)	(dscfm)	(dsm3/hr)
0	7.90	12.30	0.01	1.06	357.28	5.95	10.13
10	11.10	9.30	0.01	1.05			
20	9.50	10.80	0.01	1.06			
30	7.90	12.30	0.02	1.06			
40	6.80	13.30	0.04	1.06			
50	7.50	12.60	0.03	1.06			
60	6.80	13.30	0.04	1.06			
70	5.20	14.80	0.04	1.06			
80	5.40	14.60	0.04	1.06			
90	5.00	15.00	0.05	1.06			
100	5.20	14.80	0.04	1.06			
110	5.40	14.60	0.04	1.06			
120	2.70	16.90	0.50	1.06			
130	3.00	16.80	0.25	1.06			
140	2.60	16.40	1.50	1.06			
150	0.70	16.80	4.00	1.07			
160	1.40	17.10	2.15	1.07			
170	2.40	17.30	0.35	1.06			
180	2.40	17.30	0.35	1.06			
190	2.70	17.00	0.30	1.06			
200	3.70	16.10	0.13	1.06			
210	5.40	14.60	0.02	1.06			
220	5.90	14.10	0.02	1.06			
230	6.60	13.50	0.02	1.06			
240	9.00	11.30	0.02	1.05			
250	10.00	10.30	0.01	1.06			
260	10.20	10.10	0.01	1.06			
270	10.30	10.00	0.01	1.06			
280	10.60	9.80	0.01	1.05			
290	11.00	9.40	0.01	1.05			
300	11.80	8.60	0.01	1.06			
310	11.80	8.60	0.01	1.06			
320	12.10	8.30	0.01	1.06			
330	10.40	9.90	0.01	1.06			
340	9.90	10.40	0.01	1.06			
350	9.20	11.00	0.01	1.06			
360	9.40	10.90	0.01	1.05			
370	9.20	11.00	0.01	1.06			
375	9.20	11.00	0.01	1.06			

Method 5H Proportionality Rate and Sample Volume Calculation
(put general info in col. C; Pb,Y,& unit info in col. G)

Lab name: NORTHWEST TESTING LAB., INC.
Stv manu: MARKS CUSTOM STOVES
Model no: K-400 FREESTANDING
Tst date: APRIL 17, 1989
Run no : 6.0

Units 1=metric,
2=English: 2.0
Y, DGM: 0.971
Pb (mm,in. Hg): 29.9

NOTE: Input raw data below, use F9 for CALC.

run time (min)	tracer conc (ppm,%)	DGM rdg (m3,ft3)	DGM temp (C,F)	DGM dH (mm H2O) (in.H2O)	dDGM vol std (m3,ft3)	PR (%)	Sample vol std (m3,ft3)
0	360.0	590.901	68	0.010			
10	375.0	591.850	71	0.010	0.922	102.1	35.604
20	330.0	592.790	73	0.012	0.908	104.7	
30	307.0	593.780	75	0.014	0.953	96.7	
40	307.0	594.870	75	0.014	1.045	98.7	
50	285.0	595.950	74	0.017	1.035	97.8	
60	285.0	597.100	72	0.017	1.105	96.8	
70	300.0	598.270	71	0.015	1.128	98.9	
80	307.0	599.390	73	0.015	1.082	99.8	
90	300.0	600.510	71	0.015	1.078	101.8	
100	292.0	601.630	71	0.016	1.082	99.8	
110	300.0	602.770	71	0.015	1.101	98.9	
120	315.0	603.910	72	0.014	1.101	101.6	
130	300.0	604.980	72	0.015	1.032	99.9	
140	322.0	606.090	72	0.013	1.070	98.7	
150	307.0	607.120	72	0.015	0.993	98.3	
160	322.0	608.220	72	0.013	1.061	100.1	
170	322.0	609.250	73	0.013	0.993	98.3	
180	330.0	610.280	74	0.013	0.991	98.2	
190	337.0	611.310	74	0.012	0.989	100.4	
200	330.0	612.250	73	0.013	0.903	93.6	
210	337.0	613.280	74	0.012	0.991	100.6	
220	337.0	614.240	74	0.012	0.922	95.6	
230	345.0	615.180	74	0.011	0.903	93.6	
240	352.0	616.110	75	0.011	0.893	94.8	
250	375.0	617.030	74	0.010	0.882	95.5	
260	367.0	617.920	74	0.010	0.855	98.6	
270	382.0	618.820	73	0.009	0.864	97.6	
280	375.0	619.690	73	0.010	0.837	98.4	
290	390.0	620.620	73	0.009	0.895	103.2	
300	405.0	621.520	72	0.008	0.866	103.9	
310	405.0	622.370	72	0.008	0.820	102.1	
320	420.0	623.230	71	0.008	0.829	103.3	
330	420.0	624.070	71	0.008	0.811	104.8	
340	420.0	624.920	71	0.008	0.821	106.1	
350	420.0	625.760	71	0.008	0.811	104.8	
360	420.0	626.600	71	0.008	0.811	104.8	
370	420.0	627.440	70	0.008	0.811	104.8	
375	420.0	627.861	70	0.008	0.407	105.3	

NORTHWEST TESTING LABORATORIES
Woodstove Emmission Testing

PAGE 1 - STOVE INFORMATION AND PRE-TEST DATA

Stove Manufacturer: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. Number: 184
Run Number: 6
Date: 4-17-89
Expected Burn Rate: Med. High

STOVE

Weight: 502.1 lb.
Platform Scale Audit?: OK
Primary Air Control Setting: 5/16" open
Blower: On ___ Off ___ Auto. ___ N/A X
Flue Pipe Gauge: 24
Flue Pipe Diameter in.: 8 in.
Pictures: Yes X No ___
Operating Instructions:
Stove Manual ___ Verbal ___ Other X written
Stack Cleaned: Yes X No ___

CATALYST Yes X No ___

Catalyst Brand: Applied Ceramics
Catalyst I.D.: Firecat, 2½ x 7½ x 3, 16 cell
Catalyst Age: 50+ hrs.
Catalyst Provided: Marks Custom Stoves

AMBIENT

Dry Bulb Reading 69 °F
Wet Bulb Reading 57 °F
Relative Humidity 47 %
Baro. 29.94 in Hg.

