TANZANIA STANDARD

MEDC 12 (3857) DTZS 473:2019 - Solid fuel cookstoves — Part 1: General requirements and test methods

TANZANIA BUREAU OF STANDARDS

3rd Edition

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Foreword

Solid fuel cookstoves has been a common cooking stove used in Tanzania. The qualities of these products have been varying at large extent, resulting to the variations on their performance. Based on this fact and protecting environment and the users against inferior products and assisting manufacturers to produce quality products.

The standard has been revised to take into consideration all types of solid fuel cookstoves, efficiency, durability, safety, and emissions, which were not included in the previous version.

During the preparation of this Tanzania Standard, assistance was derived from the following standards:

TZS ### ISO 19867-1:2018 Clean cookstoves and clean cooking solutions — Harmonized laboratory test protocols Part 1: Standard test sequence for emissions and performance, safety and durability.

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

US 761:2019 – Household biomass stoves - Requirements, published by the Uganda Bureau of Standards.

1. SCOPE

This Tanzania standard specifies the classification, efficiency, durability, safety, emissions, requirements, and test methods for solid fuel cookstoves.

This standard is applicable to cookstoves using solid fuel in its natural or densified form.

2. NORMATIVE REFERENCES

The following referenced documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

TZS 2913-1/ 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.

TZS 845, Air quality – Specification

ISO/TR 21276, Clean Cookstoves and clean cooking solutions — Vocabulary

ISO 18125, Solid biofuels — Determination of calorific value

ISO 4224, Ambient air — Determination of carbon monoxide — Non-dispersive infrared spectrometric method

ISO 25597, Stationary source emissions — Test method for determining PM2.5 and PM10 mass in stack gases using cyclone samplers and sample dilution

ISO 9096, Stationary source emissions — Manual determination of mass concentration of particulate matter

ISO 12039, Stationary source emissions — Determination of carbon monoxide, carbon dioxide and oxygen — Performance characteristics and calibration of automated measuring systems

3. TERMS AND DEFINITIONS

For the purpose of this document, the terms and definitions given in ISO/TR 21276, together with ISO and IEC, maintain terminological databases for use in standardization at the following addresses: ISO Online browsing platform: available at http://www.iso.org/obp, the following terms and definitions apply.

3.1 Solid fuel cookstove

stoves with cooking function, burning solid fuel in its natural or densified form

3.2 Densified solid fuel

inter solid fuel made by mechanically compressing or binding small particles or binding thermally into a specific size and shape, such as cubes, pressed logs, pellets, or briquettes.

3.3 Useful energy

energy transferred to the contents of a cooking vessel, including sensible heat energy that raises the temperature of the contents of the cooking vessel and the latent heat of vaporization of water from the test point.

3.4 Cooking power

useful energy per unit time.

3.5 Cooking thermal efficiency

the ratio of useful energy to the energy of fuel consumed.

3.6 Emission factor

ratio of the mass of a pollutant emitted to the useful energy delivered from solid fuel consumed

3.7 $PM_{2.5}$

fine particulate matter such that the aerodynamic diameter of the particles is less than or equal to 2.5 μm, as determined in Annex C.

3.8 Energy of fuel consumed

amount of heat released during the combustion of a specified amount of solid fuel

3.9 emissions

air pollutants, visible or invisible, occurring as a result of the combustion of a solid fuel

3.10 particulate matter

solid and liquid matter of a sufficiently small size to be suspended in air

4 CLASSIFICATIONS

Solid fuel stoves shall be classified and comply with the requirements given in Tables 1, 2, 3,4, and 5 when tested in accordance with ISO 19867-1.

Table 1 — Efficiency Classification of Solid Fuel Stoves

	Class				
	1	2	3	4	5
Efficiency η_c (%)	$\eta_c \geq 50$	$45 \leq \eta_c < 50$	$40 \leq \eta_c < 45$	$36 \leq \eta_c < 40$	$30 \leq \eta_c < 36$

Table 2 – Emission ($PM_{2.5}$) classification of solid fuel cookstoves

	Class				
	A	B	C	D	E
$PM_{2.5}$ (mg/MJ_d)	$PM_{2.5} < 43$	$43 \leq PM2.5 < 89$	$89 \leq PM_{2.5} < 132$	$132 \leq PM_{2.5} < 175$	$175 \leq PM2.5 \leq 218$

