Materials Analysis, Wood Heater Safety and Comparative Fireplace Emissions Testing of the Tacoma Fire Log

Prepared for:	Rick Tebb Fred Tebb and Sons, Inc. 1906 Marc St. Tacoma WA, 98421
Prepared by:	OMNI Environmental Services, Inc. 13327 NE Airport Way Portland, OR 97230 (503) 643-3788
Date Received:	September 17, 2009
Report Date:	October 21, 2009
OMNI Project Number:	445-E-01-0

Table of Contents

List of Tables

Table **Page**

List of Figures

Figure **Page**

I. Introduction

OMNI Environmental Services, Inc. (OMNI) was contracted by Fred Tebb and Sons, Inc. to evaluate their compressed sawdust firelog product the "Tacoma Fire Log" for basic materials properties, comparative air emissions in fireplaces, and safety of use in wood heaters.

II. General Testing Discussion

A. Production Reception / Testing Personnel

Three boxes of the fire log product were received in good condition at the OMNI test facility on September 17, 2009. All testing on the product was performed at the OMNI facilities in Portland, Oregon. Testing was conducted by OMNI representatives Thomas Christensen and Jeremy Clark from September 23, 2009 through October 8, 2009. The OMNI project manager was Lyrik Pitzman.

B. Product Description

The fire log product is made from wood sawdust compressed into a brick-like shape.

C. Disclaimer

The results of this report are limited to the item submitted. Test data and calculation sheets are retained at OMNI.

D. Marking

Section 5 of ULC/ORD-C127-M1990 provides required instructions and marking for the fire log or its wrapper. The fire log product received by OMNI included no markings or wrapper.

III. Safety Testing in Wood Heaters

A. ULC/ORD-C127-M1990 Method Discussion

The method for composite fire log use in wood heaters is concerned with: documentation of safe temperatures in combustible materials that normally adjoin the wood heater (the floor, walls, and ceiling); documentation that wood heater material temperature limits are not exceeded; documentation that flue temperature limits are not exceeded; documentation that combustion of the fire log product does not produce visible liquid residue at any point in the burn; and documentation that the fire log product vapors do not represent a hazard. The vapor hazard test requires two fire logs to be placed on a bed of hot (but not incandescent) coals composed of three or more burned fire logs. Acceptance is based on non-ignition or non-explosive ignition of the vapors. In addition, ULC-S627-00 referred to in the ORD method calls for documentation that there is no flame roll-out when the wood heater door is opened under minimum combustion air conditions. It should be noted that the ORD appliance list was modified to test representative certified wood stoves, both small and medium-sized. To that end, the appliances utilized were the Nestor Martin S-33 (a small wood stove) and the Drolet Escape 1800 (a medium wood stove).

B. Testing Program

ULC/ORD-C127-M1990 calls for following the applicable appliance testing standard. For wood heaters there are two standards that apply: UL 1482 and ULC-S627-00. These standards are essentially the same; the largest difference is the fuel loads. The UL 1482 standard calls for a fuel load made up of ¾-inch by ¾-inch lumber strips, built into a rack that is equal to one third of the wood heater's hearth area. The fuel load in ULC-S627-00 is made up of ¾-inch by 1 ½-inch lumber strips, built into a rack that is equal to two thirds of the wood heater's hearth area. The UL 1482 fuel load is referred to as a "brand" and the ULC-S627-00 fuel load is referred to as a "crib." To pass UL 1482 and ULC-S627-00 safety tests a woodstove must not heat the adjacent walls, floor or ceiling more than established limits when fired with brand or crib fuel. The distance from the wood heater to the adjacent walls can be increased until the threshold temperatures are obtained. These distances, "clearances to combustibles," are listed as part of the wood heater certification test results.

As noted, the standards are for testing woodstoves and not the fuel being combusted. The booth and safety standard's principals were employed for this test but the fire log product was used as fuel in place of wood brands or cribs.