% Moisture 1.2 % Volume ___

CONTINUOUS ANALYZERS

Audited by: T. Palmer
Leak Tested by: T. Palmer

PARTICULATE TRAIN

Probe Length & Type 6" Pyrex
Nozzle Size .62 in.
ΔH @ .65
ΔH Magnehelic Range, 0-1 in H_2O
Leakage Rate: .002 $Ft.^3$/min.

TRACER GAS

Gas Used: SO2
Rotameter No.: 601
Rotameter Rdg.: 60
Ball Read: 55
CC/Min.: 70.62
$Ft.^3$/hr. .15
(cc/min. ÷ 472 = Ft^3/hr.)
Injection System Rate
Checked: Yes: X No: ___

SIGNED BY: T. Palmer

DATE: 4-17-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 2 - FUEL DATA

Stove Manufacturer: Mark's Custom Stoves
Stove Model: K-400 FS
Stove I.D. Number: 5484
Technician: T Palmer

Run Number: 6
Expected Burn Rate: Med High
Calculated Charge Wt.: 24.8 #
Coal Bed Wt. Lbs.: 4.9
HHV Sample: Yes X No
(Saw Dust Catch & Block)

I. Fuel Moisture Content, % (Dry Basis):

1.	19.2, 19.2, 19.2	11.	19.2, 19.2, 19.2	21.	
2.	19.2, 19.2, 19.2	12.	19.2, 19.2, 19.2	22.	
3.	19.2, 19.2, 19.2	13.		23.	
4.	19.8, 21.5, 20.3	14.		24.	
5.	20.3, 20.9, 19.2	15.		25.	
6.	19.2, 19.2, 19.2	16.		26.	19.2, 20.3, 19.5
7.	19.2, 19.2, 19.2	17.		27.	19.8, 20.3, 19.2
8.	19.2, 19.2, 19.2	18.		28.	24.8, 24.3, 24.8
9.	19.2, 19.8, 19.2	19.		29.	24.8, 24.8, 24.3
10.	19.2, 19.2, 19.2	20.		30.	24.3, 24.3, 24.3

II. Test Fuel:

1. No. of 2 x 4's: 0
2. No. of 4 x 4's: 5
3. Total No. of Fuel Pieces: #26 → #30
4. Weight, Lbs.: 23.4
5. Species: D.F.
6. Moisture Content, % Ave. (Dry Basis): 22.62
7. Length, In.: 19"

III. Pre-Burn Fuel:

1. No. of 2 x 4's: 12
2. No. of 4 x 4's: 0
3. Total No. of Fuel Pieces: #1 → #12
4. Weight, Lbs.: 25.6
5. Species: D.F.
6. Moisture Content, % Ave. (Dry Basis): 19.41
7. Length, In.: 21" ÷ 3 = 7"

IV. Kindling Fuel:

1. No. of 2 x 4's: 0
2. No. of 4 x 4's: 1½
3. Total No. of Fuel Pieces:
4. Weight, Lbs.: 4.4
5. Species: D.F.
6. Moisture Content, % Ave. (Dry Basis): 21.05
7. Length, In.: 15"

Date: 4-19-89

Attention: Mike Cave

Subject: Analysis on one (1) wood fuel sample received 4-17-89.

Item: Wood Fuel

Reference: Marks Custom stoves
K-400 FS
194-6
Med. High

REPORT:

Analysis:

Moisture, %, as received	15.6
Moisture, %, dry basis	18.5
Density, g/cm^3, dry basis	0.43
Higher Heat of Combustion, BTU/lb., dry basis	8585

Robert W. Hardesty

Report Number: 321591

WOOD/FUEL
(ON NTL STOVE DISK)

0800 chemical $70

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 3 - STOVE OPERATION LOG

Stove Mfg.: Marks Custom Stove Date: 4-17-89

Stove Model: K-400FS Technician: T. Palmer

Stove I.D. Number: 184

Run Number: 6

24 Hr. Time	OPERATION
09:50	Lit 4.4 lbs of Kindling, Door Ajar By-Pass open, Air 100% open
09:55	Added #1 Pre-Burn 25.6 lbs
09:58	Shut Door & By-Pass
10:15	Set Air controls 5/16" open
10:20	Started Pre-Burn Readings
10:57	Stoked Fire
11:07	Stoked Fire
11:30	Added Test Fuel 23.4 lbs, Air & By-Pass 100% open
11:32	Shut Door & By-Pass
11:35	Set Air controls 5/16" open, both sides

NOR WEST TESTING LABORATORIES
Woodstove Emission Testing

PAGE 4 - PREBURN DATA

Stove Mfg.: Marks Custom Stoves
Run Number: 6 (4.7 → 5.)
Stove Model: K-400 FS
Date: 4-17-89
Stove I.D. No.: 184
Air Control Setting: 5/16" open

