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## **REPORT ON BIO-MOTO-COOKER PERFORMANCE AND FUEL CHARACTERISTICS FOR IRDA**

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## **Introduction:**

The report is divided into four parts. Part 1 deals with Water Boiling Tests of Bio Moto Cookers; Part 2 on Fuel Parameters, Part 3 on Safety Evaluation of the Cookers and Part 4 on Material Safety Data Sheet of the fuel.

## **Part 1.**

### **WATER BOILING TESTS OF BIO-MOTO COOKERS**

#### **1.0 INTRODUCTION**

The Water Boiling Tests (WBT) with ambient emissions were carried out at the University of Nairobi, Department of Chemistry Laboratories and were conducted on the following cookers:

Bio-Moto Cookers A and B and the liquid fuel used was supplied by the supplier of Bio-Moto cookers.

#### **2.0 METHODOLOGY**

##### **2.1 WATER BOILING TESTS.**

These tests were done according to WBT version 4.2.2 Methodology and were completed on 13/05/2014.

##### **2.0 EMISSION TESTS**

The emissions were carried out in a typical kitchen environment. The kitchen dimensions were as follows:-

##### **2.1 KITCHEN DIMENSIONS**

HEIGHT-8.3FT -WIDTH-9.5FT -LENGTH -11.3FT

WINDOWS: - W1-HEIGHT-2.2FT; -WIDTH-2.8FT; W2-HEIGHT-2.8FT -WIDTH-2.1FT

DOORS: - D1-HEIGHT-6.6FT -WIDTH-2.92FT; D2-HEIGHT-6.6FT-WIDTH-4.8FT

##### **2.2. CARBON MONOXIDE (CO) AND CARBON DIOXIDE (CO<sub>2</sub>).**

Ambient concentrations of CO CO<sub>2</sub> and PM<sub>2.5</sub> emissions were measured 1 meter away and 1 meter above the stove. Real-time measurements of CO and CO<sub>2</sub> were taken using a TSI IAQ-CALC 7545 (TSI Inc., The TSI IAQ-CALCs were calibrated immediately before deployment with NIST traceable zero and span gases, and again following deployment to check for any potential changes in response.

The reported values were average for each phase: Cold start phase, hot start phase and simmering phases.

##### **2.3 PARTICULATE MATTER PM<sub>2.5</sub>**

The particulate matter (PM<sub>2.5</sub>), and which are particles suspended in the air and with an aerodynamic diameter of less than 2.5 micrometers, were monitored with UCB Particle and

Temperature Sensor (UCB-PATs). UCB data logger has a detection limit of between 30- 25,000 µg/m<sup>3</sup>, a logging interval of between 1-240 minutes and a storage capacity of 32768 records. The reported values were average for each phase: Cold start phase, hot start phase and simmering phase

### 3.0: RESULTS

#### 3.1 Bio-Moto Cookers A and B

The summary of WBT and emissions data results for cookers A and B and their averages are summarized in table 3.1.

Table 3.1: WBT Data for Bio-Moto Cooker A and B.

<b>(5L WBT ) COOKER A</b>					
	<b>units</b>	<b>1. HIGH POWER TEST (COLD START)</b>	<b>2. HIGH POWER TEST (HOT START)</b>	<b>3. LOW POWER (SIMMER)</b>	<b>AVERAGE</b>
Time to boil	<b>min</b>	27	21	45	<b>24</b>
Burning rate	<b>g/min</b>	7	10	8	<b>9</b>
Thermal efficiency	<b>%</b>	39%	37%	38%	<b>38%</b>
Specific fuel consumption	<b>g/liter</b>	42	43	119	<b>68</b>
Fuel Consumption	<b>g</b>	200	209	255	<b>221</b>
CO <sub>2</sub>	<b>ppm</b>	487	569	603	<b>553</b>
CO	<b>ppm</b>	0	1	3	<b>1</b>
Particulate	<b>ug/m<sup>3</sup></b>	30	30	60	<b>40</b>
<b>(5L WBT) COOKER B</b>					
	<b>units</b>	<b>1. HIGH POWER TEST (COLD START)</b>	<b>2. HIGH POWER TEST (HOT START)</b>	<b>3. LOW POWER (SIMMER)</b>	<b>AVERAGE</b>
Time to boil	<b>min</b>	35	22	45	<b>28</b>
Burning rate	<b>g/min</b>	6	9	6	<b>7</b>
Thermal efficiency	<b>%</b>	42%	39%	42%	<b>41%</b>
Specific fuel consumption	<b>g/liter</b>	41	41	76	<b>52</b>
Fuel Consumption	<b>g</b>	197	196	268	<b>220</b>
CO <sub>2</sub>	<b>ppm</b>	500	578	578	<b>552</b>
CO	<b>ppm</b>	0	1	2	<b>1</b>
Particulate	<b>ug/m<sup>3</sup></b>	41	38	36	<b>38</b>