The testing was conducted in a test booth designed for UL 1482/ULC-S627-00. Clearances used for each of the wood stoves were the assigned minimum clearances to combustibles based on their certification testing. The booth was wired with approximately 25 thermocouples located on the floor and walls. The fire log product was added to the wood stove, with all air inlets completely open, until the walls, floor and ceiling temperatures reached equilibrium. Based on the manufacturer's suggestion, four logs were placed in a cross-hatch configuration with a "Lightning Nugget" firestarter located in the center. Subsequent one-log additions were performed approximately every 20-30 minutes based on the consumption of previous logs. The flash test was conducted according to ULC-S627-00, which describes loading the heater with fuel such that "there is a maximum fire fill of the combustion zone consistent with maintaining the maximum flue-gas temperature." For the medium-sized wood stove, six fire logs were loaded into the heater for flash testing; in the small wood stove, five fire logs were used. Air inlets were completely open during the flash test. Temperatures were continuously monitored until maximum temperatures were measured. The fire log product fire loading protocol was modeled after that provided in ULC/ORD-C127-M1990, regarding composite fire logs.

C. Results and Discussion

1. Temperature –Brand/Crib Fire, Flash Fire

Table 1 summarizes the requirements of ULC/ORD-C127-M1990 and the results of the safety testing of the fire log product. Data collected from burning the fire log product in the medium wood stove is displayed in tables 2 and 3. Tables 4 and 5 show the results for the combustion of the product in a small wood stove. Recorded temperatures on the wood stove surfaces and in the flue gases were below the temperature thresholds outlined in the test methods. Adjacent combustible material temperatures were below the threshold for all tests. The fire log product passes all temperature safety requirements of the ORD.

2. Liquid Residue Test

There was no observed liquid residue produced at any time during the burning of one fire log.

3. Vapor Hazard Test

The vapors produced by the two fire logs did not spontaneously ignite with minimum, intermediate, or maximum combustion air within the allotted time span. Attempts at manually igniting the vapors were likewise unsuccessful.

4. Door Hazard Test

Pursuant to ULC-S627-00 no flame roll-out, no discharge of ashes or embers, and no emission of combustion products were observed when the wood stove door was opened after a prolonged period of minimum combustion air provided to a large fuel load.

D. Conclusion

The fire log product meets or exceeds the safety testing standards outlined in ULC/ORD-C127-M1990 for the wood heater appliances tested.

IV. Emissions Testing in a Fireplace

A. EPA Method 5G and ASTM E 2515-07 Method Discussion

Method 5G is concerned with the determination of particulate matter emissions from wood heaters. Per the method, combustion exhaust is collected with a collection hood and combined with ambient dilution air in a dilution tunnel. Particulate matter (PM) is sampled at a proportional rate from a specified point in the tunnel by two dual-filter dry sampling trains operated simultaneously at the same flow rate. The PM is collected on two glass-fiber filters arranged in series (front and back) and the mass of particulate matter is determined gravimetrically after the filters have been desiccated to remove uncombined water.

ASTM E 2515-07 further specifies the determination of PM emissions collected in a dilution tunnel and includes specifications concerning the flow rate of the sampling equipment, the construction and proper operation of the dilution tunnel, and calculations for determining the total particulate emissions during a test.

B. Testing Program

The Pine Mountain fire log and the cordwood bundle were each purchased from a local super-market within 7 days of their respective test run. One test was conducted for each fuel type and the following metrics were used to evaluate air emissions: Total Particulate Matter (TPM, Method 5G), Volatile Organic Compounds (VOC), and Carbon Monoxide (CO). Each test was conducted in a manufactured fireplace (Heatilator EL36) with an air-cooled chimney, chimney cap, factory supplied metal grate and glass doors and metal screens fully open. Manufacturer's instructions were followed for the fire log tests and the cordwood test replicated common in-home use conditions.

C. Results Summary

- The TPM emission rate from the Tacoma Fire Log was substantially lower than the TPM emission rate from Douglas Fir cordwood and was higher than the TPM emission rate from the Pine Mountain fire log.
- The TPM emission factor from the Tacoma Fire Log was lower than the TPM emission factor from both the Pine Mountain fire log and Douglas Fir cordwood.
- The VOC emission rate from the Tacoma Fire Log was substantially lower than the VOC emission rate from Douglas Fir cordwood and substantially higher than the VOC emission rate from the Pine Mountain fire log.
- The VOC emission factor from the Tacoma Fire Log was similar to the VOC emission factor from Douglas Fir cordwood and slightly higher than the VOC emission factor from the Pine Mountain fire log.
- The CO emission rate from the Tacoma Fire Log was lower than the CO emission rate from Douglas Fir cordwood and substantially higher than the CO emission rate from the Pine Mountain fire log.
- The CO emission factor from the Tacoma Fire Log was slightly higher than the CO emission factor from Douglas Fir cordwood and substantially higher than the CO emission factor from the Pine Mountain fire log.

