



Grass Combustion – Quadra-Fire Pellet Stove

Purpose: The purpose of this publication is to describe grass pellet combustion in the Hearth & Home Technologies Quadra-Fire Mt. Vernon AE pellet stove.

Appliance Description

The Quadra-Fire Mt. Vernon AE pellet stove has a BTU output of 14,620 to 60,200 per hour. It has an 80 lb. fuel hopper, automatic lighting, and an automated cleaning system for the burn pot. At specified intervals, the stove shuts down, then the “clam-shell” burn pot opens and drops the ash into the ash bin. The burn pot closes and stove is automatically restarted.



Fig. 1. Quadra-Fire Mt. Vernon AE pellet stove fireplace insert installed at the Big Red Barn, Cornell Univ.

Control Panel

The Mt. Vernon AE has a 7-day programmable wall thermostat, which can automatically switch to 12-volt power, if installed with a battery back-up. It has five manual or automatic heat (pellet feed) settings. Each feed rate can also be slightly modified on the control panel (flame height) to generate 10% over nominal or 15% under nominal. For grass combustion a customized grass ‘Table’ of settings was provided by Hearth & Home Technologies, with feed rates, auto cleanout rates, and combustion blower RPM modified.

Automated Cleanout

For grass pellet combustion, the interval between auto cleanout events was shortened, ranging from 40 minutes for the highest feed rate to 90 minutes for the lowest feed rate. Immediately after shutdown is initiated, CO emissions spike (Fig. 2). In this example, CO averaged 42 ppm while running, and 428 ppm for about 3 minutes during shutdown. There is also a spike in CO as the stove restarts (not shown).

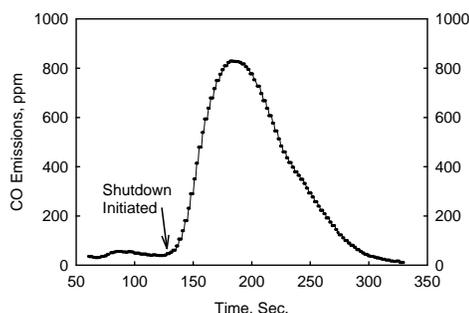


Fig. 2. Incomplete combustion (high CO) when auto cleanout sequence is initiated (Feed rate 3).

Combustion Measurements

A Testo 350XL emissions measurement system determined CO, CO₂, O₂, H₂, NO, NO₂, and SO₂ concentrations in the flue exhaust. Runs were restricted to 15-30 minutes in duration, to eliminate the possibility of overloading the CO sensor. After each run the probe filter was backwashed, and the Testo was allowed to rinse detection cells for at least 10 minutes, depending on the CO concentrations of the past run. The SO₂ cell was inconsistent and readings are not reported. All emissions measurements varied with feed rate for both fuels.

Spring-harvested switchgrass pellets (Ontario, CAN) were used here. Switchgrass pellets averaged 4.6% ash and 7621 BTU/lb. Premium wood pellets averaged 1.0% ash and 8088 BTU/lb. The BTU values are on an “as is” basis.

Smoke Spot Tests

Smoke spot tests were collected for wood pellet combustion at 3 feed rates (#1, 3, & 5). Grass smoke spot tests were collected at feed rate #3. Wood averaged readings of 5.5, 3.3 and >>10 for feed rates 1, 3, and 5. Grass readings at feed rate #3 averaged 2.8, but may not be meaningful due to variable ash color among grasses. Other grass pellets burned in the Quadra-Fire produced exhaust that immediately plugged filters, both smoke spot filters and Testo analyzer filters.

Pellet feeding events were recorded, as well as height of the flame, on a 1-5 scale. Pellet feeding events directly impacted flame height and the smoke spot tests (Fig. 3). Correlation between smoke spot number and flame height was $r = 0.88$.

Emissions Results

Emissions, recorded every second, varied but did not appear related to pellet feeding events. NO_x emissions were considerably lower with wood compared to grass pellets, as would be expected. Both NO_x and CO₂ increased with pellet feeding rate.

Table 1. Average emissions readings for wood pellets at 3 pellet feed rates, and switchgrass pellets at one feed rate.

Fuel	Setting	CO	NO _x	CO ₂
		ppm	ppm	%
Wood	1	76	59	8.62
	3	98	71	9.53
	5	131	78	11.79
Switchgrass	3	44	242	8.35

It was important to optimize the “Flame Height” setting, which tweaks the pellet feed rate. The flame should extend about 8” out of the fire pot on the high (#5) setting, with a shorter flame on lower feed rate settings. Flame height should be reduced if the flame appears tall and somewhat lazy.

Concerns with Grass Pellets

The high ash content of grass pellets requires a relatively short interval between auto cleanout events, resulting in frequent startups and shutdowns. Only the manufacturer can modify “Fuel Table” settings to optimize burning for a particular non-wood fuel.

Warranty Issues

As with almost all residential-scale combustion appliances, the Quadra-Fire is not certified to burn grass pellets, and doing so may void the warranty. It is certified to burn wood pellets, shelled field corn, wheat, and sunflower seeds.

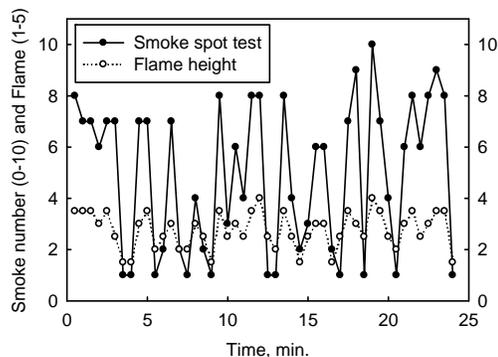


Fig. 3. Smoke spot number correlated with observed flame height ($r = 0.88$), and both were linked to pellet feeding events.

Summary

The Quadra-Fire Mt. Vernon AE is capable of burning high ash grass pellets. Ash is successfully ejected from the burn pot, regardless of whether any clinkering occurs. High ash content, however, will increase the frequency of shutdown/startup events.

Additional Resources

Cherney, J.H. and K.M. Paddock. 2013. Basic emissions testing for residential appliances. Bioenergy Information Sheet #18. www.grassbioenergy.org.

Acknowledgments

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For more information



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