<b>AVERAGE (Cookers (A &amp; B))</b>					
	<b>units</b>	<b>1. HIGH POWER TEST (COLD START)</b>	<b>2. HIGH POWER TEST (HOT START)</b>	<b>3. LOW POWER (SIMMER)</b>	<b>AVERA GE</b>
Time to boil	min	31	21	45	<b>26</b>
Burning rate	g/min	7	10	7	<b>8</b>
Thermal efficiency	%	41%	38%	40%	<b>40%</b>
Specific fuel consumption	g/liter	41	42	97	<b>60</b>
Fuel Consumption	g	199	203	262	<b>221</b>
CO <sub>2</sub>	ppm	493	573	591	<b>552</b>
CO	ppm	0	1	2	<b>1</b>
Particulate	ug/m <sup>3</sup>	35	34	48	<b>39</b>

Maximum Flame temperature recorded was 800°C

## Part 2: Fuels Characteristics

	Parameters	Fuel Sample	Ethanol	Methanol
1	Calorific Value (MJ/Kg)	26.13	29.7	19.93
2	Boiling Point ( <sup>o</sup> C)	66	78	58
3	Density (g/mL)	0.8230	0.7851	0.765

## Part 3: Safety Evaluation of Bio-Moto-Cooker

### Introduction

The Safety Test addresses the basic safety issues concerning stove. The IOWA Safety Test Protocol, designed by Nathan Johnson, is used. The results for the Safety Test are shown below, based on the following key: **1= Poor; 2= Fair; 3= Good; 4= Best.**

Safety Tests	Score	Performance benchmarks for stove safety	Remarks
1	Sharp edges and points	2 <b>Fair:</b> Sharp edges present <b>Best:</b> Sharp edges absent	The stove has some loose and protruding flap which may drop off and cause some injury in the kitchen.
2	Cook stove tipping	3 Tipping ratio(R): <b>Poor:</b> $R > 0.978$ ; <b>Fair:</b> $0.961 < R < 0.978$ <b>Good:</b> $0.940 < R < 0.961$ ; <b>Best:</b> $R < 0.940$	The stove has a wide base which improves its stability and reduces chances of tipping over while it is in use.
3	Containment	4 Number of time (n) fuel falls out of the stove: <b>Poor:</b> $n \geq 9$ ; <b>Fair:</b> $6 \leq n \leq 8$ ; <b>Good:</b> $3 \leq n \leq 5$ ; <b>Best:</b> $n \leq 2$	The fuel is properly contained in the stove's fuel tank and there is no chance of it spilling out even if the stove is tipped over. This minimizes the danger of objects catching fire after the fuel spilling out of the stove onto them.

4	Expulsion of ember	2	Distance (D) through which fuel can be seen: <b>Poor:</b> $D > 5$ ; <b>Fair:</b> $3 < D < 5$ ; <b>Good:</b> $1 < D < 3$ ; <b>Best:</b> $D < 1$	Only the flames are visible when the fuel is burning. However the flames are rather big at high power and can fall on surrounding objects or catch some clothing and cause a fire and burns
5	Obstructions near the cooking surface	4	Height difference (D) between the cooking surface and obstructions near cooking surface <b>Poor:</b> $D > 4$ ; <b>Fair:</b> $2.5 < D < 4$ ; <b>Good:</b> $1 < D < 2.5$ ; <b>Best:</b> $D < 1$	There are no obstructions near the cooking surface. A cooking pot can be placed on and removed from the stove without any obstruction
6	Stove Surface temperatures	1	Surface temperature (T) above air temperature: <b>Poor:</b> $T > 50$ ; <b>Fair:</b> $44 < T < 50$ ; <b>Good:</b> $38 < T < 44$ ; <b>Best:</b> $T < 38$	The stove's surface temperature is at 50C on the surrounding metal jacket and 30C on the fuel tank.
7	Heat transmission to the surrounding	4	Floor Temperature (T) above air temperature: <b>Poor:</b> $T > 65$ ; <b>Fair:</b> $55 < T < 65$ ; <b>Good:</b> $45 < T < 55$ ; <b>Best:</b> $T < 45$ . Wall Temperature (T) above air temperature: <b>Poor:</b> $T > 80$ ; <b>Fair:</b> $70 < T < 80$ ; <b>Good:</b> $60 < T < 70$ ; <b>Best:</b> $T < 60$	There is little change in temperature on the floor below the stove and on the walls. Thus there is little chance of receiving burns either from stepping on the surface below the stove or from the wall near the lit stove.
8	Handle temperatures	1	Handle temperature (T) above air temperature: <b>Poor:</b> $T > 32$ ; <b>Fair:</b> $26 < T < 32$ ; <b>Good:</b> $20 < T < 26$ ; <b>Best:</b> $T < 20$	The stove doesn't have handles
9	Flames surrounding the cook pot	3	Uncovered flames touching the cooking pot: <b>Poor:</b> Entire cooking pot & handles; <b>Fair:</b> Most of cooking pot, not	The stove does have uncovered flames that slightly envelop the cooking pot about on the sides. Someone holding

