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UGANDA STANDARD

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Energy efficiency stoves — Household biomass stoves — Performance requirements and test methods

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Foreword

Uganda National Bureau of Standards (UNBS) is a parastatal under the Ministry of Tourism, Trade and Industry established under Cap 323, of the Laws of Uganda. UNBS is mandated to co-ordinate the elaboration of standards and is

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The work of preparing Uganda Standards is carried out through Technical Committees. A Technical Committee is established to deliberate on standards in a given field or area and consists of representatives of consumers, traders, academicians, manufacturers, government and other stakeholders.

Draft Uganda Standards adopted by the Technical Committee are widely circulated to stakeholders and the general public for comments. The committee reviews the comments before recommending the draft standards for approval and declaration as Uganda Standards by the National Standards Council.

Committee membership

The following organisations were represented on Mechanical Engineering and Metallurgy Standards Technical Committee, UNBS/TC 4, in the preparation of this standard:

- German Technical Cooperation (GTZ)
- Kyambogo University
- Makerere University
- Ministry of Energy and Mineral Development
- Serina Stoves Limited
- Uganda Manufacturer Association
- Uganda National Bureau of Standards

Energy efficiency stoves — Household biomass stoves — Performance requirements and test methods

1 Scope

This Uganda Standard specifies the performance and test methods for household biomass stoves. The household stoves covered in this standard utilize the following biomass fuels namely charcoal, wood, baggasse, husks, plant shells and any other biomass.

2 Terms and definitions

For the purpose of this standard, the following apply.

2.1
household biomass stove
device where biomass fuel is burnt to produce heat for cooking purpose, (see Figure 1)

2.2
biomass
organic products of agriculture and forestry systems used as primary energy. It includes wood fuel, combustible vegetable materials which includes agricultural waste and animal waste.

2.3
combustion efficiency
proportion of latent heat in a fuel transferred as heat to a working fluid (water)

2.4
thermal efficiency (PHU)
ratio of energy transferred to working fluid (water) divided by the energy generated by burning fuel. It is also the thermal efficiency.

$$PHU = \left(\frac{M_n C_p (T_b - T_o) + M_e L}{M_f E_f} \right) \times 100$$

2.5
grog
any clay which has been fired and ground to particle sizes less than 0.5 mm (mesh size 10)

2.6
insulant
mixture of insulation and binding materials that is used between the ceramic liner and cladding to hold them two together firmly and reduce heat loss

2.7
thermal conductivity
heat flow per unit area developed under unit temperature gradient

2.8
ceramic liner
moulded and fired clay that give heat retention properties to the stove

2.9
ash
remaining product after complete combustion of biomass fuel

3 Symbols (and abbreviated terms)

C_p = Specific heat capacity of water (kJ/kg/^oC)

E_f = Calorific value of the fuel (kJ/kg)

HPP = High power phase

K = Kelvin temperature scale (Absolute temperature)

L = Latent heat of vaporization (kJ/kg)

LPP = Low (simmering phase of heating) power

M_e = Mass of water vaporized (kg)

M_f = Weight of fuel burned (kg)

M_n = Mass of water (kg)

O.P = Ordinary Portland cement

PHU = Percentage of heat utilized or thermal efficiency

T_b = Boiling temperature of the water (^oC)

T_o = Starting temperature of the water (^oC)

4 Material requirements

4.1 General

All components of a household biomass stove shall be manufactured from materials which comply with the relevant Uganda Standards.

4.2 Cladding

The cladding used in the manufacture of household biomass stoves shall be from a mild steel sheet (or any other steel) with a minimum thickness of 0.60 mm (Gauge 22) and maximum thickness of 1.20 mm (Gauge 18).

Table 1 — Thickness of cladding material

Gauges	Nominal thickness, mm
22	0.63
20	0.80
18	1.00

4.3 Ceramic liner

The ceramic liner used in the manufacture of stoves shall be made from suitable pottery clay that has been fired as specified in 5.1.

4.4 Pot rests

Pot rests for charcoal stoves shall be made from mild steel bars of minimum diameter (5.00 mm for solid bars and 1.5mm diameter for hollow sections). Pot rests for complete ceramic stoves shall be of same material.