Table 1. Summary of ULC/ORD-C127-M1990 Test Results

Stove	Test	ULC ORD Requirement	Result
Medium Certified Wood Stove (Drolet Escape 1800)	Equilibrium Temperature	Temperatures on appliance surfaces and flue products less than or equal to brand/crib fires	PASSED
	Flash Fire	Temperatures on appliance surfaces and flue products less than or equal to brand/crib fires	PASSED
	Door Hazard	No observable flame rollout	PASSED
	Vapor Hazard	Smooth or non-ignition of vapors	PASSED
	Liquid Residue	No appearance of liquid residues during burn period	PASSED
Small Certified Wood Stove (Nestor Martin S-33)	Equilibrium Temperature	Temperatures on appliance surfaces and flue products less than or equal to brand/crib fires	PASSED
	Flash Fire	Temperatures on appliance surfaces and flue products less than or equal to brand/crib fires	PASSED
	Door Hazard	No observable flame rollout	PASSED

Table 2. Equilibrium Test Temperature Results for a Medium Certified Wood Stove

TC Location	Product Test Results		Equilibrium Limit	
	°F	°C	°F	°C
Lab	82	28	-	-
Flue Gas (8 ft above floor)	635*	335*	1400*	760*
Stove Top	691	384	830	461
Stove Bottom	550	306	830	461
Stove Left Wall	676	375	830	461
Stove Right Wall	656	365	830	461
Stove Label/Back	728	404	830	461
Booth Side Wall	62	35	117	65
Booth Back Wall	48	27	117	65
Booth Floor	65	36	117	65

Note: All temperatures are reported as rise above laboratory temperature, with the exception of flue gases.
*Actual temperatures reported

Table 3. Flash Test Temperature Results for a Medium Certified Wood Stove

TC Location	Product Test Results		Flash Limit	
	°F	°C	°F	°C
Lab	76	25	-	-
Flue Gas (8 ft above floor)	763*	406*	1700*	927*
Stove Top	916	509	930	461
Stove Bottom	527	293	930	461
Stove Left Wall	749	416	930	461
Stove Right Wall	707	393	930	461
Stove Label/Back	788	438	930	461
Booth Side Wall	105	58	140	78
Booth Back Wall	82	46	140	78
Booth Floor	83	46	140	78

Note: All temperatures are reported as rise above laboratory temperature, with the exception of flue gases.
*Actual temperatures reported

Table 4. Equilibrium Test Temperature Results for a Small Certified Wood Stove

TC Location	Product Test Results		Equilibrium Limit	
	°F	°C	°F	°C
Lab	74	24	-	-
Flue Gas (8 ft above floor)	669*	354*	1400*	760*
Stove Top	498	277	830	461
Stove Bottom	339	189	830	461
Stove Left Wall	260	145	830	461
Stove Right Wall	227	126	830	461
Stove Label/Back	114	63	830	461
Booth Side Wall	100	55	117	65
Booth Back Wall	69	38	117	65
Booth Floor	90	50	117	65

Note: All temperatures are reported as rise above laboratory temperature, with the exception of flue gases.
*Actual temperatures reported

Table 5. Flash Test Temperature Results for a Small Certified Wood Stove

TC Location	Product Test Results		Flash Limit	
	°F	°C	°F	°C
Lab	78	25	-	-
Flue Gas (8 ft above floor)	731*	388*	1700*	927*
Stove Top	576	320	930	461
Stove Bottom	345	192	930	461
Stove Left Wall	251	139	930	461
Stove Right Wall	238	132	930	461
Stove Label/Back	114	63	930	461
Booth Side Wall	121	67	140	78
Booth Back Wall	87	48	140	78
Booth Floor	118	66	140	78

Note: All temperatures are reported as rise above laboratory temperature, with the exception of flue gases.
*Actual temperatures reported

Table 6. TPM, VOC and CO Emission Rates and Emission Factors

	Pollutant	Tacoma Fire Log	Pine Mountain Fire Log	Cordwood Bundle (Douglas Fir)
Emission Rate (g/h)	TPM (M5G)	20.26	14.08	34.99
	VOC*	24.74	12.53	36.60
	CO	139.33	26.21	191.64
Emission Factor (g/Kg, dry basis)	TPM (M5G)	14.51	16.61	17.51
	VOC*	17.27	14.43	17.93
	CO	97.25	30.18	93.89

*Reported as carbon, as measured from a continuous total hydrocarbon (THC) analyzer with flame ionizing detector (FID).