Table 3 – Emission (CO) classification of solid fuel cookstoves

	Class				
	A	B	C	D	E
CO (g/MJ_d)	$CO < 3.84$	$3.84 \leq CO < 4.68$	$4.68 \leq CO < 5.52$	$5.52 \leq CO < 6.36$	$6.36 \leq CO \leq 7.2$

Table 4 – Safety classification of solid fuel cookstoves

	Class				
	A	B	C	D	E
Safety (Score)	<10	<15	<20	<25	<35

Table 5 – Durability classification of solid fuel cookstoves

	Class				
	A	B	C	D	E
Durability (Score)	≥95	≥86	≥77	≥68	≥60

5 TECHNICAL REQUIREMENTS

5.1 General requirements

The stove shall have a good finish without burrs (rough or sharp edges) or rust outside (if made of metal).

5.2 Manufacturing requirements

5.2.1 The stove or any of its parts may be manufactured using different suitable materials and/or methods.

5.2.2 Castings shall have a good finish without cracks, stomata (holes), and sand holes.

5.2.3 Weldments shall be flat and uniform without perforations and slag stomata.

5.2.4 Stamped parts shall have a good finish without cracks, wrinkles, flashes, or burrs.

5.2.5 Sheet metal surfaces and edges shall have a good finish without cracks, wrinkles, bumps, or any type of imperfection.

5.2.6 Riveted pieces shall be firmly attached, and the rivets shall not be loose and/or skewed. Rivet heads shall be smooth and shall not protrude.

5.2.7 Ceramic parts shall have a good finish without cracks and voids.

5.2.8 For stoves made of different parts, such as a ceramic core and a metal cladding, the parts shall be firmly assembled.

5.2.9 For stoves that have insulation material, such material shall be environmentally friendly and non-hazardous to human health.

5.3 Performance requirements

Solid fuel stoves shall comply with the performance criteria given in Tables 1, 2, 3,4, and 5 when tested in accordance with ISO 19867-1.

6 SAFETY REQUIREMENTS

6.1 When the stove is in use, the surface temperature shall be less than 50 ℃ when tested in accordance with ISO 19867-1.

6.2 The stove shall be stable on a flat surface and shall score a minimum of 0.94 when tested in accordance with D.2.

6.3 Surfaces which in normal use have to be touched for short periods, e.g. handles, the difference between maximum temperature and air temperature shall not exceed 38 ℃ when tested in accordance with Annex D.7.

6.4 Flames touching the cooking pot shall be concealed and not able to come into contact with hands or clothing.

6.5 Flames or fuel shall not protrude from any fuel loading area, storage container, or flow pipes during use.

6.6 If the cookstove with a chimney fails a test in D.8.2, a shield shall be employed to increase safety. The chimney shielding shall pass the test in D.8.3.

6.7 For a stove with a chimney

a) the chimney shall exit outside the dwelling, ensuring the smooth flow of exhaust, and
b) there shall be no smoke leakage.

6.8 The stove with electrical fans shall meet electrical safety measures.

7 DURABILITY REQUIREMENTS

7.1 When subjected to the durability test, as specified in Annex E, the stove shall maintain its basic structure and stability and shall not have broken parts, cracks, or warping.

8 PRODUCT DESCRIPTION, USER INSTRUCTIONS, AND SAFETY PRECAUTIONS

The cookstove shall be supplied with a suitable form of user instructions and safety precautions.

The manufacturer/supplier shall provide documentation giving a detailed description corresponding to the stove provided. Information to be provided shall include:

a) parts and assembly instructions, where applicable;

b) user instructions;

c) dimensions and mass; and

d) fuel type.

9 TESTS FOR COOKSTOVES

9.1 Stove description and physical characteristics

The information in Clause 8 shall be made available for use during the tests

9.2 Visual inspection

Prior to the testing, a detailed visual inspection of the cookstove shall be conducted, noting the features in relation to the tests to be done. Observations shall be recorded on a data sheet as given in Annex F. Photographs taken shall be attached to the data sheet. A ruler or a tape measure should be included in photographs, as a point of reference.

10 PACKAGING

Stoves shall be packaged in suitable packages that shall protect them during normal handling, transportation, and storage.