			handles; <b>Good:</b> Less than 4cm up the sides, not handles; <b>Best:</b> None	the pot while cooking can sustain burns from these flames. However the stove has a flap that controls the power of the fire and can reduce the size of the flames hence reducing chances of sustaining the burns.
10	Flames exit fuel magazine	4	<b>Poor:</b> Flames protrude; <b>Best:</b> Flames are contained	Fuel cannot be loaded onto the stove while it is in use. Thus we can say the stove is safe in this respect.
Sum of scores (S)/40	28		<b>Poor:</b> $S \leq 16$ ; <b>Fair:</b> $17 \leq S \leq 25$ ; <b>Good:</b> $26 \leq S \leq 34$ ; <b>Best:</b> $S \geq 35$	Since the sum is between 26 and 34, it is ranked GOOD. The score for safety evaluation is thus 70%

## PART 3: Material Safety Data Sheet

**Product Name: Methylated Spirit (Ethyl Alcohol --%, Methanol ---%, Water \_\_\_% \_\_\_ Denature rant)**

### Section 1: Product and Company Identification

**Methylated XX %, Denatured**

**Synonyms/General Names:** Methylated spirit

**Product Use:** Fuel use only

**Manufacturer:** \_\_\_\_\_ ---/05/2014.

**24 Hour Emergency Information Telephone Numbers** \_\_\_\_\_

### Section 2: Hazards Identification

*Clear, purple liquid, ----- odor.*

**WARNING!** Flammable liquid and moderately toxic by ingestion.

Flammable liquid, keep away from all ignition sources.

Target organs: Eyes, Liver, Kidneys, Central Nervous System.

### Section 3: Composition / Information on Ingredients

**Ethyl Alcohol >%.XX Methyl Alcohol <X%. Water <X%.**

### Section 4: First Aid Measures

***Always seek professional medical attention after first aid measures are provided.***

**Eyes:** Immediately flush eyes with excess water for 15 minutes, lifting lower and upper eyelids occasionally.

**Skin:** Immediately flush skin with excess water for 15 minutes while removing contaminated clothing.

**Ingestion:** Call Poison Control immediately. **Aspiration hazard.** Rinse mouth with cold water.

Give victim 1-2 tbsp of activated charcoal mixed with 8 oz water.

**Inhalation:** Remove to fresh air. If not breathing, give artificial respiration.

### Section 5: Fire Fighting Measures

Class IB Flammable Liquid. When heated to decomposition, emits acrid fumes **3**

**Protective equipment and precautions for firefighters:** Use foam or dry chemical to extinguish fire. **2 0**

Firefighters should wear full firefighting turn-out gear and respiratory protection (SCBA). Cool container with water spray. Material is not sensitive to mechanical impact. Material is sensitive to static discharge.

### Section 6: Accidental Release Measures

Use personal protection recommended in Section 8. Isolate the hazard area and deny entry to unnecessary and unprotected

personnel. Remove all ignition sources and ventilate area. Contain spill with sand or absorbent material and place material in a sealed bag or container for disposal. Wash spill area after pickup is complete. See Section 13 for disposal information.

### Section 7: Handling and Storage Red

**Handling:** Use with adequate ventilation and do not breathe dust or vapor. Avoid contact with skin, eyes, or clothing. Wash hands thoroughly after handling.

**Storage:** Store in Flammable Area [Red Storage] with other flammable materials and away from any strong oxidizers. Store in a dedicated flammables cabinet. Store in a cool, dry, well ventilated, locked store room away from incompatible materials.