Data Set No.	Elapsed 24/Hr. Time	TEMPERATURES Amb.(1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Fuel Wt/lb	Prim. Temp. (7)	Cat. Temp. (8)	Cat. Temp. (16)	
1 5	10:20	64	887	486	542	669	529	14.3	694	1046		
2 10	10:25	66	881	430	523	635	530	13.7	685	1025		
3 15	10:30	66	879	453	511	626	530	12.4	679	1010		
4 20	10:35	65	878	466	506	625	530	11.6	687	1022		
5 25	10:40	67	826	473	536	624	550	10.2	717	987		← STOKED
6 30	10:45	67	815	478	531	611	552	9.2	719	981		
7 35	10:50	67	794	484	526	602	555	8.5	735	1018		
8 40	10:55	66	799	487	525	599	550	7.9	710	1031		
9 45	11:00	66	793	486	519	597	543	7.5	702	1025		
10 50	11:05	67	767	491	515	598	538	7.1	688	1060		← STOKED
11 55	11:10	68	762	495	533	615	553	6.3	694	939		
12 60	11:15	69	766	503	533	611	553	5.7	704	1006		
13 65	11:20	69	756	505	529	606	554	5.4	694	1048		
14 70	11:25	66	731	498	520	589	547	5.1	672	1026		
					Test	Fuel	Added	at	4.9 lbs			

SIGNED: [signature] DATE: 4-17-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400FS
Stove I.D. No.: 184
Run No.: 6
Date: 4-17-89

+274 = 1.9
+416 = 1.25

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES Amb. (1)	570.0 °F Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Primry Comb. (7)	Catl. or Secondry Comb.(8)	Catl. or Secondary Comb.(16)	Flue db (9)	wb (10)	Dry Gas In (11)	Out (12)	Oven Temp °F (13)	Imp. Temp. °F (14)	Tracer Temp. °F (15)
1	0	11:30	23.4	68	714	497	516	581	542	667	1000		268	125	66	70	228	32	67
2	10	11:40	22.2	67	672	505	435	477	472	489	939		307	141	71	71	227	32	68
3	20	11:50	21.6	68	577	506	391	418	419	457	874		264	138	76	70	227	32	70
4	30	12:00	20.9	68	558	487	369	396	390	453	963		270	139	80	69	227	32	71
5	40	12:10	19.8	67	599	466	364	408	386	464	1014		285	144	82	68	228	32	71
6	50	12:20	18.9	69	626	452	365	416	386	471	1005		286	144	76	71	228	32	67
7	60	12:30	18.0	67	667	439	366	420	397	489	1063		294	146	77	71	229	32	65
8	70	12:40	17.0	67	678	432	377	443	412	509	1073		305	148	72	70	232	32	64
9	80	12:50	15.9	67	695	451	383	458	428	527	1094		316	149	76	67	230	32	66
10	90	13:00	14.8	68	723	428	395	483	448	548	1121		319	150	77	68	232	32	64
11	100	13:10	13.8	69	721	426	402	492	457	555	1120		323	149	74	67	229	32	65
12	110	13:20	12.8	69	729	420	407	504	460	566	1105		321	148	77	65	232	32	68
13	120	13:30	11.7	69	778	411	419	528	471	593	1094		323	149	79	64	233	32	69
14	130	13:40	10.7	68	792	413	428	553	495	636	1152		328	150	80	64	235	32	70
15	140	13:50	9.7	69	804	424	443	520	543	685	1105		323	147	80	64	236	32	69
16	150	14:00	8.4	70	818	432	457	563	574	714	1024		320	150	80	64	237	32	69
17	160	14:10	7.3	71	808	437	469	619	586	738	1051		309	146	79	65	237	32	69
18	170	14:20	6.4	70	811	447	480	637	588	733	1075		304	140	81	65	236	33	71
19	180	14:30	5.6	72	806	458	488	641	594	728	1085		299	138	81	66	237	33	71
20	190	14:40	4.9	72	797	467	494	651	596	728	1105		300	138	81	66	234	34	70
				1375	14373	8978	8446	10158	9640	11750	19113		6064		1587	1347			1364

SIGNED BY: J. Tabum DATE: 4-17-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400FS
Stove I.D. No.: 184
Run No.: 6
Date: 4-17-89

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES Amb. (1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Primry Comb. (7)	Catl. or Secondry Comb.(8)	Catl. or Secondary Comb.(16)	Flue db (9)	wb (10)	Dry Gas In (11)	Out (12)	Oven Temp °F (13)	Imp. Temp. °F (14)	Tracer Temp. °F (15)
21	200	14:50	4.J	72	784	472	497	62J	596	7J0	1092		296	1J4	79	66	2J2	34	71
22	210	15:00	J.8	72	744	47J	501	610	59J	720	105J		293	127	80	67	2JJ	J4	71
23	220	15:10	J.J	72	710	476	494	588	578	697	1039		282	127	80	67	2J1	J4	70
24	230	15:20	2.9	73	698	482	487	57J	564	684	1027		279	125	80	67	2J2	J5	71
25	240	15:30	2.6	73	659	476	481	558	551	671	94J		267	119	81	68	2J4	J6	71
26	250	15:40	2.4	73	620	470	47J	538	532	649	868		248	113	80	68	2J7	J7	72
27	260	15:50	2.2	72	586	461	461	578	575	637	836		246	111	80	68	239	J7	71
28	270	16:00	2.0	73	569	45J	457	571	50J	622	832		246	110	77	69	242	J8	69
29	280	16:10	1.8	74	552	447	449	500	488	605	815		238	108	76	70	246	40	68
30	290	16:20	1.6	74	537	429	443	491	477	589	802		235	107	76	69	246	41	68
31	300	16:30	1.5	74	522	424	43J	47J	455	561	764		228	104	75	69	248	42	68
32	310	16:40	1.4	72	496	422	426	46J	441	546	747		222	103	75	68	248	43	69
33	320	16:50	1.3	73	480	417	418	45J	427	53J	73J		218	104	74	68	248	45	68
34	330	17:00	1.1	73	471	409	40J	450	416	524	759		222	110	74	68	248	46	68
35	340	17:10	.9	73	464	401	424	475	412	5J2	721		216	109	74	68	248	47	67
36	350	17:20	.6	73	465	389	455	49J	421	554	736		217	110	74	67	248	48	67
37	360	17:30	.4	72	423	375	465	508	436	568	743		222	110	74	67	248	49	67
38	370	17:40	.1	74	476	365	477	570	444	569	732		217	107	74	66	248	51	67
39	375	17:45	.0	73	476	361	483	571	445	576	726		219	106	74	66	248	52	68
			avg	71	645	440	440	513	485	598	900		274		77	68			69

