

Aprovecho Research Center

Advanced Studies in Appropriate Technology Laboratory

79093 Highway 99, PO Box 1175
Cottage Grove, Oregon 97424 USA

541-767-0287
www.aprovecho.org

Testing Results of the Ecocina Cooking Stove from El Salvador

By Nordica MacCarty

March 5th, 2008

Introduction

The Ecocina Stove, developed by Larry Winiarski and Nancy Hughes, was received at the Aprovecho laboratory in March of 2008. Aprovecho conducted standard laboratory testing to determine the performance of the stove in relation to the benchmarks for improved stoves. The safety of the stove was also evaluated. The stove performed extremely well for heat transfer and combustion efficiency, and the design is quite safe. A benchmark certification document is provided at the end of this report.



The Ecocina Stove

The Ecocina Stove consists of a baldosa combustion chamber surrounded by a wide sheet metal body. A grate/fuel shelf made of re-bar is also included. The stove is supplied with and was tested with an adjustable skirt. The tested stove was a prototype of the final model.

Testing Methodology

The stove was tested under the Aprovecho portable emissions collection hood, in which real-time emissions of CO₂, CO and PM_{TSP} were recorded. The system also measured the flow rate of the diluted exhaust gases, enabling mass-based calculations of the emissions produced during the test.



Emissions Measurement Hood

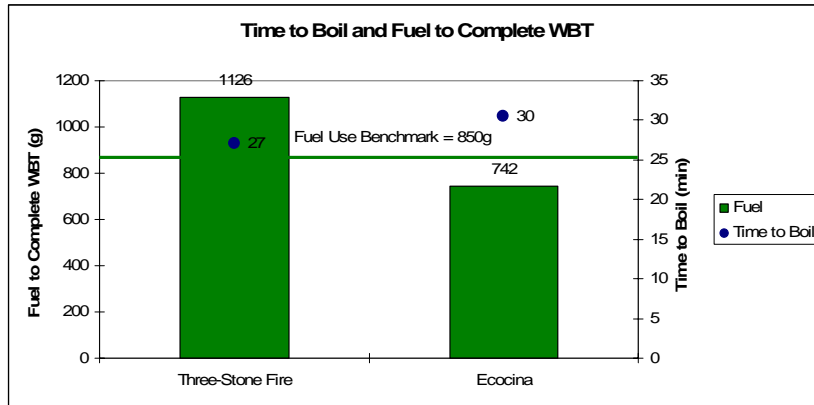
The Ecocina was tested using a 2003 UCB Water Boiling Test (WBT). The first phase of the test consists of a high-power analysis in which 5 Liters of water are brought to a boil twice in an uncovered 7 Liter pot. First the water is boiled with the stove body starting cold, and then again with the body starting hot. In the low power phase of the test, 5 Liters of water is simmered at about 3 degrees C below full boiling temperature for 45 minutes.

Standard testing wood consisting of sticks (2 cm X 2 cm by 30 cm long) of kiln-dried Douglas fir at 14.4% moisture content (on a wet basis) were used for testing.

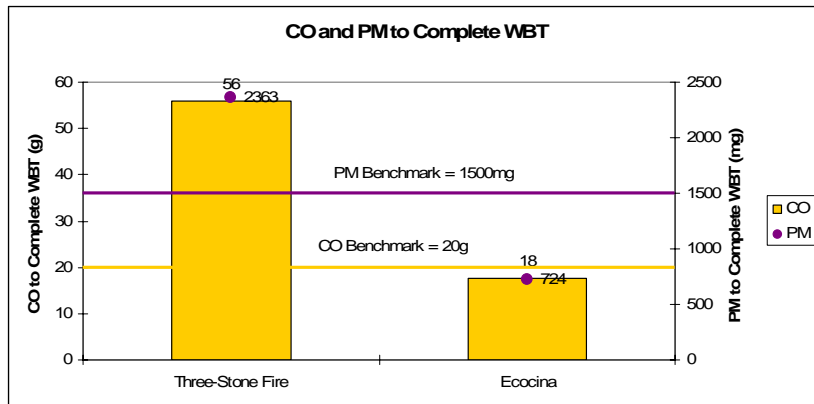
Aprovecho has been designing, testing, and helping to disseminate improved stoves for the past 20 years. Over 60 cooking stoves from around the world have been tested in the Aprovecho Laboratory in the last several years using this standard testing protocol. Based on this extensive library of tests, Aprovecho has developed suggested “benchmarks” of stove performance. These benchmarks help to define the performance of a truly “improved” cooking stove.