### Section 8: Exposure Controls / Personal Protection

Use ventilation to keep airborne concentrations below exposure limits. Have approved eyewash facility, safety shower, and fire extinguishers readily available. Wear chemical splash goggles and chemical resistant clothing such as gloves and aprons. Wash hands thoroughly after handling material and before eating or drinking. Use NIOSH-approved respirator with an acid/organic cartridge. Exposure guidelines: Ethyl Alcohol: OSHA PEL: 1900 mg/m<sup>3</sup> and ACGIH TLV: 1000 ppm, STEL: N/A.

### Section 9: Physical and Chemical Properties

**Molecular formula** C<sub>2</sub>H<sub>5</sub>OH. **Appearance** Clear, colorless liquid.

**Molecular weight** 46.07. **Odor** alcohol .

**Specific Gravity** 0.8230 g/mL @ 20°C. **Odor Threshold** N/A.

**Vapor Density (air=1)** 1.59. **Solubility** Completely soluble in water.

**Melting Point** -114°C. **Evaporation rate** 3.3 (*Butyl acetate* = 1).

**Boiling Point/Range** 78.5°C. **Partition Coefficient** -0.32 (*log POW*).

**Vapor Pressure (20°C)** 59.3 mm Hg. **pH** N/A.

**Flash Point:** 17°C (63°F) CC. **UEL** 3.3%.

**Autoignition Temp.:** 363°C (685°F). **LEL** 19 %.

N/A = Not available or applicable

### Section 10: Stability and Reactivity

Avoid heat and ignition sources.

**Stability:** Stable under normal conditions of use.

**Incompatibility:** Oxidizers, nitric acid, sulfuric acid, aldehydes, halogens, peroxides, acid anhydrides, ammonia, alkali metals

**Shelf life:** Indefinite if stored properly.

### Section 11: Toxicology Information

**Acute Symptoms/Signs of exposure:** **Eyes:** Stinging pain, watering of eyes, inflammation of eyelids and conjunctivitis. **Skin:**

Insensitivity to pain, feel of coolness or cold, skin looks white and feels hard and cold.

**Ingestion:** Breath has sweet, organic odor, metal confusion, drowsiness, nausea, vomiting and headache. **Inhalation:** Rapid irregular breathing, headache, fatigue, mental confusion, nausea and vomiting, giddiness and poor judgment, convulsions and death.

**Chronic Effects:** Repeated/prolonged skin contact may cause dryness or rashes.

**Sensitization:** none expected *Ethyl Alcohol: LD50 [oral, rat]; 7060 mg/kg; LC50 [rat]; 20,000 mg/l (10 hours); LD50 Dermal [rabbit]; 20 mg/24H MOD Material has not been found to be a carcinogen nor produce genetic, reproductive, or developmental effects.*

## Section 12: Ecological Information

**Ecotoxicity (aquatic and terrestrial):** Ecological impact has not been determined

## Section 13: Disposal Considerations

Check with all applicable local, regional, and national laws and regulations. Local regulations may be more stringent than regional or national regulations. Small amounts of this material may be suitable for sanitary sewer or trash disposal.

## Section 14: Transport Information

**DOT Shipping Name:** Ethanol. **Canada TDG:** Ethanol.

**DOT Hazard Class:** 3, pg II. **Hazard Class:** 3, pg II.

**Identification Number:** UN1170. **UN Number:** UN1170.

## Section 15: Regulatory Information

**EINECS:** Listed (200-578-6). **WHMIS Canada:** Not WHMIS controlled.

**TSCA:** All components are listed or are exempt. **California Proposition 65:** Not listed.

*The product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all the information required by the Controlled Products Regulations.*

## Section 16: Other Information

**Current Issue Date:** January 23, 2014

*Disclaimer: \_\_\_\_\_ (Name of the manufacturer) believes that the information herein is factual but is not intended to be all inclusive. The information relates only to the specific material designated and does not relate to its use in combination with other materials or its use as to any particular process. Because safety standards and regulations are subject to change and because S&C has no continuing control over the material, those handling, storing or using the material should satisfy themselves that they have current information regarding the particular way the material is handled, stored or used and that the same is done in accordance with federal, state and local law. \_\_\_\_\_ makes no warranty, expressed or implied, including (without limitation) warranties with respect to the completeness or continuing accuracy of the information contained herein or with respect to fitness for any particular use.*