4.5 Insulation

The insulation between the steel sheet or cladding and ceramic liner shall be made of various mixtures of material as described in Table 2. Any other material mixtures may be used provided that they meet the requirements of 8.4.

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

5 Workmanship and constructional requirements

5.1 Construction

For the household biomass stoves in Figures 1 and 3, (two-component parts) the ceramic liner shall be assembled into steel plate cladding using insulation materials specified in Table 2. The other types of biomass stoves as described in Figures 2, 4 and 5 shall be assembled into any other utilizing materials. The stoves shall be of robust construction and stable.

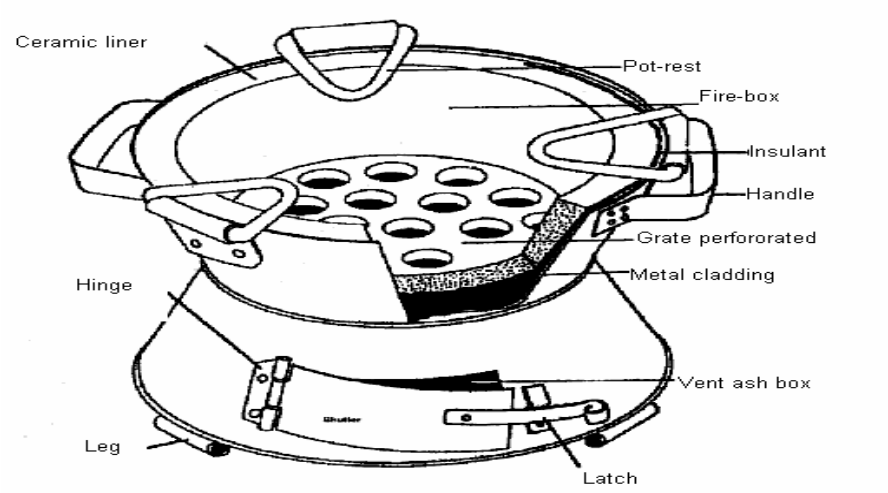


Figure 1 — Illustration of a typical household biomass stove

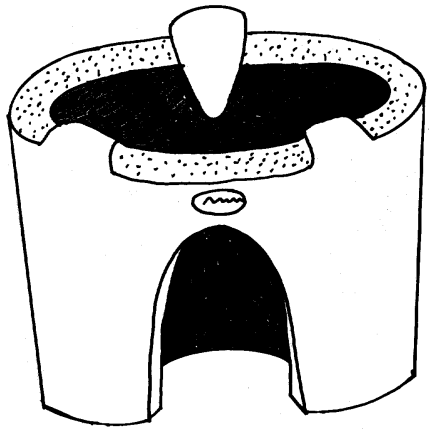


Figure 2 — Single ceramic household biomass stove for wood (used in the manufacture of wood stove with cladding in Figure 3 and also wood stoves in Figure 4 and Figure 5).

NOTE Design and dimensions of fixed stoves shall vary in accordance with purchaser/user instructions.