455.2°F

72

SIGNED BY: [signature]

DATE: 4-17-89

ΔT = -114.8°F

Avg Exin = 505°F

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 6 - PARTICULATE TRAIN OPERATION

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 6

Date: 4-17-89
Expected Burn Rate: Med. High
Oven Temp. Setting: 248°F
Tracer Rota, mm: 60
Tracer Pressure in H_2O: 1.2

Data Point	24 hr. Time	Elap. Time Δt	SO2 Scale	SO2 ppm	CO2 Scale	CO %	O2 %	Orifice Δ H In H2O	Dry Gas Meter ft 3	Vacuum in Hg	Stove Static Pressure In H2O	Comments
1	11:30	0	24	360	49	0.01	7.91	0.010	590.901	<.5	0.050	
2	11:40	10	25	325	57	.01	11.09	0.010	591.85	<.5	0.060	
3	11:50	20	22	330	47	.01	9.5	0.012	592.79	<.5	0.060	
4	12:00	30	20.5	307	49	.02	7.9	0.014	593.78	<.5	0.055	
5	12:10	40	20.5	307	53	.04	6.83	0.014	594.87	<.5	0.060	
6	12:20	50	19	285	50.5	.05	7.50	0.017	595.95	<.5	0.060	
7	12:30	60	19	285	51	.04	6.83	0.017	597.10	<.5	0.065	
8	12:40	70	20	300	59	.04	5.24	0.015	598.27	<.5	0.065	
9	12:50	80	20.5	307	58.5	.04	5.37	0.015	599.39	<.5	0.065	
10	13:00	90	20	300	60	.05	4.97	0.015	600.51	<.5	0.065	
11	13:10	100	19.5	292	59	.04	5.24	0.016	601.63	<.5	0.065	
12	13:20	110	20	300	58.5	.04	5.37	0.015	602.77	<.5	0.065	
13	13:30	120	21	315	67.5	.50	2.7	0.014	603.91	<.5	0.065	
14	13:40	130	20	300	67	.25	2.99	0.015	604.98	<.5	0.065	
15	13:50	140	21.5	322	65.5	1.50	2.63	0.013	606.09	<.5	0.060	
16	14:00	150	20.5	307	67	4.0	.71	0.015	607.12	<.5	0.060	
17	14:10	160	21.5	322	68.5	2.15	1.44	0.013	608.22	<.5	0.060	
18	14:20	170	21.5	322	69	.35	2.4	0.013	609.25	<.5	0.060	
19	14:30	180	22	330	69	.35	2.4	0.013	610.28	<.5	0.060	
20	14:40	190	22.5	337	68	.50	2.7	0.012	611.31	<.5	0.055	
21	14:50	200	22	330	64.5	.13	3.73	0.013	612.25	<.5	0.055	
22	15:00	210	22.5	337	58.5	.02	5.39	0.012	613.28	<.5	0.050	
23	15:10	220	22.5	337	56.5	.02	5.92	0.012	614.24	<.5	0.050	
24	15:20	230	23	345	54	.02	6.58	0.011	615.18	<.5	0.050	
25	15:30	240	23.5	352	45	.02	8.96	0.011	616.11	<.5	0.050	
								1.337			1.475	

SIGNED: [signature]

DATE: 4-17-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 6 - PARTICULATE TRAIN OPERATION

Stove Mfg.: Hawks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 6
Run No.: 6

Date: 4-17-89
Expected Burn Rate: Med. High
Oven Temp. Setting: 2480F
Tracer Rota, mm: 60
Tracer Pressure in H_2O: .12

Data Point	24 hr. Time	Elap. Time Δt	SO2 Scale	SO2 ppm	CO2 Scale	CO %	O2 %	Orifice Δ H In H2O	Dry Gas Meter ft 3	Vacuum in Hg	Stove Static Pressure In H20	Comments
1	15:40	250	25	375	41	.01	10.03	.010	617.03	<.5	.050	
2	15:50	260	24.5	367	40.5	.01	10.16	.010	617.92	<.5	.050	
3	16:00	270	25.5	382	40	.01	10.29	.009	618.82	<.5	.040	
4	16:10	280	25	375	39	.01	10.56	.010	619.69	<.5	.040	
5	16:20	290	26	390	37.5	.01	10.96	.009	620.62	<.5	.040	
6	16:30	300	27	405	34.5	.01	11.75	.008	621.52	<.5	.040	
7	16:40	310	27	405	34.5	.01	11.75	.008	622.37	<.5	.040	
8	16:50	320	28	420	33	.01	12.15	.008	623.23	<.5	.040	
9	17:00	330	28	420	39.5	.01	10.43	.008	624.07	<.5	.040	
10	17:10	340	28	420	41.5	.01	9.9	.008	624.92	<.5	.040	
11	17:20	350	28	420	44	.01	9.23	.008	625.76	<.5	.035	
12	17:30	360	28	420	43.5	.01	9.37	.008	626.60	<.5	.035	
13	17:40	370	28	420	44	.01	9.23	.008	627.44	<.5	.035	
14	17:45	375	28	420	44	.01	9.23	.008	627.861	<.5		
15												
16			avg		51.44	0.26		0.012	36.96		-0.052	
17					12.86							
18												
19												
20												
21												
22												
23												
24												
25												

SIGNED: [signature]