Appendix 1: Cooker A								
<b>WATER BOILING TEST - VERSION 4.2.2</b>		<b>TEST #</b>						
<b>All cells are linked to data worksheets, no entries are required</b>								
Stove type/model		BIO MOTO COOKER (A)						
Location		UON - CHIROMO						
Fuel description		METHYLATED SPIRIT Ethanol						
Wind conditions		Light breeze; Light breeze; Light breeze						
Ambient temperature		22.2; 20; 21.5						
<b>1. HIGH POWER TEST (COLD START)</b>		<b>units</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>CO V</b>
Time to boil Pot # 1		min	22	28	32	27	5.0	18.4%
Temp-corrected time to boil Pot # 1		min	23	30	33	28	5.2	18.2%
Burning rate		g/min	9	7	6	7	1.4	18.4%
Thermal efficiency		%	39%	38%	42%	39%	2%	4.8%
Specific fuel consumption		g/liter	40	43	41	42	1.5	3.7%
Temp-corrected specific consumption		g/liter	42	46	42	43	2.6	6.0%
Temp-corrected specific energy cons.		kJ/liter	1,006	1,119	1,014	1046	62.9	6.0%
Firepower		watts	3,593	2,996	2,483	3024	555.7	18.4%
<b>2. HIGH POWER TEST (HOT START)</b>		<b>units</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>CO V</b>
Time to boil Pot # 1		min	19	21	22	21	1.5	7.4%
Temp-corrected time to boil Pot # 1		min	21	23	24	22	1.7	7.7%

Burning rate	g/min	11	11	9	10	1.0	9.7 %
Thermal efficiency	%	36%	35%	39%	37%	2%	5.6 %
Specific fuel consumption	g/liter	42	47	41	43	3.0	6.8 %
Temp-corrected specific consumption	g/liter	45	50	45	47	3.1	6.7 %
Temp-corrected specific energy cons.	kJ/liter	1,098	1,221	1,083	1134	75.6	6.7 %
Firepower	watts	4,331	4,302	3,630	4088	396.5	9.7 %
<b>3. LOW POWER (SIMMER)</b>	<b>units</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>CO V</b>
Burning rate	g/min	12	8	5	8	3.2	38.6%
Thermal efficiency	%	35%	36%	42%	38%	4%	9.6 %
Specific fuel consumption	g/liter	183	109	63	119	60.7	51.2%
Temp-corrected specific energy cons.	kJ/liter	4,440	2,641	1,527	2869	1,469.6	51.2%
Firepower	watts	4,732	3,289	2,124	3382	1,306.6	38.6%
Turn down ratio	--	0.76	0.91	1.17	1	0.2	21.9%
<b>BENCHMARK VALUES (for 5L)</b>		<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>CO V</b>
Fuel Use Benchmark Value	g	1,135	787	532	818	302.4	37.0%
Energy Use Benchmark Value	kJ	27,459	19,054	12,881	19798	7,317.5	37.0%

Carbon Monoxide Benchmark Value	g	7.5	3.6	0.7	3.9271	3.4	86.6%
Particulate Matter Benchmark Value	g			0.044	0.0436		
<b>IWA PERFORMANCE METRICS</b>	<b>units</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>CO V</b>
High Power Thermal Efficiency	%	37.6%	36.6%	40.4%	38%	2.0%	5.2%
Low Power Specific Fuel Consumption	MJ/(min·L)	0.099	0.059	0.034	0.0638	0.033	51.2%
High Power CO	g/MJ	0.1	0.2		0.1875		
Low Power CO	g/(min·L)	0.032	0.014	0.003	0.0164	0.015	89.6%
High Power PM	mg/MJ			5	5.4830		
Low Power PM	mg/(min·L)			0.1	0.1450		
Indoor CO Emissions	g/min	0.092	0.047	0.011	0.0503	0.041	80.7%
Indoor PM Emissions	mg/min			0.5	0.5444		
<b>IWA PERFORMANCE TIERS</b>	<b>units</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>		
High Power Thermal Efficiency	%	3	3	3	3		
Low Power Specific Fuel Consumption	MJ/(min·L)	0	0	2	4		
High Power CO	g/MJ	4	4	4	NA		
Low Power CO	g/(min·L)	4	4	4	0		
High Power PM	mg/MJ	4	4	4	NA		
Low Power PM	mg/(min·L)	4	4	4	NA		

		in·L)						
Indoor CO Emissions		g/min	4	4	4	0		
Indoor PM Emissions		mg/min	4	4	4	NA		
			NA = Not Applicable; IWA Performance Tiers are not reported if there are fewer than 3 tests conducted.					