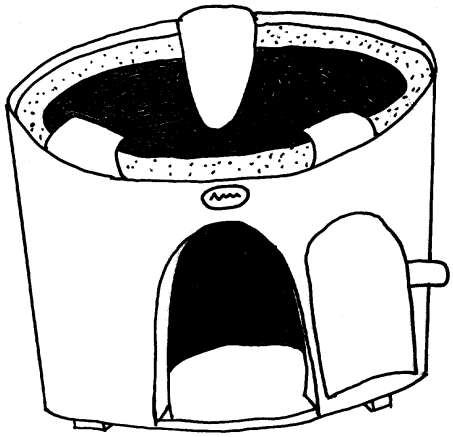


Figure 3 — Example ceramic wood stove

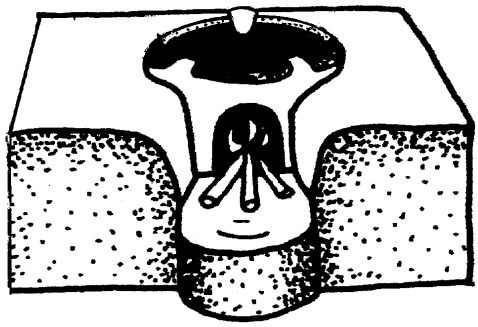


Figure 4 — Example single ceramic household biomass stove for wood as installed

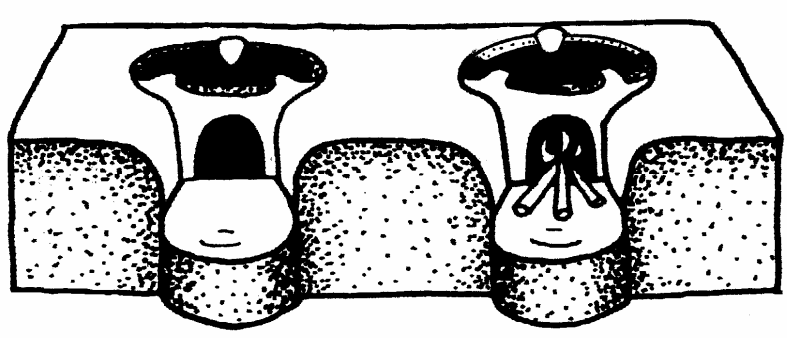


Figure 5 — Example double ceramic biomass cook-stove for wood as installed

5.2 Firing of the ceramic liner and insulation media/material

The ceramic liner shall be uniformly fired at 700 °C – 900 °C in the firing facility.

5.3 Assembling

The liner shall be assembled into the cladding as illustrated in Figure 2 and using the insulant specified in Table 2. The same material shall be used to insulate the base of the ash box as illustrated in Figure 2. The other types of assembly shall comply with 4.2.

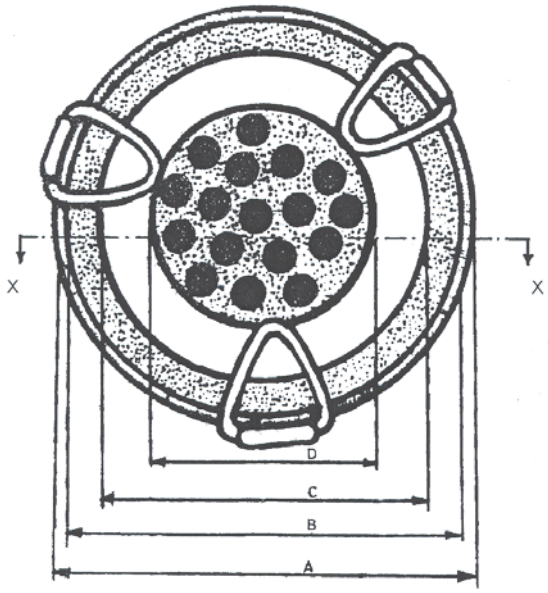


Figure 6 — Top view of stove

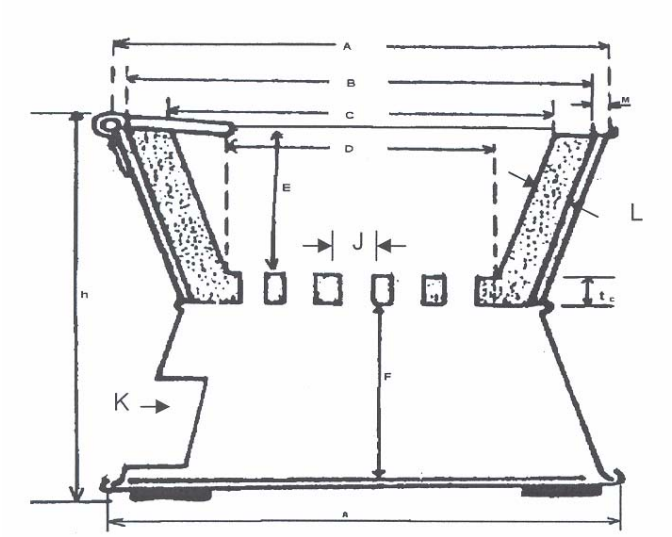


Figure 7 — Cross sectional view of the charcoal stove (view x-x)

