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Advanced Studies in Appropriate Technology

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Results of Testing Wonder Werk Strata Stove

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The Wonder Werk Strata was received at the Aprovecho laboratory in July of 2014, during the Stove Camp of the same year. Aprovecho conducted standard laboratory testing under its emissions hood [LEMS, WBT4.2.3] to determine the performance of the stove in relation to the proposed ISO benchmarks. A “Super Pot” was used in all tests. The “Super Pot” dimensions were 24 cm diameter, 16 cm height, including a 15 cm tall skirt that covers the sides of the pot. The skirt gap was 10 mm. The pot was filled with 5 L of water.

The Wonder Werk Strata is a Top Lit up Draft stove that was tested using 800 g of home heating pellets as fuel. The fuel was manufactured from Douglas fir and had a moisture content of 3.45% (wet basis).

The stove features a lever to control the primary air. The bottom half of the stove contains the fuel, a space that the manufacturer, Mr. Kirk Harris, calls the reactor. Secondary air is introduced in three places: 1.) In six holes which are 5 mm in diameter and are located 18 mm below the top of the reactor. 2.) At the top of the reactor after traveling through an annulus which surrounds the reactor. 3.) In the combustion chamber from an array of five tubes that have slots on either side of normal opening down and angled approximately 30 degrees from normal. The primary air and the first two sources of secondary air enter the stove through 6 holes that are 2 cm in diameter, and the third source of secondary air enters the stove through five holes that are also 2 cm in diameter.

Above the tubes inside the combustion chamber there is a shallow propeller with five blades whose position is fixed within the stove. Resting on top of the propeller is a 5.5 cm diameter, 9 cm tall cylinder.

The propeller blades cause the flames to travel in a helical pattern above the blades.

A StoveTec cast iron top was used for the test since the prototype stove did not have a top.

The total height of the stove (including the StoveTec top) is 45 cm. The reactor height is 25 cm. The dimensions of the space for the fuel are 16.5 cm height by 15 cm diameter. The chamber height above the fuel magazine (reactor) is 18 cm.



Figure 1: Wonder Werk Strata Stove

Overview of Metrics Reported

The emissions are characterized following the specifications of the ISO IWA. Two sets of measures are reported, one for total emissions, and one for indoor emissions. For high power total emissions, the measures are specific to the amount of energy delivered to the cooking pot. For indoor emissions there are no power levels and the measure is specific to time. The thermal efficiency is calculated from the ratio of the energy embodied in the water after the test and from the energy used to evaporate the water during the tests, and the energy in the fuel consumed during the test. The ISO IWA adds a new metric for low power CO, PM and fuel efficiency based on specific consumption (or emissions) rate.

The Tiers of performance proposed by ISO are quoted in Appendix 1 from the February 2012 International Workshop Agreement [IWA]. The definition of the tiers is quoted from the same document:

“One end of the spectrum is the performance of a defined laboratory three stone fire. The other end of the spectrum is an aspirational goal specific to each performance indicator. Five tier levels are currently used (with 0 being lowest performing and 4 being the highest performing of the current tiers).”

Test Results

Stove type/model		wwstratak2	wwstratak3	wwstratak4	wwstratak8	Wonder Werk Strata		
Location		apro	apro	apro	apro	Average	COV	Tier
IWA Performance Metrics	units	Value	Value	Value	Value			
High Power Thermal Efficiency	%	41.2%	42.7%	44.7%	46.6%	✔ 43.8%	5%	3.8
Low Power Specific Consumption	MJ/min/L	0.014	0.019	0.018	0.019	✔ 0.018	12%	3.9
High Power CO	g/MJ _d	0.20	0.09	0.13	0.17	✔ 0.15	34%	4.9
Low Power CO	g/min/L	0.007	0.011	0.012	0.005	✔ 0.01	37%	4.9
High Power PM	mg/MJ _d	20.4	26.6	28.2	30.2	✔ 26.4	16%	4.3
Low Power PM	mg/min/L	0.11	0.24	0.49	0.28	✔ 0.28	57%	4.7
Indoor Emissions CO	g/min	0.04	0.07	0.07	0.03	✔ 0.05	37%	4.8
Indoor Emissions PM	mg/min	3.4	3.5	3.8	3.8	✔ 3.6	5%	3.7
		Tier	Tier	Tier	Tier	✔		
High Power Thermal Efficiency		3.6	3.7	3.9	4.0	3.8		
Low Power Specific Consumption		4.1	3.8	3.8	3.8	3.9		
High Power CO		4.9	4.9	4.9	4.9	4.9		
Low Power CO		4.9	4.8	4.8	4.9	4.9		
High Power PM		4.5	4.3	4.3	4.2	4.3		
Low Power PM		4.8	4.7	4.5	4.7	4.7		
Indoor Emissions CO		4.8	4.8	4.8	4.9	4.8		
Indoor Emissions PM		3.8	3.7	3.7	3.7	3.7		