Note: "TPM" denotes Total Particulate Matter, "M5G" denotes Method 5G, "VOC" denotes Volatile Organic Compounds, and "CO" denotes Carbon Monoxide.

End Point Definition: The end point was defined as the first ten minute interval to occur after all visible flames had been out for at least 5 minutes.

Emission Calculations: Emissions were calculated by dividing the total grams of pollutant emitted during the test run by total time of test in hours (Emission Rates) and by the total dry mass (in Kg) of fuel consumed (Emission Factors).

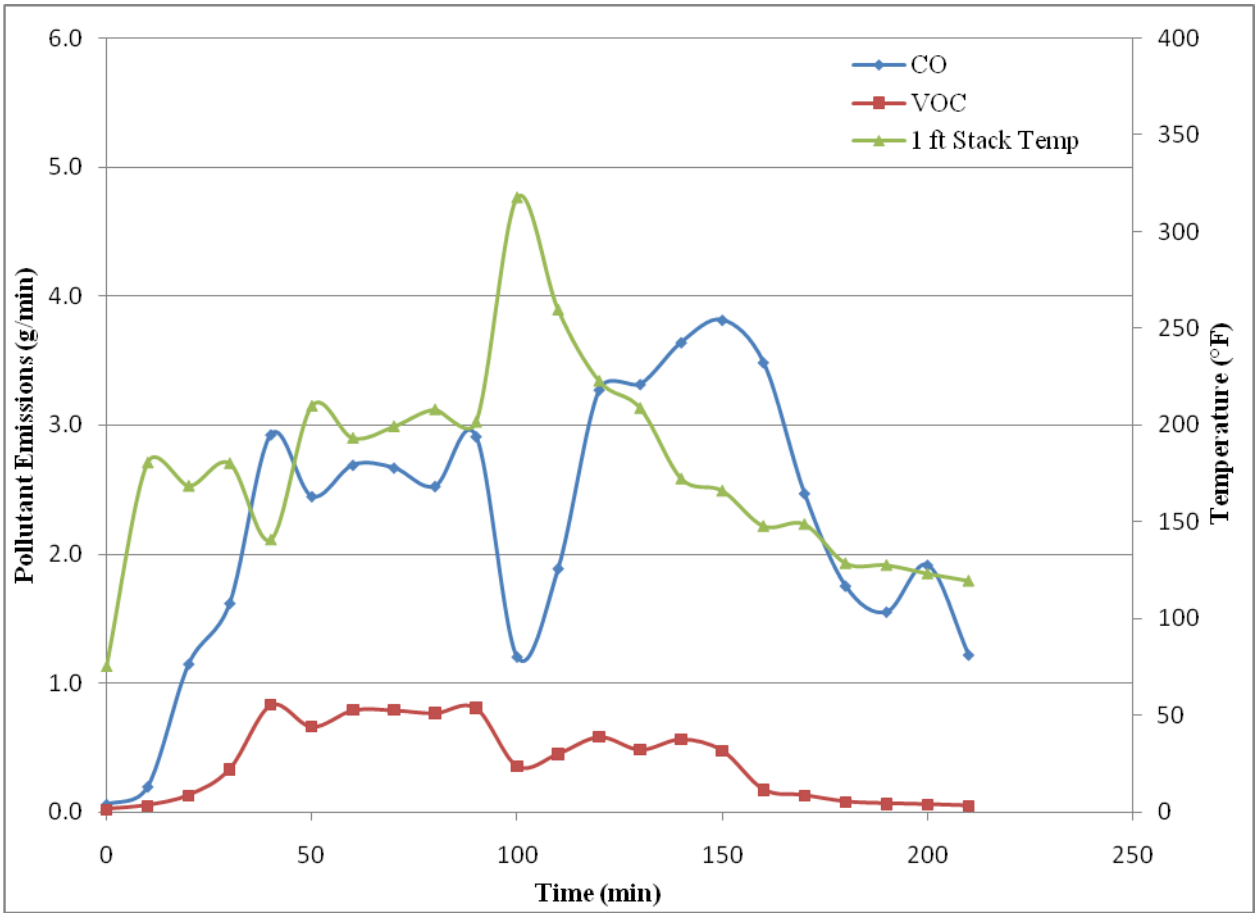

Figure 1. Tacoma fire log VOC and CO emissions and stack temperature at one foot.