11 LABELLING

11.1 The stove shall be legibly and indelibly marked with the following information and shall :

a) Name of the manufacturer and or trademark;
b) Country of origin;
c) Stove classifications (according to clause 4);
d) Serial/ Batch number;
e) Nominal cooking power;
f) Reference to this Tanzania Standard; and

11.2 The package shall contain the following information/documentation:

a) name and address of manufacturer;
b) user instructions;
c) safety instructions;
d) Parts list; and
e) Gross and net weight

ANNEX A
(NORMATIVE)
TEST REPORT

The format of the stove performance test report is provided in Table A.1.

Table A.1 — Test report of cookstove

Name and type of the stove:		Manufacturer:		
Fuel type and water content:		Lower heating value, as received:		
Stove description and physical characteristics				
Manufacturer classification				
Test site:		Test date:		
Standard referred:		Fan power (W):		
Test environment conditions:				
Ambient temperature, Humidity, Wind speed				
Model, serial number and last date of calibration of principal test equipment and number of test repetitions				
Test items		Unit	Average	Standard deviation
Thermal performance	Cooking power, Pc	kW		
	Thermal Efficiency, ηc High power	%		
	Low power			
Emission factor	PM2.5	mg/MJ		
	CO	g/MJ		
Safety score				
Durability score				
Classification as per test results				
Notes				
Test institution:		Tester:		
Examine and verify:		Sign and issue:		

ANNEX B

(NORMATIVE)

THERMAL PERFORMANCE TESTS

B.1 Test equipment and instruments

B.1.1.1 Weighing balance with a resolution of 5 g and an accuracy of 1.0 g

B.1.1.2 Stopwatch

B.1.1.3 Thermometers with an accuracy of ± 1 °C and resolution of 0.2 °C

B.1.1.4 Humidity measuring device

B.1.1.5 Wind speed measuring device with a resolution of 0.5 m/s

B.1.1.6 Moisture content measuring device of accuracy to 1 %

B.1.1.7 Fuel removing device

B.1.1.8 Bomb calorimeter

B.1.2 Pot size and water quantity

The size of pot and water quantity used is determined according to the cooking power given in Table B.1.

Table B.1 — Pot size and the water quantity

Cooking power kW	Diameter of pot mm	Initial water kg
≤2.0	200	2.5
2 - 4	280	5
4 - 6	320	7.5

B.2 Test conditions

B.2.1 The following conditions shall be applied during the test:

a) Ambient air temperature: 10℃ - 35℃;
b) Relative humidity:<85%; and
c) Wind speed:<1.0 m/s;

B.2.2 The test stove should be far away from other heat and combustion sources. If multiple stoves are to be tested in the same room, the distance between each stove should be greater than 3 m.

B.3 Test preparation

B.2.1 The tester shall be familiar with the operation of the stove and have sufficient experience in testing stoves.

B.2.2 The instruments shall be calibrated.

B.2.3 Use appropriate fuel types according to the stove instructions.

B.2.4 Weigh and record the mass of enough biomass fuels, B_1 based on a burning duration of 1 h.

B.2.5 Measure the low calorific value of biomass fuel according to ISO 18125.

B.2.6 Record the initial mass of water in the pot, G_1 and initial water temperature T_1.

B.2.7 Place the thermometer in the pot using a holder; the sensor of the thermometer should be 5 cm above the bottom of the pot. Do not use a pot lid.

B.4 Test at maximum power

B.1.1 Light the fire according to the appropriate fuel type.

B.1.2 When the ignition material (for example, match stick, drops of paraffin, grass, lighting sticks, candle etc) is exhausted, place the pot on the stove and record the time as t_1;

B.1.3 Operate the stove according to manufacturer's instructions.

B.1.4 If boiling occurs within one hour, record the temperature of the water T_2 and the time as t_2. Stop adding the fuel and continue with the test until the temperature falls 5 ºC below the boiling point. Record time t_3. If the temperature does not fall 5 ºC below boiling point, stop the test at one hour, record temperature T_3.

B.1.5 If boiling does not take place within one hour, record the temperature T_2 at one hour, t_2 and stop the test.

B.1.6 During the evaporation phase, record water temperature every five minutes.

B.1.7 Record the mass fuel left, B_2 and mass of residual char, B_{char} and the mass of water G_2 left in the pot at the end of the test.