Figure 8 — Photographic representation of biomass stoves

Table 3 — Stove dimensions

Stove parts	Size, mm		
	Small	Medium	Large
Bottom and top diameter of cladding, A	250 - 260	280 - 290	300
Overall height, h	200	220 ± 10	230
Top inside diameter of liner, C	215	230	240
Base inside diameter of liner, D	150	165	175
Fire box depth, E	60	90	90
Ash box depth, F	60	90	90
Grate diameter, D	150	165	175
Grate thickness, t_c	20	20	20
Grate hole diameter, J	20	20	20
Inlet air door, K	80 x 120	100 x 130	100 x 130
Thickness of ceramic liner, L	20	20	20
Thickness for insulation, M	15	15	15

5.4 Grate

The grate shall have holes separated by material of minimum diameter 15 mm. Hole sizes shall be 10 mm - 20 mm.

5.5 Legs

Each stove shall be provided with minimum three legs measuring 20 mm in height and shall be spaced at equidistance for stability. Legs shall be of minimum thickness 1.5 mm.

6 Finish

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

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

6.3 The liner shall not be painted.

7 Marking and packaging

7.1 Marking

The stoves manufactured shall be marked with the name and/or trademark or any other means of identifying the manufacturer, vendor or distributor of the biomass stoves.

7.2 Packaging

Stoves shall be packaged in cartons in order to protect them while in storage and transportation. The biomass stoves shall be supplied with a hang tag or label with the wording “FRAGILE — HANDLE WITH CARE”.

The biomass stoves shall be supplied with an instruction leaflet which shall be in pictorial form as shown in Annex E.

8 Test requirements

8.1 Heat transfer tests

Stoves selected at random shall undergo a heat transfer test in accordance with Annex A. A complete heat transfer water boiling shall comprise of two phases:

a) HPP shall involve bringing the water to the boil at ambient temperatures as quickly as possible and allowing it to continue boiling for a further period of 15 min; and

b) LPP shall involve reducing the power after the high power phase to the lowest needed to keep the water simmering for 60 min.

8.2 Safety test requirement

The outside surface temperature of the stove body shall not be high so as to cause burns when it is in use or when handling it. Outside surface temperatures of not more than 45 °C shall be considered appropriate for purposes of human safety.

8.3 Thermal conductivity test for ceramic liner

The ceramic liner shall be tested for thermal conductivity as specified in Annex D.

9 Acceptance criteria

9.1 Acceptance criteria for biomass stoves

9.1.1 Biomass stoves shall comply with tests in Annex B. The ceramic liners shall not crack due to heating and cooling cycles developed due to thermal stress. The more the number of cycles the liner endures, the better it is in resisting thermal shocks. As the test is extremely severe, a liner which can withstand five cycles can be considered to be made from a clay mix which is thermal shock resistance. As the stove is used over a period of time, the ceramic liner should withstand many cycles of heating and cooling without cracking.

9.1.2 Biomass stoves, which comply with the requirements of Clause 4, Clause 5, Clause 6, 8.2 and tests in Annexes A, B, and C, shall be accepted**.** Stoves, which have been tested in accordance with Clause 8 and Annex A and have achieved PHU of more than 30 % at power output of 3 kW, shall be accepted.

9.2 Criteria of acceptance of insulant

The insulant shall be considered to meet the requirements of this standard if, when the stove is in use, the outside surface temperature does not exceed 45 °C. The insulation and binding materials shall be in accordance with Table 2.

9.3 Acceptance criteria for ceramic liner

A ceramic liner shall be considered to have met the requirements of this standard if its thermal conductivity value does not exceed 2.5 $WK^{-1}m^{-1}$ at 500 °C when determined in accordance with the procedure specified in Annex D.