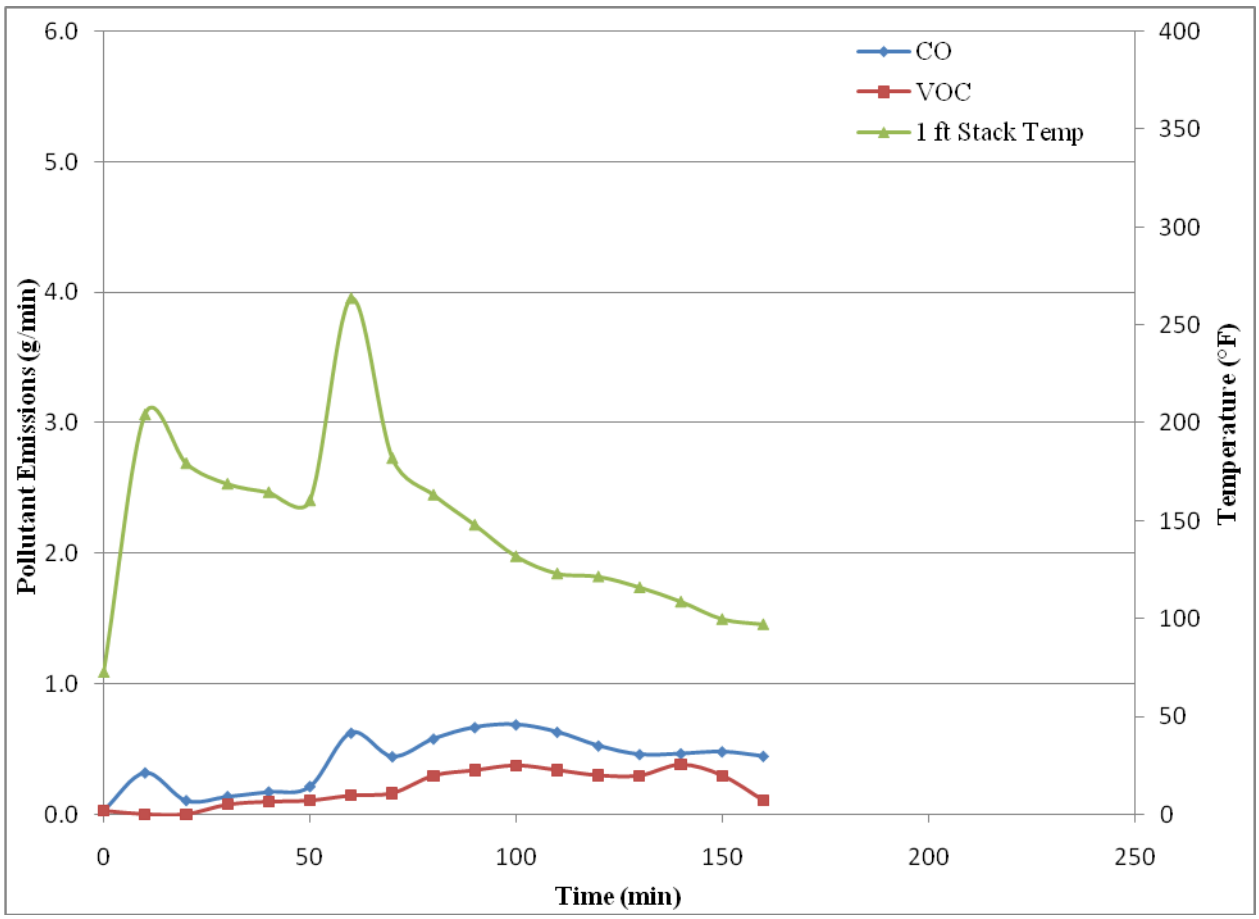

Figure 2. Pine Mountain fire log VOC and CO emissions and stack temperature at one foot.

