

Biomass stoves — Performance requirements

DKS 1814:2019

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DKS 1814:2019

Foreword

This Kenya Standard was prepared by the Appropriate Technology Technical Committee under the guidance of the Standards projects Committee, and it is in accordance with the procedures of the Kenya Bureau of Standards.

This Kenya Standard is dedicated to biomass stoves as energy-saving products. Development of this standard is aimed at achieving the following objectives:

- a) To control the quality of biomass stoves being marketed in the country;
- b) To increase the use as energy-saving biomass stoves;
- c) To conserve forests and protect the environment through sustainable use;
- d) To improve the living standards and health of stove users;

During the development of this standard, reference was made to the following documents:

DB11/T 540—2008, Beijing Local Standard, General technical specification of domestic biomass stove/boiler.

SOP No. 1.05, Revised February 16, 2012, UJ SeTAR Centre Standard Operating Procedure, The *Heterogeneous* testing procedure for thermal performance and trace gas emissions.

Biomass Stove Safety Protocol, available at: <http://www.pciaonline.org/files/Stove-Testing-Safety-Guidelines.pdf>

IS 13152 (Part 1): 2013, Indian Standard, Portable solid biomass cookstove (Chulha).

ISO/TR ISO 19867-3, Clean cookstoves and clean cooking solutions - Harmonized laboratory test protocols - Part 3 Voluntary performance targets for cookstoves based on laboratory testing

Acknowledgement is hereby made for assistance derived from these sources.

Biomass stoves — Performance requirements

1 Scope and field of application

1.1 This Kenya Standard specifies the performance requirements for biomass stoves.

1.2 This Kenya Standard applies to both domestic and institutional stoves that utilize solid biomass fuels derived from organic products of agriculture and forest systems.

2 Normative references

The following referenced documents are indispensable for the application of this Kenya Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

KS ISO 19867-1, *Clean cookstoves and clean cooking solutions -- Harmonized laboratory test protocols -- Part 1: Standard test sequence for emissions and performance, safety and durability*

3 Definitions

For the purposes of this standard, the definitions in KS ISO 19867-1 and following shall apply:

3.1

biomass cook stove

apparatus that converts biomass into heat energy typically through combustion and its subsequent utilization

3.2

biomass

the organic products of agriculture and forestry systems used as primary sources of energy. It includes wood fuel, agricultural waste and animal waste

NOTE 1

Organic products of forestry systems include charcoal.

NOTE 2

Agriculture waste includes sawdust, baggase, coconut shells, husks, maize cobs and any other agricultural waste.

3.3

insulation material

a mixture of lagging and binding materials that is used between two stove components to hold the two together firmly to reduce heat loss.

3.4

thermal conductivity

heat flow per unit area developed under unit temperature gradient

3.4

ceramic liner

molded and fired clay that give heat retention properties to the stove

3.6

ash

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residue remaining after combustion of a fuel under specified conditions, typically expressed as a percentage of the mass of dry matter in fuel

3.7

biomass institutional stove

a stove designed to hold and cook on a pot size of 20 litres and above

3.8

emissions

fuel gas, visible and invisible, occurring as a result of combustion of a fuel

3.9

cooking Vessel

pot or container in which food is prepared, cooked or water is heated

3.10

improved biomass cookstoves

biomass cookstove that meets the set criteria of this standard on emission factors, fuel consumption, energy efficiency, durability, and/or safety.

3.11

useful energy delivered

energy that provided the serviced desired by the *biomass cookstove* user, especially heating the contents of a *cooking vessel*

Note 1: When *biomass cookstoves* are used for both cooking and heat spacing, the useful energy delivered may include the heat delivered to a living space.

Note 2: The determination of the useful energy delivered depends on the cooking practice and the purpose of the relevant performance metric. Depending on this factors, useful energy delivered may include all or a fraction of the energy transferred to the cooking vessel.

Note 3: Energy transferred to the contents of a *cooking vessel* includes the energy that raises the temperature of the contents and the latent heat of evaporation of water from the vessel.

3.12

fuel energy in

product of the heating value of the raw fuel and the mass of the raw fuel as fired

3.13

heating value

energy per unit mass released in the complete combustion of a sample fuel.

Note 1: The state of the fuel, as defined by the as fired, as received, or dry fuel conditions, shall be recorded, and the heating value shall be stated as either higher heating value or lower heating value.