## Appendix 2: Cooker B

		<b>TEST #</b>						
		BIO-MOTO COOKER B						
		UON-CHIROMO						
		METHYLATED SPIRIT Ethanol						
		Light breeze; Light breeze; Light breeze						
		19.5; 21; 22.9						
<b>1. HIGH POWER TEST (COLD START)</b>		<b>units</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>CO V</b>
Time to boil Pot # 1		min	31	36	37	35	3.2	9.3 %
Temp-corrected time to boil Pot # 1		min	33	37	39	36	3.0	8.3 %
Burning rate		g/min	7	6	5	6	0.8	14.0%
Thermal efficiency		%	40%	43%	43%	42%	2%	3.6 %
Specific fuel consumption		g/liter	43	41	39	41	2.0	4.9 %
Temp-corrected specific consumption		g/liter	46	42	42	43	2.6	6.1 %

Temp-corrected specific energy cons.			1,123	1,017	1,008	1050	63.8	6.1%
Firepower			2,667	2,218	2,038	2308	323.8	14.0%
<b>2. HIGH POWER TEST (HOT START)</b>		<b>units</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>CO V</b>
Time to boil Pot # 1		min	22	22	22	22	0.0	0.0%
Temp-corrected time to boil Pot # 1		min	24	23	24	23	0.6	2.6%
Burning rate		g/min	9	10	8	9	0.5	5.9%
Thermal efficiency		%	39%	38%	41%	39%	2%	4.5%
Specific fuel consumption		g/liter	40	43	39	41	2.4	5.9%
Temp-corrected specific consumption		g/liter	44	45	41	43	1.7	4.0%
Temp-corrected specific energy cons.			1,058	1,082	1,001	1047	41.7	4.0%
Firepower			3,557	3,832	3,410	3599	214.1	5.9%
<b>3. LOW POWER (SIMMER)</b>		<b>units</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>CO V</b>
Burning rate		g/min	8	5	5	6	2.1	35.2%
Thermal efficiency		%	39%	42%	46%	42%	3%	8.0%
Specific fuel consumption		g/liter	115	54	57	76	34.1	45.1%
Temp-corrected specific energy cons.			2,781	1,317	1,391	1829	824.6	45.1%

Firepower	watts	3,379	1,891	1,936	2402	846.4	35.2%
Turn down ratio	--	0.79	1.17	1.05	1	0.2	19.5%
<b>BENCHMARK VALUES (for 5L)</b>		<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>CO V</b>
Fuel Use Benchmark Value	g	800	489	495	594.576	177.8	29.9%
Energy Use Benchmark Value	kJ	19,356	11,832	11,978	14388.741	4,302.1	29.9%
Carbon Monoxide Benchmark Value	g	3.8	1.3	0.8	1.975	1.6	79.1%
Particulate Matter Benchmark Value	g		0.030	0.033	0.031		
<b>IWA PERFORMANCE METRICS</b>		<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>	<b>St Dev</b>	<b>CO V</b>
High Power Thermal Efficiency	%	39.8%	40.2%	42.2%	41%	1.3%	3.2%
Low Power Specific Fuel Consumption	MJ/(min·L)	0.062	0.029	0.031	0.041	0.018	45.1%
High Power CO	g/MJ	0.1	0.1	0.1	0.111	0.0	6.5%
Low Power CO	g/(min·L)	0.016	0.005	0.003	0.008	0.007	88.1%
High Power PM	mg/MJ		7	7	7.004		
Low Power PM	mg/(min·L)		0.1	0.1	0.076		
Indoor CO Emissions	g/min	0.051	0.019	0.011	0.027	0.022	79.4%
Indoor PM Emissions	mg/min		0.5	0.4	0.485		

<b>IWA PERFORMANCE TIERS</b>		<b>units</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Average</b>		
High Power Thermal Efficiency		%	3	3	3	3		
Low Power Specific Fuel Consumption		MJ/(min·L)	0	2	2	0		
High Power CO		g/MJ	4	4	4	0		
Low Power CO		g/(min·L)	4	4	4	0		
High Power PM		mg/MJ	4	4	4	NA		
Low Power PM		mg/(min·L)	4	4	4	NA		
Indoor CO Emissions		g/min	4	4	4	0		
Indoor PM Emissions		mg/min	4	4	4	NA		
			NA = Not Applicable; IWA Performance Tiers are not reported if there are fewer than 3 tests conducted.					