DATE: 4-17-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Marks Custom Stoves
Stove Model: IC-400 FS
Stove I.D. No.: 184
Run No.: 6
Date: 4-17-89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:		PRE-Test Calibration		
ZERO GAS:	0.0	0.0	NA	0.0
AUDIT GAS:	5.9	5.01		34.2
DESIRED:	5.9	5.01		34.2
PERCENT DIFFERENCE:	0.0%	0.0%	↓	0.0%
TIME (24 HOUR):	11:00	11:00		11:00

SIGNED: T. Palmer
DATE: 4-17-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400FS
Stove I.D. No.: 184
Run No.: 6
Date: 4-17-89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:		120		
ZERO GAS:	0.0	0.0	N/A	0.5
AUDIT GAS:	59.9	5.01		34.8
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.0%	0.0%	↓	3.2%
TIME (24 HOUR):	13:30	13:30		13:30

SIGNED: T. Tolman
DATE: 4-17-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 6
Date: 4-17-89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:		240		
ZERO GAS:	0.0	0.0	N/A	0.5
AUDIT GAS:	59.9	5.01		3.48
DESIRED:	59.9	5.01		34.2
PERCENT DIFFERENCE:	0.0%	0.0%	↓	3.2%
TIME (24 HOUR):	15:30	15:30		15:30

SIGNED: T. Palmer
DATE: 4-17-89

NORTHWEST TESTING LABORATORIES
Woodstove Emmission Testing

PAGE 7 - POST TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400ES
Stove I.D. No.: 184

Run No.: 6
Date: 4-17-89
Time: 18:00

Analyzer Audit

	Scale Readings			
	CO_2	O_2	CO	SO_2
Zero Gas	0.0	N/A	0.0	0.5
Audit Gas	59.9		5.01	14.8
Desired	59.9		5.01	14.2
% Difference	0.0%		0.0%	3.2%
% Drift Check:				
Zero Drift	0.0%		0.0%	0.5%
Mid Level Drift	0.0%		0.0%	0.6%
Leak Test Results	OK			

Particulate Train

Leakage Rate: .001 ft^3/min.

Extra Filters Used: N/A

Ambient

Tdb 72 °F 29.945
Twb 58 °F 1.2
Pbaro 29.95 in Hg.
Moisture 1.2 % By Volume
Relative Humidity, % 42

SIGNED: D. Tahm DATED: 4-17-89

SAMPLE EXTRACTION DATA

Stove Mfg.: Marks Custom Stoves Test: 7

Stove Model: K-400 FS Test Cycle: High

Date: 4-18-89 Stove I.D. No.: 184

Technician: D Windsor

V_V

CONDENSED WATER VOLUME, GMS

	Modified Temp. 100 ml H20	Standard Imp 100 ml Hz	Modified Imp. Dry	Modified Imp. 200 Gms Silica Gel
Gross Weight	621.6	609.2	487.3	742.6
Initial Weight	563.4	607.5	487.3	738.2
Net Weight	58.2	1.7	0.0	4.4

TOTAL 64.3 GMS

W

PARTICULATE CATCH, GMS

	OVEN FILTER(S)				TRAIN FILTER(S)
Gross Weight	.8046				.7840
Initial Weight	.7619				.7768
Net Weight	0.0427				-0.0072

TOTAL 0.0499 GMS

#1 5-05

	Front Catch Probe	Rear Catch Impingers	DCM	H20
Beaker, ml	45ml	125ml	150ml	200ml+75
Gross, Weight	95.4469	101.4671	96.0613	104.0679
Initial Weight	95.4213	101.4239	96.0361	104.0515
Net Weight	0.0256	0.0432	0.0252	0.0164
Evaporation	0.0004	0.0011	0.0009	0.0026
Residue Weight	0.0252	0.0421	0.0243	0.0138

TOTAL 0.1054 GMS 0.0673 0.0381

Total Particulate = 0.1553 g

= 155.3 mg

ANALYSIS CONTROL LOG

DATE	CLIENT	TEST I.D.	SAMPLE WEIGHTS						TIME 24 HR.
			OVEN FILTER	TRAIN FILTER	PROBE	ACETONE	DCM	H20	
4-18	Marks Custom K-400 FS	184-7	.8163	.7824					15:00
4-19			.8069	.7839					13:30
4-19			.8059	.7840					15:30
4-20			.8042		95.4466	101.4662	96.0609		07:30
4-20			.8032		95.4469	101.4674	96.0613		09:30
4.20			.8042			101.4671		104.0676	12:00
4-20			.8046					104.0684	14:15
4-21								104.0678	07:15
4-21								104.0679	09:15

METHOD 5H FLOW RATE (STACK) CALCULATIONS
(Put general info in col B, data info in col H.)

Lab name: NORTHWEST TESTING LABS, INC.
Stv manu: MARKS CUSTOM STOVES
Model no: K-400 FREESTANDING
Tst Date: APRIL 18, 1989

Yhc 1=cat,2=ncat : 1
Wc (if supplied) :
Burn rate (kg/hr): 4.73
Run Number : 7

run time (min)	O2 (%)	CO2 (%)	CO (%)	Fo (1.-1.12)	Stack Gas Flow Rate (dscfh)	(dscfm)	(dsm3/hr)
0	3.90	15.80	0.45	1.06	1028.27	17.14	29.15
10	2.10	16.40	2.35	1.07			
20	3.00	16.50	0.62	1.06			
30	2.80	16.50	1.00	1.06			
40	1.63	17.40	1.40	1.06			
50	1.62	17.50	1.20	1.06			
60	4.10	15.80	0.20	1.06			
70	5.20	14.80	0.10	1.06			
80	4.80	15.10	0.08	1.06			
90	6.04	14.00	0.03	1.06			
100	9.35	10.90	0.04	1.06			
110	10.14	10.10	0.04	1.06			

Method 5H Proportionality Rate and Sample Volume Calculation
(put general info in col. C; Pb,Y,& unit info in col. G)