3.14

as fired

condition of a fuel as it is about to be tested in a biomass cookstove.

3.15

as received

condition of a fuel as it is received for testing in a biomass cookstove

3.16

higher heating value

measured value of the energy of combustion of a fuel burned in oxygen in a bomb calorimeter under such conditions that all the water of the reaction products is in the form of liquid water.

3.17

2

lower heating value

Calculated value of the energy of combustion of a fuel burned in oxygen in a bomb calorimeter under such conditions that all the water of the reaction products remain as water vapour.

Note: the heating value at constant pressure is generally used.

3.18**emission factors**

ratio of the mass of a pollutant emitted to a defined measure that quantifies the activity emitting the pollutant.

3.19**energy/thermal efficiency**

ratio of the useful energy delivered to the fuel energy in.

Note 1: This metric is not appropriate by itself for calculating fuel savings when a biomass cookstove produces char that is conserved for use as fuel.

Note 2: The use of either lower heating value or higher heating value is recorded and should be specified by the protocol. It is essential to record this selection because it affects the calculation of efficiency.

Note 3: The firepower at which the efficiency is determined should be clearly specified.

3.20**char**

carbonaceous residue resulting from pyrolysis or incomplete combustion

3.21**durability**

ability of a biomass cookstove to continue to be operated for an extended period safely and with minimal loss of performance under conditions of the user

3.22**ash solid**

portion of the remaining solids that has negligible recoverable heating value

3.23**Burn Sequence**

Combustion of fuel in a biomass cookstove from ignition to an end point defined in a specific Protocol

3.24**Carotific Value**

synonym of heating value

3.25**combustible mass**

portion of the fuel consisting of fixed carbon and volatile components, excluding ash and moisture, which can potentially be combusted

3.26**conventional fuel**

fuel or fuels regularly employed by the users

3.27**dry fuel**

fuel from which all moisture has been removed by heating to 3 °C above the local boiling point

3.28

dry basis

Basis for describing the compositing of a fuel sample as the ratio of the mass of a component to the mass of dry fuel, expressed in percent

3.29**fly ash**

ash that is entrained in the exhaust

3.30**exhaust**

gases and suspended particulate matter resulting from the combustion process

3.31**ignition**

start of a period of combustion

3.32**raw fuel**

mass of the unburned fuel supplied to a cookstove during the course of the burn sequence

3.33**recovered fuel**

material that has a usable energy content that remains after a burn sequence is completed

3.34**remaining solids**

solids (excluding fly ash) remaining at the completion of a burn sequence

3.35**residual Fuel**

portion of the recovered fuel that is not reused fuel

3.36**reused fuel**

material separated from the recovered fuel that has properties such that it can be employed in a subsequent burn sequence in the same biomass cookstove

3.37**total fuel**

sum of the masses of the raw fuel and the reused fuel

3.38**particulate matter**

solids and liquids of a sufficiently small size to be suspended in air

3.39**cooking sequence**

operation of a cookstove that uses the heat released during a burn sequence for the preparation of food or the heating of water, with a recorded or prescribed series of power level settings, durations and cooking vessel utilizations

Note 1 to entry: The cooking sequence commences with the placement of the first cooking vessel on the stove and ends when the last vessel is removed. The entire cooking sequence is normally embedded within a burn sequence, though in special cases retained heat cookers might continue cooking after the fire has been extinguished or while additional cooking tasks are undertaken.

3.40**ceramic stoves**

cook stoves that have used ceramic Clay for construction of the liner / combustion chamber.

3.50**other stoves**

all cook stoves including metallic stoves not using ceramic clay as a liner/combustion chamber

4 Symbols and abbreviations used in this standard

°C	=	Degrees celsius
mm	=	millimetre
O.P	=	Ordinary portland cement
kW	=	Kilowatt

5 Durability requirements

5.1 Ceramic stoves

5.1.1 Cladding

5.1.1.1 Material thickness

The cladding used in the manufacture of household and institutional biomass stoves shall be from a mild steel sheet or materials of equal or higher performance requirements shall be used as shown in the table 1 below.

Table 1 — Thickness of cladding material for mild steel

Gauges	Nominal thickness (institutional) in mm	Nominal thickness (Household) in mm
Stove top	2	1.5
Stove clad	1.5	1.0

5.1.1.2 Protection against corrosion

The casing shall be rust-treated when tested in accordance to standard salt//method, there shall be no rust.