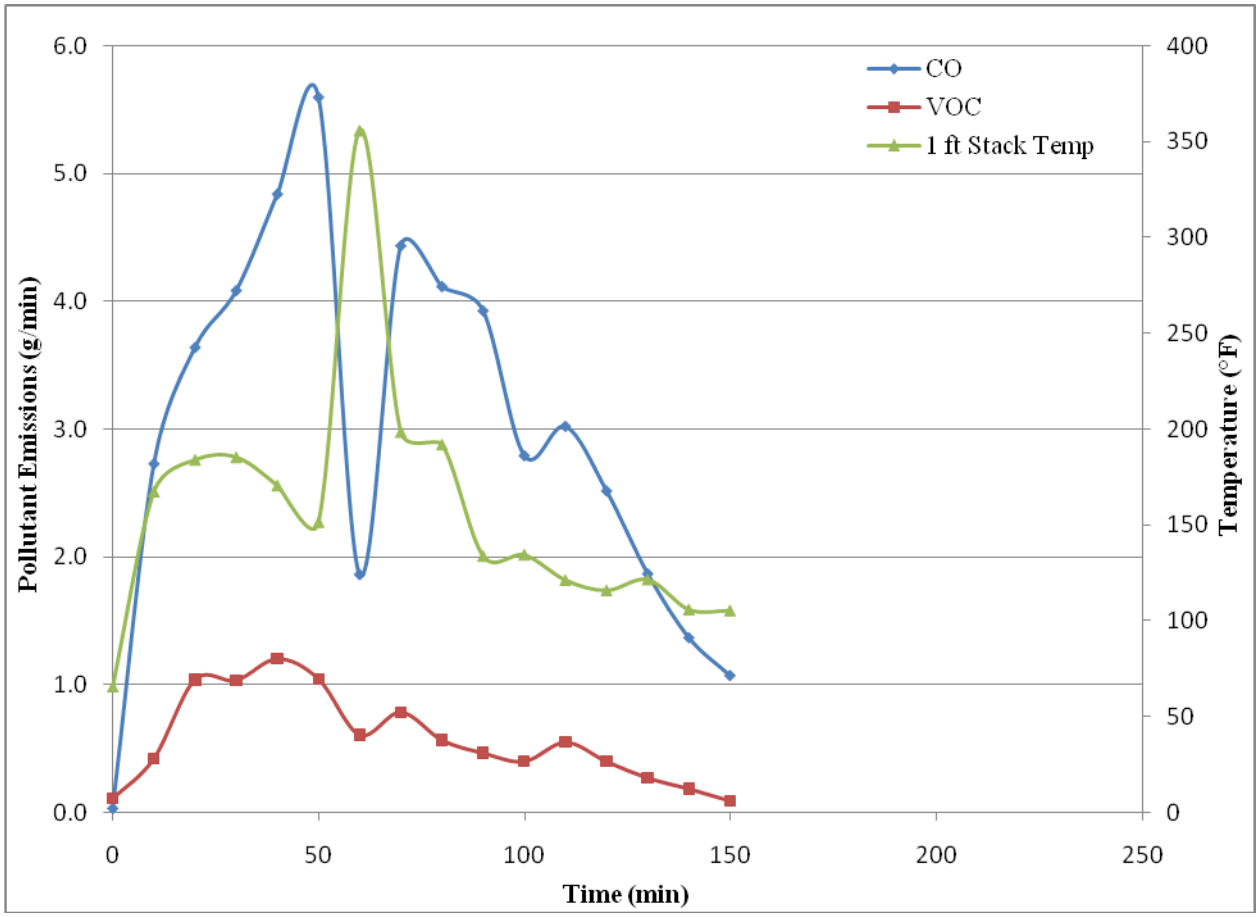

Figure 3. Douglas Fir cordwood VOC and CO emissions and stack temperature at one foot.

V. Fuel and Residue Analysis

Table 7. Heating Value, Ultimate and Chloride Analysis of the Fire Log Product and Ash Residue from Four Burned Fire Logs

	Fuel		Ash Residue	
	As-Received	Dried & Ground	As-Received	Dried & Ground
Moisture (%)	6.84	N/A	1.52	N/A
Ash (%)	0.24	0.26	54.44	55.28
C (%)	47.73	51.23	40.18	40.80
H (%)	6.49	6.14	0.90	0.74
N (%)	0.04	0.04	0.21	0.21
O (%)	45.40	42.21	23.98	22.98
S (%)	0.02	0.02	0.91	0.92
HHV (Btu/lb)	8131	8728	5419	5503
Chloride (mg/Kg)	188	N/A	N/A	N/A

VI. Photographs

Figure 4. Configuration of the fire log product in a fireplace.

Figure 5. Fire log product emissions testing.

Figure 6. Pine Mountain fire log emissions testing.


Figure 7. Douglas Fir cordwood emissions testing.