Results

The test results of the Ecocina stove are compared to the performance of the laboratory three-stone fire as seen below:



The Ecocina stove with skirt used only $2/3^{\text{rds}}$ of the fuel compared to the laboratory three-stone fire, and boiled 5 Liters of water in about the same time. The fuel use benchmark was comfortably met when the stove was used with a skirt. There is no benchmark for time to boil.



The Ecocina produced only $1/3^{\text{rd}}$ of both the carbon monoxide (CO) and particulate matter (PM) emissions compared to the laboratory three-stone fire. Emissions of CO and PM were similar to other well-designed rocket stoves tested in the Aprovecho laboratory. The measures of both emissions easily met the Aprovecho benchmark of performance.

Three full Water Boiling Tests are performed on each stove tested at the Aprovecho Lab for statistical validation. The Aprovecho Laboratory EPA Quality Assurance Plan states that the Coefficient of Variation on all measures should be less than 25%. This requirement was fulfilled in this test series. The variation between tests was as follows:

Standard Performance Measures		Ecocina Test 1	Ecocina Test 2	Ecocina Test 3	Average	COV
Fuel to Cook 5L (850/1500)	g	675	787	761	742	8%
CO to Cook 5L (20)	g	14.8	19.3	18.8	18	13%
PM to Cook 5L (1500)	mg	901	715	554	724	24%
Energy to Cook 5L (15,000/25,000)	kJ	11,147	12,997	12,569	12,238	8%
Time to Boil	min	28.9	31.8	30.8	30	5%
CO2 to Cook 5L	g	1004	946	1137	1029	10%

Safety Evaluation

The Ecocina is given a safety score of 37 out of 40, based on the protocol developed by Nathan Johnson of Iowa State University as a Master's Thesis. The protocol includes an evaluation on a scale of 1-4 (with 4 being highly safe) in ten different areas. The Ecocina received scores as follows:

Safety Evaluation	Score/4	Comments
Sharp Edges/Points	4	
Cookstove Tipping	4	
Containment of Combustion	4	
Expulsion of Fuel	4	
Obstructions Near Cooking Surface	2	The skirt can be cumbersome for cooking
Surface Temperature	4	
Heat Transfer to Surroundings	4	
Cookstove Handle Temperature	4	
Flames/Heat Surrounding Cookpot	3	
Flames/Heat Exiting Fuel Chamber	4	
Total Score (out of 40)	37	

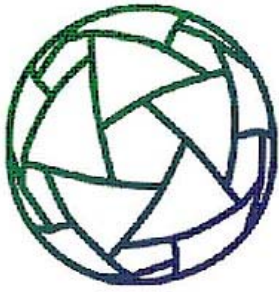
The safety of the Ecocina Stove is quite good. The body is wide, making it stable and unlikely to tip. This also helps to keep the outside of the stove body cool, reducing burns. The fuel entrance tunnel is long and small, protecting the user from the fire from exiting the stove entrance. The use of a skirt generally makes the stove less safe, as the pot is surrounded by flames and hot metal.

Conclusions and Recommendations

- The heavy grate should be durable and long-lasting.
- It would be helpful to create a sloped stove top, following constant cross sectional area, to help maximize heat transfer in case the stove might be used without a skirt.

A benchmark certification document can be found in the remaining pages.

