

**TITLE: ORIGINAL WHEEL KEROSENE STOVE**

Date: June 13<sup>th</sup>, 2018



The Original Wheel Kerosene Stove was received at the National Stove Eligibility Laboratory, National Centre for Energy Research and Development University of Nigeria, Nsukka on May 29<sup>th</sup>, 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  $\mu\text{m}$  (PM<sub>2.5</sub>). 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.

<b>IWA Performance Metrics</b>	<b>units</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Test 4</b>	<b>Test 5</b>	<b>Average</b>	<b>Standard Deviation</b>	<b>Coefficient of Variation (COV),%</b>
High Power Thermal Efficiency	%	40.1	43.6	41.5	42.5	41.2	41.78	1.3293	3.18
Low Power Specific Consumption	MJ/min/L	0.156	0.096	0.121	0.085	0.134	0.1184	0.0286	24.19
High Power CO	g/MJ <sub>d</sub>	2.02	1.51	1.66	2.7	1.65	1.908	0.4812	25.22
Low Power CO	g/min/L	0.06	0.04	0.08	0.08	0.06	0.064	0.0167	26.15
High Power PM	mg/MJ <sub>d</sub>	470.1	408.9	576.4	602.2	588.6	529.24	85.22044	16.10
Low Power PM	mg/min/L	224.05	160.01	146.66	110.8	152.6	158.824	41.0757	25.86
High Power Indoor Emissions CO	g/min	0.05	0.03	0.04	0.056	0.036	0.0424	0.0105	24.83
High Power Indoor Emissions PM	Mg/min	102.7	76.9	75.2	68.8	62.8	77.28	15.2662	19.75

<b>IWA Tiers</b>	<b>Tier</b>	<b>Tier</b>	<b>Tier</b>	<b>Tier</b>	<b>Tier</b>	<b>Average</b>
High Power Thermal Efficiency	3	3	3	3	3	3
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	2	2	2	2	2	2
Low Power PM	0	0	0	0	0	0
High Power Indoor Emissions CO	2	3	3	2	3	3
High Power Indoor Emissions PM	0	0	0	0	0	0

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	1029.2	670.7	818.4	616.6	896.1	806.2	167.5323	20.78
CO to Cook 5L (20)	g	17.4	10.4	15.6	12.85	13.6	13.97	2.671984	19.13
PM to Cook 5L (1500)	mg	8102.4	12900.7	13129.1	8118.4	8067.8	10063.68	2695.355	26.78
Energy to Cook 5L (15,000/25,000)	kJ	19624	25740	28410	18908	34500	25436.4	6470.845	25.44
Time to Boil	min	15.3	20.7	14.8	16.7	22.2	17.94	3.321596	18.52
CO2 to Cook 5L	g	5733	3369.2	3860.3	4529.4	5466.8	4591.74	1012.633	22.05

### Summary

The Original Wheel Kerosene stove was received at NSEL on May 29<sup>th</sup> 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 **41.78%**. Most of the metrics were within the recommended 25% CoV.



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