5.1.2 Ceramic liner

The ceramic liner used in the manufacture of stoves shall be made from suitable pottery clay and pottery sand where applicable that has been cured and uniformly fired at 700 °C - 900 °C in the firing facility.

For institutional stoves, fire bricks must be used for the combustion chamber.

5.1.3 Pot rests

Pot rests for charcoal stoves shall be made from mild steel bars of minimum diameter 5mm or materials of equal or higher performance requirements shall be used. Pot rests for complete ceramic stoves shall be of same material.

5.1.4 Insulation

The insulation between the steel sheet or cladding and ceramic liners/fire bricks shall be made of various mixtures of material as described in Table 2. Any other material mixtures may be used if its thermal conductivity value does not exceed $2.5 \text{ WK}^{-1}\text{m}^{-1}$ at 500 °C when determined in accordance with the procedure specified in Annex A.

Table 2 — Material composition of insulation

Material	Ratio (Volume)
O.P Cement — Vermiculite	1:3
O.P Cement — Diatomite	1:3
O.P cement — Rice husks ash	1:4
O.P cement — Sand - ash	2:1:6
NOTE High Alumina Ceramic sheet, granules, powder etc (Al ₂ O ₃ = 95 %) may be used for insulation	

5.2 Water jackets

For the stove with the water jacket, the water jacket of stove with waste heat utilization function or hot water heating function shall not leak or change water quality.

5.3 Working life

The cook stove shall working life of 3 years for household stoves 5 years for institutional stoves.

NOTE 1 The thickness of the material used for different component of community/commercial biomass cook stoves are to be higher for providing adequate strength and life.

NOTE 2 All institutional stoves must have a wood shelf/fuelwood rack

5.4 Hazardous materials

The materials used in production of stoves shall not pose health hazard. Hazardous materials as defined in Environment Management and Coordination Act (EMCA) shall not be used.

6 Safety requirements

6.1 Sharp edges and points

Sharp edges and points on a cook stove that can cut flesh or entangle clothes and overturn the stove shall not be present.

6.2 Cook stove tipping

The construction of the cook stove shall be sturdy so that while in actual use on level floor they cannot get shaky or yield at any point.

Cook stove, both when full of fuel and when empty, shall be capable of being tilted in any direction to an angle of 15° from the vertical, without overturning at that inclination or on being released.

6.3 Containment of fuel

Burning fuel shall not be expelled from a combustion chamber or spilled when a stove is in use or when tilted at an angle of 15 degrees.

6.4 Obstructions near cooking surface

Areas surrounding the cooking surface shall be flat so that pots being moved from the stove do not collide with protruding components and overturn boiling contents onto hands or nearby children.

NOTE Typical obstructions include handles perpendicular to the griddle that are used for removing the cooking surface during cook stove maintenance

6.5 Surface temperature

Surfaces, which in normal use have to be touched for short periods (for example, handles, etc), shall not have a temperature exceeding 45°C when measured in accordance with KS ISO 19867-1.

5.6 Heat transmission to surroundings

Cook stoves shall not cause elevated temperatures on surrounding surfaces in the environment that would cause ignition, damage or harm.

6.7 Chimney and chimney shielding

Where biomass cooking stoves are installed with chimney, the chimney shall lead to the outdoor. The chimney outlet height from the ground shall not be less than 3m and the ventilation device shall be installed.

Appropriate insulation shall be placed around the chimney, or a cage may be utilized to “shield” people from accidental contact. For the cook stoves fitted with chimney, the outer surface temperature of the chimney shall not exceed 45°C at any point along its surface.

6.8 Flames surrounding the cook pot

Flames touching the cook pot, when the right size of the pot is used, shall be concealed and not able to come into contact with hands or clothing.

6.9 Flames/fuel exiting fuel chamber

Flames shall not protrude from the fuel loading area during use. Minor flames associated with lighting charcoal, wood, or other biomass fuel stoves shall be excluded.

NOTE Wood fuel, as long as it is not burning, is allowed extend out of the fuel loading area for a stick fed stove.

7 Thermal performance requirements

7.1 Thermal efficiency for natural draft domestic biomass stove when tested in accordance with KS ISO 19867-1 shall not be less than:

- a) 30% for charcoal ceramic stoves and 35% for other stoves such as metallic stoves.
- b) 25% for firewood ceramic stoves and 35% for other stoves such as metallic stoves.