Annex A
(normative)

Heat transfer test

A.1 Equipment and materials

A.1.1 Stoves

A.1.2 Aluminium pots and lids

A.1.3 Weighing balances, two with an accuracy of 10 g and a capacity of 15 kg

A.1.4 Electronic balance, accuracy to 1 g for weighing charcoal

A.1.5 Stop-watch

A.1.6 Mercury thermometers, of up to 105 °C and accuracy to ± 1 °C

A.1.7 Moisture content measuring device, of accuracy to 1 %

A.1.8 Gauge, for removing charcoal and test sheet form

A.2 Materials

A.2.1 Wood (cypress), of 2 cm diameter pieces

A.2.2 Water, 3 L

A.2.3 Kerosene/kindling

A.2.4 Match box/lighter/source of fire

A.3 Applicability of test

The test is used to determine

a) the Percentage Heat Utilized (PHU), (often referred to as the thermal efficiency) and the power output range of the metal;

b) the time required to boil a given amount of water;

c) the effects of changing the dimensions and method of operation of a stove on PHU and time to boil; and

d) the operating characteristics of a stove.

Factors that can be accurately fixed in water boiling tests are:

i) type and moisture content of wood to be used;

ii) type and size of pots;

iii) amount of water used;

iv) initial water and stove temperatures;

v) the method of ignition;

vi) the method of operating the stove; and

vii) the accuracy of test equipment to be used.

A.4 Procedure

A.4.1 Weigh the empty pot and lid.

A.4.2 Weigh the pot, lid and the specified amount of water.

A.4.3 Note the initial water and room temperature.

A.4.4 Weigh 2 kg of wood. Measure its moisture content which should be the same for the entire tack of wood that is between 10 % - 15 %.

A.4.5 Insert wood into the stove and spill about 10 mL of kerosene over the wood or use balls of paper. This is a common practice used in lighting stoves.

A.4.6 Ignite the wood with a match. Place the pot with its contents on the stove and start the stopwatch. This marks the start of the HPP.

A.4.7 Bring the water to the boil as rapidly as possible and at the same time record the water temperatures at intervals of 5 min. Also record the number of times wood is added.

A.4.8 Note the time water starts to boil. Open a gap of about 3 cm for water to evaporate off and continue at the same burning rate for another 15 min. This marks the end of the HPP.

A.4.9 Weigh the pot and its contents.

A.4.10 Remove the remaining wood from the stove and knock off charcoal from the ends. Weigh the wood left and also the charcoal produced during the HPP.

A.4.11 Record all the data in the water boiling test data sheet (see Annex C).

A.2.12 Place the wood and charcoal back into the stove. Put the pot and its contents back on the stove and re-light the wood by vigorous blowing.

A.4.13 Note the temperature of the water and start the clock. This marks the start of the LPP. A gap of about 3 cm is left and care is taken such that the water temperature is within – 2 °C of the boiling point.

A.4.14 The LPP is continued for a period of 60 min with water temperature being taken after every 5 min.

A.4.15 At the end of LPP, weigh the pot and its contents, the wood remaining and also the charcoal produced. Record the data in the data sheet.

A.4.16 Calculate the Percentage Heat Utilized (PHU) both in the HPP and LPP. PHU of over 30 % at power output of about 3 kW is considered good.

A.4.17 A series of five tests shall be done per stove and the average values computed for comparison purposes. A table of calorific values of wood at different moisture contents shall be made available.

A.4.18 If not there, the value has to be determined using the bomb calorimeter. The water boiling tests are also used in testing charcoal stoves.

A.4.19 Data collection and report shall be made on water boiling test data forms specified in Annex C.

Annex B
(normative)

Thermal shock/stress resistance test

To test whether ceramic liners made from particular clay mix are thermal shock resistant, the liners shall be heated to temperature ranging 800 °C – 900 °C and then immersed in cold water at room temperature. These temperatures are attained in fireboxes when in use. This is repeated several times until the liner cracks. The heating can be done using a gas flame or an electric kiln.

As the test is extremely severe, a liner which can withstand five cycles shall be considered to be made from a clay mix that is thermal shock resistant.

Annex C
(normative)

Water boiling test data form

Test number……. Location…….

Data……. Air temp…….

Stove…….. Stove condition…….