Lab name: NORTHWEST TESTING LAB., INC.
Stv manu: MARKS CUSTOM STOVES
Model no: K-400 FREESTANDING
1st date: APRIL 18, 1989
Run no : 7.0

Units 1=metric, 2=Englsh: 2.0
Y, DGM: 0.971
Pb (mm,in. Hg): 30.0

NOTE: Input raw data below, use F9 for CALC.

run time (min)	tracer conc (ppm,%)	DGM rdg (m3,ft3)	DGM temp (C,F)	DGM dH (mm H2O) (in.H2O)	dDGM vol std (m3,ft3)	PR (%)	Sample vol std (m3,ft3)
0	187.0	627.913	75	0.023			
10	172.0	629.400	76	0.028	1.427	103.7	17.244
20	180.0	631.000	76	0.025	1.532	102.4	
30	165.0	632.480	76	0.030	1.417	99.1	
40	157.0	634.090	76	0.034	1.542	98.9	
50	165.0	635.800	76	0.031	1.638	99.9	
60	157.0	637.430	75	0.034	1.561	100.1	
70	157.0	639.140	75	0.034	1.641	100.1	
80	157.0	640.820	74	0.033	1.612	98.3	
90	157.0	642.490	75	0.033	1.605	97.9	
100	157.0	644.190	74	0.033	1.631	99.5	
110	157.0	645.895	74	0.033	1.639	100.0	

NORTHWEST TESTING LABORATORIES
Woodstove Emmission Testing

PAGE 1 - STOVE INFORMATION AND PRE-TEST DATA

Stove Manufacturer: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. Number: 184
Run Number: 7
Date: 4-18-89
Expected Burn Rate: High

STOVE

Weight: 502.1 lb.
Platform Scale Audit?: OK
Primary Air Control Setting: 2" open Both Sides
Blower: On ___ Off ___ Auto. ___ N/A X
Flue Pipe Gauge: 24
Flue Pipe Diameter in.: 8 in.
Pictures: Yes X No ___
Operating Instructions:
Stove Manual ___ Verbal ___ Other X written
Stack Cleaned: Yes X No ___

CATALYST Yes X No ___

Catalyst Brand: Applied Ceramics
Catalyst I.D.: Firecat, 2½ x 7½ x 3, 16 cell
Catalyst Age: 50+ hrs
Catalyst Provided: Marks Custom Stoves

AMBIENT

Dry Bulb Reading 74 °F
Wet Bulb Reading 65 °F
Relative Humidity 62 %
Baro. 29.99 in Hg.

% Moisture 1.8 % Volume ___

CONTINUOUS ANALYZERS

Audited by: T. Palmer
Leak Tested by: T. Palmer

PARTICULATE TRAIN

Probe Length & Type 6" Pyrex
Nozzle Size .162 in.
ΔH @ .65
ΔH Magnehelic Range, 0 → 1 in H_2O
Leakage Rate: 0.011 $Ft.^3$/min.

TRACER GAS

Gas Used: SO_2
Rotameter No.: 601
Rotameter Rdg.: 60
Ball Read: 55
CC/Min.: 70, 62
$ft.^3$/hr. 1.55
(cc/min. ÷ 472 = Ft^3/hr.)
Injection System Rate
Checked: Yes: X No: ___

SIGNED BY: T. Palmer

DATE: 4-18-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 2 - FUEL DATA

Stove Manufacturer: Mark's Custom Stoves
Stove Model: K-400FS
Stove I.D. Number: #184
Technician: T Fetmer

Run Number: 7
Expected Burn Rate: 10.2
Calculated Charge Wt.: 24.8
Coal Bed Wt. Lbs.: 4.7
HHV Sample: Yes X No
(Saw Dust Catch & Block)

I. Fuel Moisture Content, % (Dry Basis):

1.	19.2, 19.2, 19.2	11.	19.2, 19.8, 20.5	21.	
2.	19.2, 19.8, 19.2	12.	19.8, 19.8, 21	22.	
3.	19.2, 19.2, 19.8	13.	19.2, 19.2, 19.8	23.	
4.	19.2, 21, 21	14.	19.2, 20.5, 20.5	24.	
5.	22, 20.5, 20	15.	21, 21, 21	25.	
6.	19.2, 19.2, 19.2	16.	20.5, 20, 20.5	26.	23.7, 24.8, 24.8
7.	19.2, 19.8, 19.8	17.	21, 20, 20.5	27.	23.1, 20.4, 20.9
8.	19.8, 20.5, 19.8	18.	21, 20, 21	28.	14.2, 24.3, 21.5
9.	21, 19.2, 19.2	19.		29.	21.5, 23.7, 23.7
10.	19.2, 19.2, 20.5	20.		30.	19.2, 21.5, 23.7

II. Test Fuel:

1. No. of 2 x 4's: 0
2. No. of 4 x 4's: 5
3. Total No. of Fuel Pieces: #26 → #30
4. Weight, Lbs.: 23.4
5. Species: D.F.
6. Moisture Content, % Ave. (Dry Basis): 22.4%
7. Length, In.: 20"

III. Pre-Burn Fuel:

1. No. of 2 x 4's: 12
2. No. of 4 x 4's: 0
3. Total No. of Fuel Pieces: #1 → #12
4. Weight, Lbs.: 23.9
   #2=6.3
5. Species: D.F
6. Moisture Content, % Ave. (Dry Basis): 20.3%
7. Length, In.: 21" ÷ 3 = 7"

IV. Kindling Fuel:

1. No. of 2 x 4's: 0
2. No. of 4 x 4's: 1½
3. Total No. of Fuel Pieces:
4. Weight, Lbs.: 4.4
5. Species: D.F
6. Moisture Content, % Ave. (Dry Basis): 19.0%
7. Length, In.: 16"

Date: 4-20-89

Attention: Mike Cave

Subject: Analysis on one (1) wood fuel sample received 4-18.