7.2 The minimum thermal efficiency for forced draft types shall not be less 45 % for all domestic biomass stoves.

7.3 For all institutional biomass stoves, the thermal efficiency shall not be less than 45 % for all types, designs and sizes.

6.4 The minimum cooking power shall be 0.85kW for charcoal stoves and 1.4 kW for firewood stoves when tested in accordance with KS ISO 19867-1.

8 Emissions

8.1 When tested in accordance with KS ISO 19867-1, all stoves shall meet all the requirements as given in Table 3.

Table 3 — Stove emission requirements

Stoves	Performance Tier for PM _{2.5}	Performance Tier for CO
	Max value	Max value
Firewood - ceramic	1031mg/MJ _d (Tier 1)	11.5g/MJ _d (Tier 2)
Firewood - others	481mg/MJ _d (Tier 2)	7.2g/MJ _d (Tier 3)
Charcoal - ceramic	137mg/MJ _d	25g/MJ _d
Charcoal - others		
NOTE See Annex B for the default for PM _{2.5} and CO		

8.2 All institutional stoves shall be fitted with a chimney and focus shall be on fugitive emissions with CO and PM_{2.5} being ≤38,0 mg/MJ_d and ≤8 mg/MJ_d respectively.

8.3 Gasifier stoves shall have emissions of ≤218 mg/MJ_d for PM_{2.5} and ≤4,4 mg/MJ_d for CO.

9 Workmanship and finish

9.1 All component parts of the stove shall be protected against corrosion by a suitable anticorrosion and shall be smooth and free from defects such as cracks, sharp edges or burrs.

9.2 The stove and its component parts shall be free of defects that adversely affect the appearance, durability, performance and safety aspects during use.

10 Marking, packaging, storage and usage

10.1 Marking

10.1.1 The following information shall indelibly and legibly mark in a prominent position on a portable biomass stove.

- a) name of manufacturer and/or trademark;
- b) serial number;
- d) KEBS Standardization Mark or KEBS Import Standardization Mark

10.1.2 In addition to the above, all non-portable biomass stoves shall be legibly and indelibly marked with the details of the installer.

10.1.3 The indented parts shall have no defects such as cracks, wrinkles or flash.

10.2 Packaging

10.2.1 The packaging shall comply with the requirements of the user.

10.2.2 The following shall be delivered with each biomass stove:

- a) KEBS Standardization Mark or recognized equivalent recognized mark of approval;
- b) Instructions manual; and
- c) Warranty.

Annex A (normative)

Determination of thermal conductivity of ceramic liner

A.1 A specimen measuring 80 mm x 30 mm x 10 mm shall be cut from the ceramic liner whose thermal conductivity is to be determined.

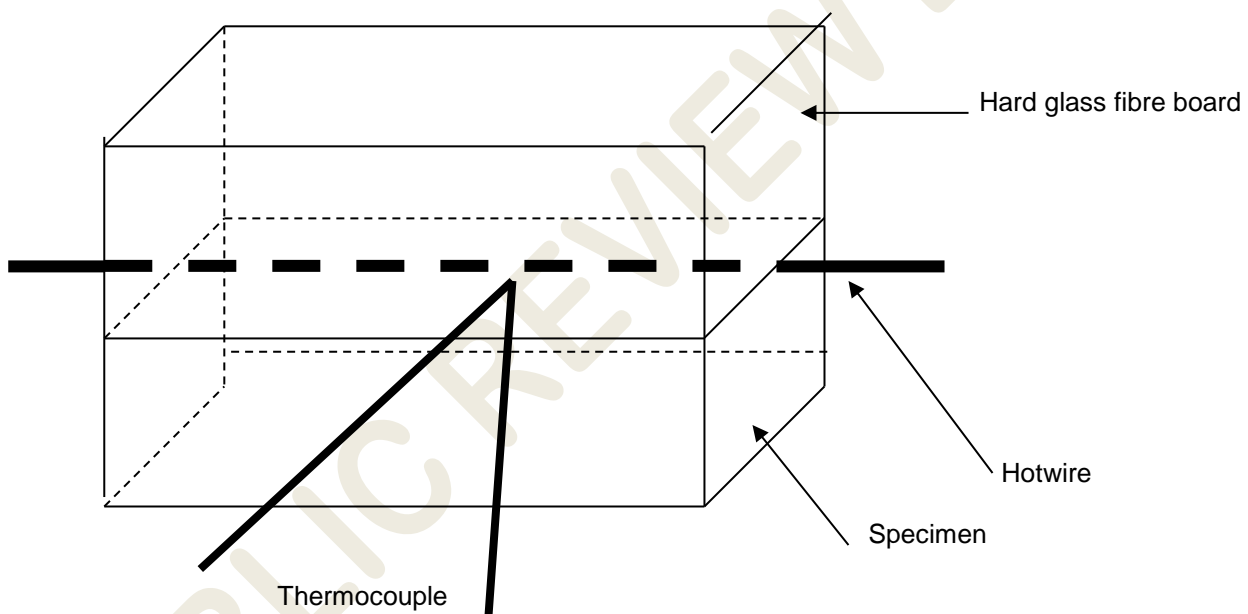
A.2 The reference material measuring 80 mm x 30 mm x 10 mm shall be of hard fibreglass board, whose thermal conductivity is known.