Tested……. Remarks…….

Basic test data initial measurement	**End of HPP**	**LPP**
Amount of water ……kg		
Moisture cont. of wood ……..kg		
Low heat value of wood……kg		
Weight of wood ……..kg	……kg	……kg
Weight of charcoal……kg	……kg	……kg
Weigh pot 1 (……..cm)……..kg	……kg	……kg
Weigh pot 2 (……..cm)……..kg	……kg	……kg
Water temp. Pot 1 ……..°C	……°C	……°C
Water temp. Pot 2 ……..°C	……°C	……°C

Boiling point (pot 1) ……min

	HPP	**LPP**
Wood consumed	……kg	……kg
Charcoal remaining	……kg	……kg
Water vaporized pot 1	……kg	……kg
Duration of test	……min	……min

Water temperature

High Power Phase			**Low Power Phase**		
Min	pot 1(°C)	pot 2 (°C)	Min	pot 1 (°C)	pot 2 (°C)
0	……..	……..	0	……..	……..
5	……..	……..	5	……..	……..
10	……..	……..	10	……..	……..
15	……..	……..	15	……..	……..
20	……..	……..	20	……..	……..
25	……..	……..	25	……..	……..
30	……..	……..	30	……..	……..
35	……..	……..	35	……..	……..
40	……..	……..	40	……..	……..
45	……..	……..	45	……..	……..

50	……..	……..	50	……..	……..
55	……..	……..	55	……..	……..
60	……..	……..	60	……..	……..

Data sheet — Water boiling test

Comparison of different test within one test series

1-Pot stove: stove design:……
Diameter of pots:……..
Kg. of water:……..

Test carried out by

……..
Date ……..

Place:……

Test Number						Average
Wf 1 (kg)						
Wf 2 (kg)						
Wf 3 (kg)						
We.1 (kg)						
We.2 (kg)						
We.1 (kg)						
We.2 (kg)						
We.3 (kg)						
(boil) (min)						
Pf3 (kw)						
Pin3 (kw)						
L3 9 (min)						
Dtl (°C)						
BR (kg/min)						
ER (kg/min)						
PHU1 (%)						
PHU2 (%)						
PHU3 (%)						

Annex D
(normative)

Determination of thermal conductivity of ceramic liner

D.1 Sample preparation

D.1.1 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.

D.1.2 The reference material measuring 80 mm x 30 mm x 10 mm shall be of hard fibreglass board, whose thermal conductivity is known.

D.2 Procedure

D.2.1 The transient hot wire method of comparison shall be employed as seen in Figure 9.

D.2.2 The hot wire is sandwiched between a plate-type experimental specimen and a reference specimen whose value of thermal conductivity is known.

D.2.3 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.