Item: Wood Fuel

Reference: Marks Custom Stoves
K-400 FS
184-7
High

REPORT:

Analysis:

Moisture, %, as received	18.0
Moisture, %, dry basis	21.9
Density, g/cm^3, dry basis	0.57
Higher Heat of Combustion, BTU/lb., dry basis	9615

Robert W Hardaker

Report Number: 321591

WOOD/FUEL
(ON NTL STOVE DISK)

D800 charges $70

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 2 - FUEL DATA

Stove Manufacturer: Mark-Cu-Iron Stove
Stove Model: IK-400 FS
Stove I.D. Number: 184
Technician: T. Talmer

Run Number: 5
Expected Burn Rate: Med. Hi
Calculated Charge Wt.: 24.8
Coal Bed Wt. Lbs.: 4.6
HHV Sample: Yes X No
(Saw Dust Catch & Block)

I. Fuel Moisture Content, % (Dry Basis):

1.	21.5	19.2	22	11.	24.3	23.1	21.0	21.	
2.	20.9	21.5	19.2	12.	21.0	23.0	22.0	22.	
3.	19.2	20.3	20.3	13.	22.0	22.0	22.0	23.	
4.	23.1	23.1	23.1	14.	21.0	21.5	22.0	24.	
5.	22.5	23.1	23.1	15.	22.0	21.5	21.0	25.	
6.	22.5	22.5	22.0	16.				26.	
7.	23.1	23.1	22.5	17.				27.	21.5, 21.5, 19.2
8.	22.0	22.0	21.0	18.				28.	21.5, 19.2, 19.2
9.	21.0	21.0	21.5	19.				29.	22, 19.2, 20.3
10.	21.5	22.0	23.1	20.				30.	20.9, 19.2, 19.8

II. Test Fuel:

1. No. of 2 x 4's: 0
2. No. of 4 x 4's: 4
3. Total No. of Fuel Pieces: #27 → #30
4. Weight, Lbs.: 22.7
5. Species: D.F.
6. Moisture Content, % Ave. (Dry Basis): 20.29
7. Length, In.: 21"

III. Pre-Burn Fuel:

1. No. of 2 x 4's: 10
2. No. of 4 x 4's: 0
3. Total No. of Fuel Pieces: #1 → #10
4. Weight, Lbs.: 23.2
   12.2
5. Species: D.F.
6. Moisture Content, % Ave. (Dry Basis): 21.76
7. Length, In.: 21" ÷ 3 = 7"

IV. Kindling Fuel:

1. No. of 2 x 4's: 0
2. No. of 4 x 4's: 1
3. Total No. of Fuel Pieces:
4. Weight, Lbs.: 4.0
5. Species: D.F.
6. Moisture Content, % Ave. (Dry Basis): 20.0%
7. Length, In.: 17"

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 3 - STOVE OPERATION LOG

Stove Mfg.: Marks Custom Stoves Date: 4-18-89

Stove Model: K-400 FS Technician: T. Palmer

Stove I.D. Number: 184

Run Number: 7

24 Hr. Time	OPERATION
10:52	Lit 4.4 lbs of Kindling. Door Ajar
	Air controls open 2" each side
	By-Pass open
10:57	Shut Door
11:00	Added #1 Pre-Burn
11:05	Shut By-Pass
11:10	started Pre-Burn Readings
11:32	Added 6.3 lb of Pre-Burn
12:07	Added 5.4 lbs
12:30	Added Test Fuel 23.4 lbs
12:37+30sec	Shut Door & By-Pass

NORTHWEST TESTING LABORATORIES
Woodstove Emission Testing

1.11

PAGE 4 - PREBURN DATA

Stove Mfg.: Marks Custom Stoves Run Number: 7

Stove Model: K-400 ES Date: 4-18-89

Stove I.D. No.: 184 Air Control Setting: 2" open Both S.D.'s

4.7→5.9

Data Set No.	Elapsed 24/Hr. Time	TEMPERATURES Amb.(1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Fuel Wt/lb	Prim. Temp. (7)	Cat. Temp. (8)	Cat. Temp. (16)	
1 5	11:10	66	596	185	322	517	349	19.5	496	1108		
2 10	11:15	68	814	275	375	600	450	16.6	659	1196		
3 15	11:20	69	890	325	417	616	503	14.0	690	1222		
4 20	11:25	70	957	397	474	636	580	11.5	760	1168		
5 25	11:30	72	985	437	513	663	628	9.3	799	1227		← STOKED + Added 6.3 lbs
6 30	11:35	71	958	484	657	708	671	13.1	772	1228		
7 35	11:40	71	997	530	616	720	655	11.3	782	1300		
8 40	11:45	76	1024	560	610	732	704	9.8	878	1327		
9 45	11:50	77	1048	583	616	755	776	8.4	1056	1298		
10 50	11:55	79	1059	614	644	790	837	6.9	1015	1297		
11 55	12:00	80	1072	634	671	800	843	5.8	979	1306		
12 60	12:05	79	1043	656	694	808	870	5.1	983	1292		← Added 5.4
13 65	12:10	78	955	666	711	767	792	4.1	896	1228		
14 70	12:15	77	1004	675	675	692	769	7.6	784	928		
15 75	12:20	80	1023	681	701	785	804	6.5	944	1257		
16 80	12:25	80	1056	686	712	798	823	5.5	997	1304		
-	12:30		Added Test Fuel →					4.7				

SIGNED: J. Talum DATE: 4-18-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 5 - STOVE TEST DATA

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400 FS
Stove I.D. No.: 184
Run No.: 7
Date: 4-18-89

