

TITLE: CLEANCOOK STOVE

Date: June 13th, 2018



The Cleancook Stove was received at the National Stove Eligibility Laboratory, National Centre for Energy Research and Development University of Nigeria, Nsukka on May 29th, 2018 for testing in accordance with the International Organization for Standardization (ISO) International Working Agreement (IWA) using the Water Boiling Test (WBT) version 4.2.2. The stove is made of all-metal body.

The Stove was tested using the Water Boiling Test, WBT4.2.2, in accordance with the ISO International Working Agreement (IWA). The Water Boiling Test includes three phases - a Cold Start, Hot Start, and Simmer. During the Cold and Hot Start phases, the tester brings the stove to a boil operating the fire at a constant rate. For Charcoal stoves, the Hot Start is not usually carried out. The Simmer phase requires the operator to maintain the water temperature three degrees below boiling temperature, assuring the water does not fall six degrees below boiling temperature. The test was conducted with 1 L of water in a 4.5 L capacity flat bottom pot, with **no** pot skirt. The fuel used was anhydrous ethanol/methanol mix with a heating value of 23.580 MJ/kg and moisture content of 0.5%. The WBT was carried out five (5) times for statistical validity.

Overview of Reporting Metrics:

The International Organization for Standardization (ISO) International Workshop Agreement (IWA) testing and rating system of the IWA was approved in February 2012 at an international workshop held in The Hague, Netherlands. The rating system defines “tiers” of performance in the areas of fuel

efficiency, emissions of fine particulate matter (PM 2.5) and carbon monoxide (CO), and safety. Each area is ranked separately on a scale of Tier 0 – Tier 4, Tier 0 being the baseline or unimproved stove, and Tier 4 being the aspirational goal. Definitions of the Tiers are found below in *Detailed Test Data*.

Fuel Efficiency -- For the fuel efficiency metrics, the high power thermal efficiency is the ratio of the energy absorbed by the water in the pot to the energy released by the fuel consumed during the test. If a Cold Start and Hot Start are both performed they are averaged to find the high power result. For low power, the ISO IWA reports specific fuel consumption as fuel consumed divided by water remaining after the duration of the simmer phase.

Emissions – Emissions measured are carbon monoxide (CO) and particulate matter less than 2.5 μm (PM_{2.5}). Two categories of metrics are reported for each, total emissions and indoor emissions. For high power total emissions, the metrics are based on energy delivered to the cooking pot. For low power total emissions, the metrics are specific to the amount of water remaining and the length of the simmer period. Indoor emissions are displayed in emissions rates - mass of pollutant over time.

IWA Performance Metrics	units	Test 1	Test 2	Test 3	Test 4	Test 5	Average	Standard	Coefficient
								Deviation	of Variation (COV),%
High Power Thermal Efficiency	%	49.5	45.3	50.4	50.6	50.4	49.24	2.2434	4.56
Low Power Specific Consumption	MJ/min/L	0.067	0.058	0.098	0.086	0.07	0.0758	0.0160	21.12
High Power CO	g/MJ _d	1.25	1.46	1.66	1.77	2.01	1.63	0.2908	17.84
Low Power CO	g/min/L	0.021	0.042	0.031	0.032	0.026	0.0304	0.0078	25.75
High Power PM	mg/MJ _d	77.5	95.3	90.5	69.1	75.1	81.5	10.9790	13.47
Low Power PM	mg/min/L	0.8	1.34	1.2	0.56	0.6	0.9	0.3533	39.25
High Power Indoor Emissions CO	g/min	0.06	0.11	0.07	0.08	0.08	0.08	0.0187	23.39
High Power Indoor Emissions PM	Mg/min	1.6	1.46	1.84	2.2	0.87	1.594	0.4924	30.89

IWA Tiers	Tier	Tier	Tier	Tier	Tier	Average
High Power Thermal Efficiency	4	4	4	4	4	4
Low Power Specific Consumption	0	0	0	0	0	0
High Power CO	4	4	4	4	4	4
Low Power CO	4	4	4	4	4	4
High Power PM	3	3	3	3	3	3
Low Power PM	4	3	3	4	4	4
High Power Indoor Emissions CO	2	0	1	1	1	1
High Power Indoor Emissions PM	4	4	4	3	4	4

Standard Performance Measures		Test 1	Test 2	Test 3	Test 4	Test 5	Average	Standard Deviation	Coefficient of Variation (COV), %
Fuel to Cook 5L (850/1500)	g	857.3	898.1	1153.7	1056.3	877.1	968.5	130.0802	13.43
CO to Cook 5L (20)	g	1.28	1.4	2.4	1.8	1.6	1.696	0.4405	25.98
PM to Cook 5L (1500)	mg	440	612.4	508.5	427.8	600	517.74	86.524	16.71
Energy to Cook 5L (15,000/25,000)	kJ	19084	13386	25681	21353	19629	19826.6	4434.9669	22.37
Time to Boil	min	8.7	9.3	8.0	9.4	9.7	9.02	0.6760	7.49
CO2 to Cook 5L	g	1214.9	1513	2086.5	2170.2	2324.3	1861.78	474.2489	25.47

Summary

The Cleancook Ethanol stove was received at NSEL on May 29th 2018 for testing in accordance with the International Organization for Standardization (ISO) International Working Agreement (IWA) using the Water Boiling Test (WBT). Testing was carried out using a flat bottom pot. It was carried out five (5) times to ensure statistical accuracy. The high power thermal efficiency of the stove averaged **49.24%**. Most of the metrics were within the recommended 25% CoV.



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