A.3 Procedure

A.3.1 The Transient hot wire method of comparison shall be employed.

A.3.1.1 The hot wire is sandwiched between a plate-type experimental specimen and a reference specimen whose value of thermal conductivity is known.

A.3.1.2 The specimen to be tested is cut into a plate type experimental specimen just the same shape and size as the reference specimen of fibreglass board.



A.3.2 Transient hot wire method for comparison

A.3.2.1 Both the specimen and reference material are pressed by loading to come into close contact with each other.

A.3.2.2 At the centre of the hot wire, a thermocouple is installed by means of spot welding.

A.3.2.3 Care should be taken so that the thermocouple wires have no gap between them because a gap at the junction will lead to the voltage due to the current of the hot wire to be added (or subtracted) to the e.m.f. of the thermocouple.

The thermocouple wires are fitted directly to thermocouple thermometer, which reads in °C. The specimens are placed inside a furnace so that the temperature at which the thermal conductivities are measured may be varied.

A.4 Calculations

Report of results

Thermal conductivity test — Data form

Oven temperature	Thermal conductivity $WK^{-1}m^{-1}$					Mean Value
	1	2	3	4	5	
200						
400						
600						
800						
1000						

Annex B
(Informative)
Default values for PM_{2.5} and CO

Table B.1 - Default emission factors, rates, equivalent concentrations and % homes meeting specified criteria, for PM_{2.5}



Dimensions and tiers	Tier	RR	mg/MJ _d	Normalized Emission Rate (mg/min)	µg/m ³	Percentage of home meeting the tier level
Better 	5	≤1.0	≤5	≤0,2	≤10	≥90%
	4	≤1,5	≤62	≤2,7	≤50	≥50%
	3	≤2,5	≤218	≤9,5	≤170	≥50%
	2	≤3,0	≤481	≤21	≤400	≥50%
	1	≤3,15	≤1031	≤45	≤800	≥50%
	0	>3,15	>1031	>45	>800	<50%

Table B.2 – Default emission factors, rates, equivalent concentrations, and % homes meeting specified criteria, for CO

Dimensions and tiers	Tier	Emission factor g/MJ _d delivered	Emission Rate (mg/min)	24 hour concentration at 50% coverage mg/m ³ (ppm)	Cooking event concentration at 50% coverage mg/m ³ (ppm)	Percent of homes covered at 7 mg/m ³ daily average ^a	Percent of homes covered at 230 mg/m ³ during cooking ^b
Better 	5	≤3,0	≤133	2,3 (2,0)	13,6 (11,9)	≥90%	≥99,9
	4	≤4,4	≤190	3,2 (2,8)	19,3 (16,8)	≥80%	≥99,9
	3	≤7,2	≤315	5,4 (4,7)	32,6 (28,5)	≥60%	≥99,3
	2	≤11,5	≤500	8,8 (7,7)	52,5 (45,8)	≥40%	≥97,1
	1	≤18,3	≤800	14,0 (12,2)	84,1 (73,4)	≥20%	≥ 90
	0	>18,3	>800	14,0 (12,2)	84,1 (73,4)	<20%	<90

^a WHO 24-hour air quality guideline [8]
^b Concentration during cooking at which subjects experience slight headache and impaired judgement within 2-3 hours from start of exposure [22]