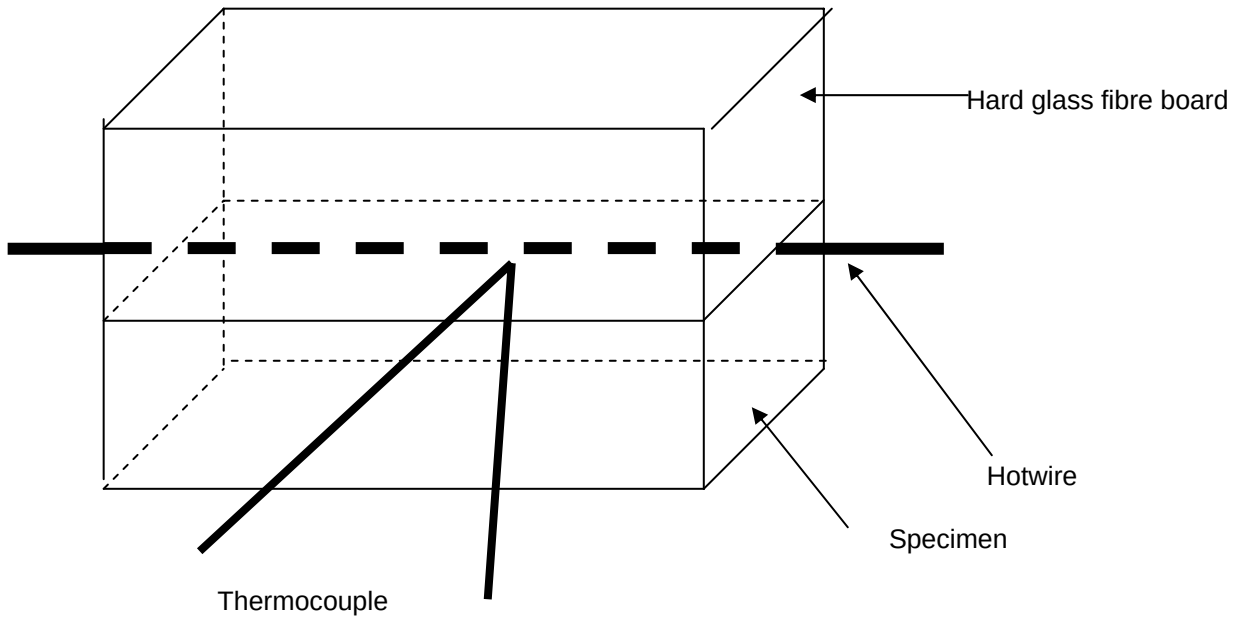


Figure 9 — Transient hot wire set-up

D.2.4 Both the specimen and reference material are pressed by loading to come into close contact with each other.

D.2.5 At the centre of the hot wire, a thermocouple is installed by means of spot welding.

D.2.6 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.

D.2.7 The thermocouple wires are fitted directly to thermocouple thermometer, which reads in ºC. The specimens are placed inside a furnace so that the temperature at which the thermal conductivities are measured may be varied.

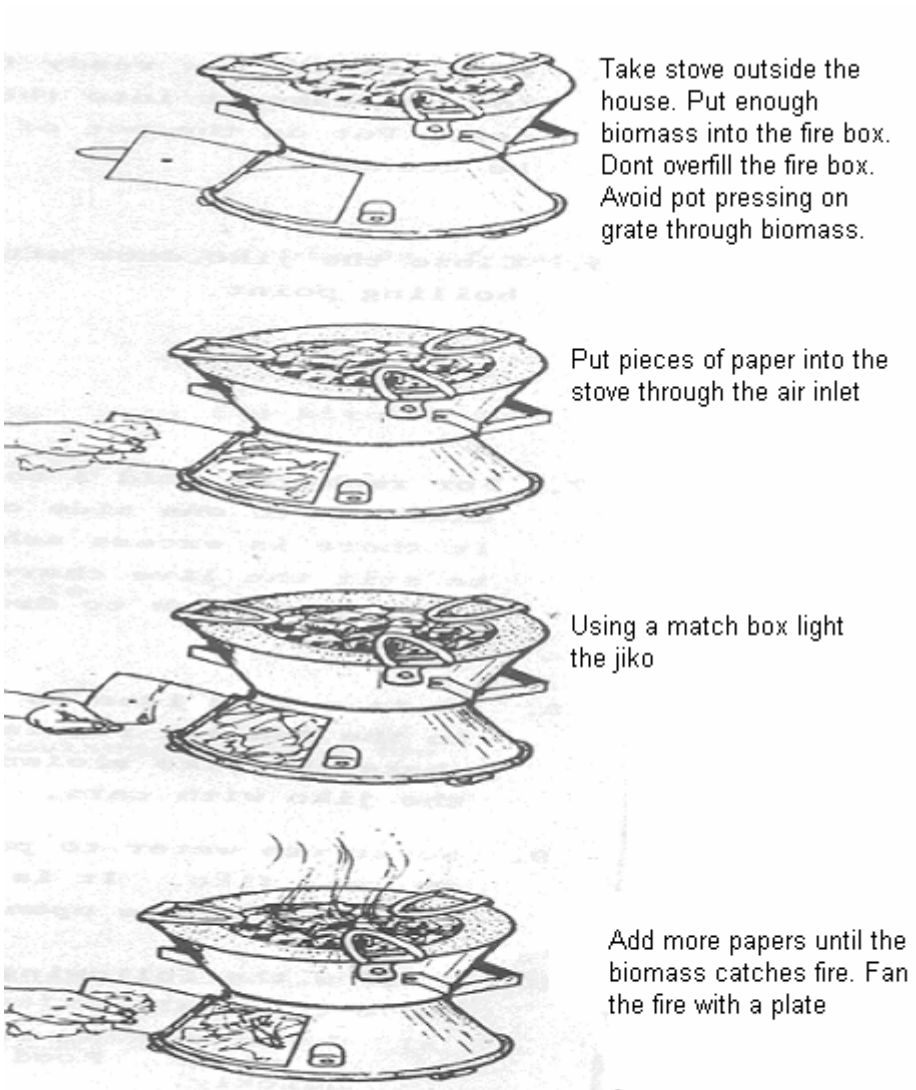
D.3 Data form for results for thermal conductivity test