IWA Tiers of Performance Report

Cookstove Manufacturer	Kirk Harris
Model	Wonder Werk Strata
Testing Center	Aprovecho
Protocol	WBT 4.2.3
Fuel Used	Douglas Fir Pellets
Pot Used	StoveTec SuperPot
Test Dates	August, 2014

These results were obtained in accordance with the IWA and the Global Alliance for Clean Cookstoves' reporting requirements. [1] This data and additional supporting data are shared publically through the Stove Performance Inventory.

Signature	
Name	

[1] Interim Stove Performance Reporting Requirements:
<http://community.cleancookstoves.org/files/318>

		Metric	Value	Unit	Sub-Tier
Efficiency/Fuel Use					
Tier	3	High power Thermal Efficiency	44%	%	3
		Low power Specific Consumption	0.018	MJ/min/l	3
Emissions					
Tier	4	High power CO	0.15	g/MJ _d	4
		Low power CO	0.01	g/min/l	4
		High power PM 2.5	26.36	mg/MJ _d	4
		Low power PM 2.5	0.28	mg/min/l	4
Indoor emissions					
Tier	3	High power Indoor emissions CO	0.02	g/min	4
		Low power Indoor emissions CO	0.05	g/min	4
		High power Indoor emissions PM 2.5	3.61	mg/min	3
		Low power Indoor emissions PM 2.5	1.70	mg/min	4
Safety					
Tier	NA	Points from 10 weighted safety parameters	NA	points	

Tier 0 → Improving Importance → Tier 4

Appendix 1. Proposed ISO Tiers

EMISSIONS

	High Power CO (g/MJ)	Low Power CO (g/min/L)
Tier 0	>16	>0.20
Tier 1	≤16	≤0.20
Tier 2	≤11	≤0.13
Tier 3	≤9	≤0.10
Tier 4	≤8	≤0.09

	High Power PM (mg/MJ)	Low Power PM (mg/min/L)
Tier 0	>979	>8
Tier 1	≤979	≤8
Tier 2	≤386	≤4
Tier 3	≤168	≤2
Tier 4	≤41	≤1

EFFICIENCY

	High Power	Low Power
	Thermal Efficiency (%)	Specific Consumption (MJ/min/L)
Tier 0	<15	>0.050
Tier 1	≥15	≤0.050
Tier 2	≥25	≤0.039
Tier 3	≥35	≤0.028
Tier 4	≥45	≤0.017

INDOOR EMISSIONS**

	Indoor Emissions CO (g/min)	Indoor Emissions PM (mg/min)
Tier 0	>0.97	>40
Tier 1	≤0.97	≤40
Tier 2	≤0.62	≤17
Tier 3	≤0.49	≤8
Tier 4	≤0.42	≤2

* Similar Tiers will be developed for other laboratory tests.

Based on room size of 30m³, air exchange of 15 per hour, and assuming perfect mixing

References

IWA <http://community.cleancookstoves.org/files/172>

LEMS <http://www.aprovecho.org/lab/emissionsequip/docs/category/45>

WBT4.2.3

http://www.aprovecho.org/lab/index.php?option=com_rubberdoc&view=doc&id=231&format=raw