For further questions about this report, please contact Nordica MacCarty, Laboratory Manager, at nordica.maccarty@gmail.com.



Aprovecho Research Center

Advanced Studies in Appropriate Technology Laboratory

79093 Highway 99, PO Box 1175
Cottage Grove, Oregon 97424 USA

541-767-0287
www.aprovecho.org

Benchmark Testing

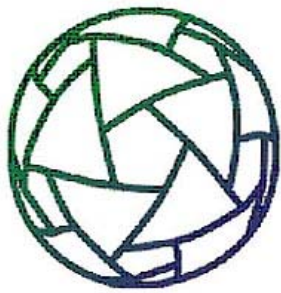
September 17th, 2007

Since 2003, Aprovecho Research Center has been a world leader in emissions and efficiency testing of biomass cooking stoves. In 2006, Aprovecho was requested by the Shell Foundation to propose benchmarks of performance that define improved stoves. The definition of an improved stove was based on comparisons to a library of results from over 50 tested stoves. Stoves that pass the following benchmarks are defined as improved.

Stoves are tested using the 2003 UCB Laboratory Water Boiling Test. The improved stove should meet the proposed performance benchmarks:

- 1.) **Fuel use:** Using the International Testing Pot, a wood burning stove without a chimney should use less than 850 grams (15,000 kJ) of wood to bring to boil 5 liters of 25 degree C. water and then simmer it for 45 minutes during the UCB revised Water Boiling Test.
- 2.) **Emissions:** The wood burning stove without a chimney should produce less than 20 grams of Carbon Monoxide to boil 5 liters of 25 degree C. water and then simmer it for 45 minutes during the UCB revised Water Boiling Test.
- 3.) **Emissions:** The wood burning stove without a chimney should produce less than 1500 milligrams of Particulate Matter to boil 5 liters of 25 degree C. water and then simmer it for 45 minutes during the UCB revised Water Boiling Test.
- 4.) **Chimney Stoves:** Wood burning stoves with chimneys are exempt from the above standard if the stove does not allow more than an average of 50 parts per million of Carbon Monoxide to pollute the air anywhere within 30cm of the stove. A wood burning stove with chimney should use less than 1500 grams (30,000 kJ) of wood to bring to boil 5 liters of 25 degree C. water and then simmer it for 45 minutes during the UCB revised Water Boiling Test.

The Ecocina stove did meet or exceed all performance benchmarks, and is hereby certified as shown below.



Aprovecho Research Center

Advanced Studies in Appropriate Technology Laboratory

79093 Highway 99, PO Box 1175
Cottage Grove, Oregon 97424 USA

541-767-0287
www.aprovecho.org

Benchmark Certification for the Ecocina Stove

March 5th, 2008



STOVE NAME	Ecocina	
ORGANIZATION	Eugene Rotary Club	
LOCATION	El Salvador	
DESCRIPTION	A wide-based rocket stove with baldosa combustion chamber and skirt.	
IMPROVEMENTS MADE	None necessary.	
MET BENCHMARKS?	YES	
	As Received	As Improved
TIME TO BOIL 5L	30	
FUEL TO COOK <i>850 G BENCHMARK</i>	742	
CO EMISSION TO COOK <i>20 G BENCHMARK</i>	18	
PM EMISSION TO COOK <i>1500 MG BENCHMARK</i>	724	
SAFETY SCORE	37/40	

Safety Evaluation	Score/4	Comments
Sharp Edges/Points	4	
Cookstove Tipping	4	
Containment of Combustion	4	
Expulsion of Fuel	4	
Obstructions Near Cooking Surface	2	The skirt can be cumbersome for cooking
Surface Temperature	4	
Heat Transfer to Surroundings	4	
Cookstove Handle Temperature	4	
Flames/Heat Surrounding Cookpot	3	
Flames/Heat Exiting Fuel Chamber	4	
Total Score (out of 40)	37	

Certified By: Nordica MacCarty, Laboratory Manager