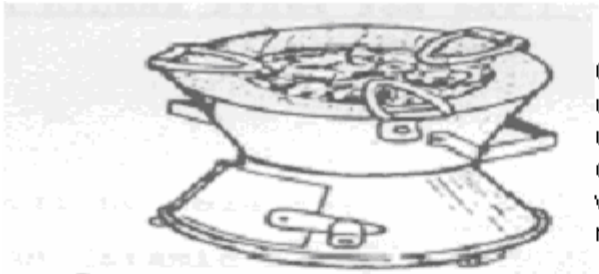
Oven temperature	Thermal conductivity $WK^{-1}m^{-1}$					
	1	2	3	4	5	Mean value
200						
400						
600						
800						
1000						

Annex E
(normative)

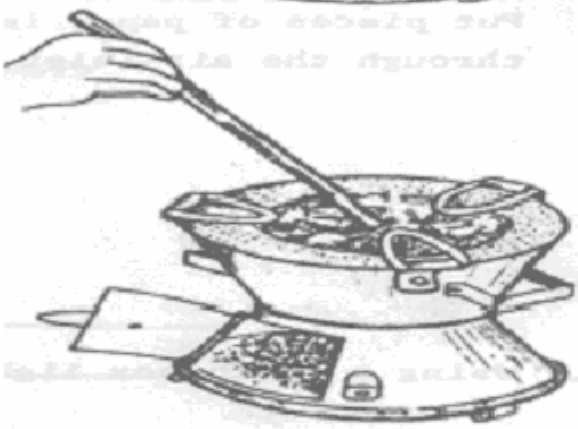
Operating instructions

Every biomass stove supplied shall contain operating instructions as illustrated below for its safe and efficient use.

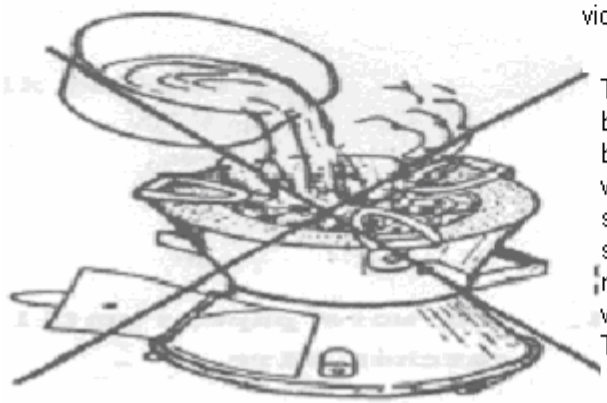




Once the stove is ready for use, take it to a safe point of use and put on it a pot of food or liquid to be cooked. Shut the vent after the water has reached boiling point.



For recharge, add a few pieces of the biomass to one side of the fire box. Don't shake assembly to remove ash. Rake the fire using a poker. Empty the ash tray regularly. Handle the stove with care. Don't invert the assembly to remove biomass. Don't shake the stove violently.



To save biomass, remove the biomass first and pour water on the biomass separately. Never use water to put off the fire in your stove. It is not advisable to leave the stove in the open. Use the remaining biomass for heating water. DO NOT LEAVE STOVE IN THE RAIN.

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