+116

Data Set No.	ΔT	24 hr. Time	Test Fuel Wt. Lb.	TEMPERATURES Amb. (1)	Stove Surfaces T(2)	B(3)	R(4)	RS(5)	LS(6)	Primry Comb. (7)	Catl. or Secondry Comb.(8)	Catl. or Secondary Comb.(16)	Flue db (9)	wb (10)	Dry Gas In (11)	Out (12)	Oven Temp °F (13)	Imp. Temp. °F (14)	Fracer Temp. °F (15)
1	0	12:30	2J.4	81	1032	687	72J	821	856	1118	1J02		456	158	72	77	247	J2	72
2	10	12:40	20.9	81	979	686	578	6J9	675	659	1280		470	165	75	76	229	J2	73
3	20	12:50	18.0	8J	1029	695	5J7	624	667	742	1298		476	166	76	76	252	J2	72
4	30	13:00	15.4	81	1037	676	5J6	657	70J	8J6	1J19		476	168	77	75	256	J2	71
5	40	13:10	12.4	8J	1043	647	554	694	805	1006	1J11		487	171	77	74	258	JJ	71
6	50	13:20	9.7	83	1041	620	59J	778	882	120J	1J46		484	169	78	7J	258	JJ	71
7	60	13:30	7.2	83	10J1	589	625	914	910	1076	1J06		464	167	78	72	240	J4	70
8	70	13:40	5.0	83	1023	561	648	918	890	10J5	1294		455	166	78	71	245	J4	71
9	80	13:50	J.J	84	969	550	676	906	880	966	1281		427	161	78	70	244	J4	70
10	90	14:00	1.9	85	930	578	720	914	87J	1014	1185		412	157	79	70	245	J4	71
11	100	14:10	.8	85	867	599	764	907	839	917	1089		400	150	79	69	242	JJ	71
12	110	14:20	.0	84	792	607	763	842	800	821	1008		J84	148	79	69	240	JJ	71
								760.8											
			Avg	83	981	624	643	802	815	949	1252		449		77	73			71
															75				

SIGNED BY: T. Fahrner DATE: 4-18-89

ΔT = -63.0°F
Avg Skin = 773°F

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

PAGE 6 - PARTICULATE TRAIN OPERATION

Stove Mfg.: Marks Custom Stoves
Stove Model: IC-400 FS
Stove I.D. No.: 184
Run No.: 7

Date: 4-18-89
Expected Burn Rate: High
Oven Temp. Setting: 248°F
Tracer Rota, mm: 60
Tracer Pressure in H_2O: .12

Data Point	24 hr. Time	Elap. Time Δt	SO2 Scale	SO2 ppm	CO2 Scale	CO %	O2 %	Orifice Δ H In H2O	Dry Gas Meter ft 3	Vacuum in Hg	Stove Static Pressure In H2O	Comments
1	12:30	0	12.5	187	6J	.45	J.93	.023	627.91J	5.5	.090	
2	12:40	10	11.5	172	65.5	2.J5	2.11	.028	629.40	.5	.095	
3	12:50	20	12	180	66	.62	J.03	.025	6J1.00	.5	.090	
4	13:00	30	11	165	66	1.0	2.8	.0J0	6J2.48	.5	.095	
5	13:10	40	10.5	157	69.5	1.40	1.63	.0J4	634.09	.5	.095	
6	13:20	50	11	165	70	1.20	1.62	.0J1	6J5.80	.5	.095	
7	13:30	60	10.5	157	6J	.20	4.1	.034	6J7.43	.5	.090	
8	13:40	70	10.5	157	59	.10	5.2	.0J4	639.14	.5	.090	
9	1J:50	80	10.5	157	60.5	.08	4.82	.033	640.82	.5	.090	
10	14:00	90	10.5	157	56	.0J	6.04	.033	642.49	.5	.085	
11	14:10	100	10.5	157	4J.5	.04	9.35	.033	644.19	.5	.085	
12	14:20	110	10.5	157	40.5	.04	10.14	.033	645.895	.5	.080	
13												
14												
15			avg		60.21	0.63		0.031	17.982		-0.090	
16					15.05							
17												
18												
19												
20												
21												
22												
23												
24												
25												

SIGNED: D. Fahrni DATE: 4-18-89

NORTHWEST TESTING LABORATORIES, INC.
Woodstove Emission Testing

Stove Mfg.: Marks Custom Stoves
Stove Model: K-400FS
Stove I.D. No.: 184-7
Run No.: 7
Date: 4-18-89

	CO_2	CO	O_2	SO_2
ANALYZER AUDIT:		PRE-Test Calibration		
ZERO GAS:	0.0	0.0	N/A	0.0
AUDIT GAS:	59.9	5.01		54.2
DESIRED:	59.9	5.01		54.2
PERCENT DIFFERENCE:	0.0%	0.0%		0.0%
TIME (24 HOUR):	12:00	12:00		12:00

SIGNED: [signature]
DATE: 4-18-89

NORTHWEST TESTING LABORATORIES
Woodstove Emmission Testing

PAGE 7 - POST TEST DATA

Stove Mfg.: Mark Custom Stoves
Stove Model: K-400FS
Stove I.D. No.: 184

Run No.: 7
Date: 4-18-89
Time: 14:35

Analyzer Audit

	Scale Readings			
	CO_2	O_2	CO	SO_2
Zero Gas	0.0	N/A	0.0	0.5
Audit Gas	59.3		4.98	35.0
Desired	59.9		5.01	34.2
% Difference	1.0%		0.6%	3.8%
% Drift Check:				
Zero Drift	0.0%		0.0%	0.5%
Mid Level Drift	0.6%		0.3%	0.8%
Leak Test Results	OK			

Particulate Train

Leakage Rate: .002 ft^3/min.

Extra Filters Used: N/A

Ambient

Tdb 85 °F
Twb 68 °F
Pbaro 29.94 in Hg. 29.965
Moisture 1.7 % By Volume 1.75
Relative Humidity, % 42

SIGNED: J. Tahun DATED: 4-18-89