B.5 Calculation

B.5.1 Useful energy

The useful energy, Q1, expressed as kilojoules, shall be calculated as follows:

$$Q1 = 4.18*G1*(T_2 - T_1) + (G1 - G2)\gamma \quad \ldots\ldots 1)$$

Where;

Q_1 is the useful energy, kJ;

G_1 is the initial mass of water in the pot, kg;

G_2 is the final mass of water in the pot, kg;

T_1 is the initial temperature of water, ℃;

T_2 is the boiling point of the water or the highest temperature attained, ℃;

γ is the latent heat of water vaporization at boiling point, kJ/kg at temperature T_2; and

4.18 is the specific heat capacity of water, kJ/ (kg·℃).

B.5.2 Cooking power

The cooking power, *Pc*, expressed as kilowatts, shall be calculated as follows:

$$P_c = \frac{Q_1}{t_3 - t_1}$$

Where;

Pc cooking power, Kw

Q_1 is the useful energy delivered, kJ;

t_3 is the final time at end of a test phase, s;

t_1 is the initial time at beginning of a test phase, s.

B.5.3 Cooking thermal efficiency

The cooking thermal efficiency, η_c, shall be calculated as follows:

$$\eta_C = \frac{Q_1}{Q_{net}} \times 100$$

$$Q_{net} = B_{fuel} C_{fuel} - B_{char} C_{char}$$

Where;

ηc cooking thermal efficiency;

B mass of biomass fuel, kg;

Qnet.ar lower heating value (as received) of the biomass fuel, kJ/kg

Where

B_{fuel} mass, in kilograms (kg), of biomass fuel consumed during the test;

B_{char} mass, in kilograms (kg), of char;

C_{fuel} lower heating value (as received), in kilojoules per kilogram (kJ/kg), of the biomass fuel,

C_{char} lower heating value, in kilojoules per kilogram (kJ/kg), of residual char.

NOTE Since US ISO 18125 determines the gross heating value; the lower heating value should be calculated as follows:

$$LHV = HHV - r_{H_2O}\left[\left(\frac{M_{H_2O}}{M_{H_2}}\right).H + F\right]$$

Where;

r_{H_2O} is the evaporation heat of water at normal conditions (2 256 kJ/kg)

M is molar mass, in kilomole per kilogram (kmol/kg), of respective water and hydrogen

H is the mass percentages of hydrogen, and

F is the mass percentages of moisture.

ANNEX C

(NORMATIVE)

EMISSIONS TESTS

C.1 Emission measurements of PM2.5 and CO

C.1.1 Test preparation

C.1.1.1 Emission tests shall be conducted simultaneously with the thermal performance tests.

C.1.1.2 The test procedure shall depend on whether or not the stove has a chimney.

C.1.1.3 For a stove with a chimney, locate the hood over the stove chimney exhaust (see Figure C.1). Operate the blower at the gas flow velocity of at least 5 m/s. Measure the static pressure imposed on the stove by the dilution tunnel (that is, the difference in the draft measured with and without the dilution tunnel operating) at a location no greater than 0.3 m above the flue connector. Adjust the distance between the top of the stove chimney and the hood so that the induced static pressure of the dilution tunnel is less than 1.25 Pa. During this check and adjustment activity, no fire shall be in the stove.

C.1.1.4 When the stove is burning at high burning rates, make sure that all emissions are captured by the hood system by adjusting the dilution tunnel flow rate or adjusting the distance between the top of the stove chimney and the hood, or both. The gas flow rate in the dilution tunnel should be no less than 5m/s. If the distance between the top of the stove chimney and the hood decrease, recheck the static pressure imposed on the stove by the dilution tunnel according to C.1.1.3.

C.1.1.5 When testing stoves with low emissions, in order to ensure sufficient capture of emissions in the form of mass collected on filters, additional dilution as shown in Figure C.1 should not be applied. When testing stoves with high emissions, additional dilution may be used to prevent overloading filters and to prevent instrument ranges from being exceeded. If increased air flow causes an excessive increase in hood face velocity, dilution air should be used to reduce hood face velocity. Dilution air may be filtered.

C.1.1.6 For a stove without a chimney, locate the stove under the hood (see Figure C.2).

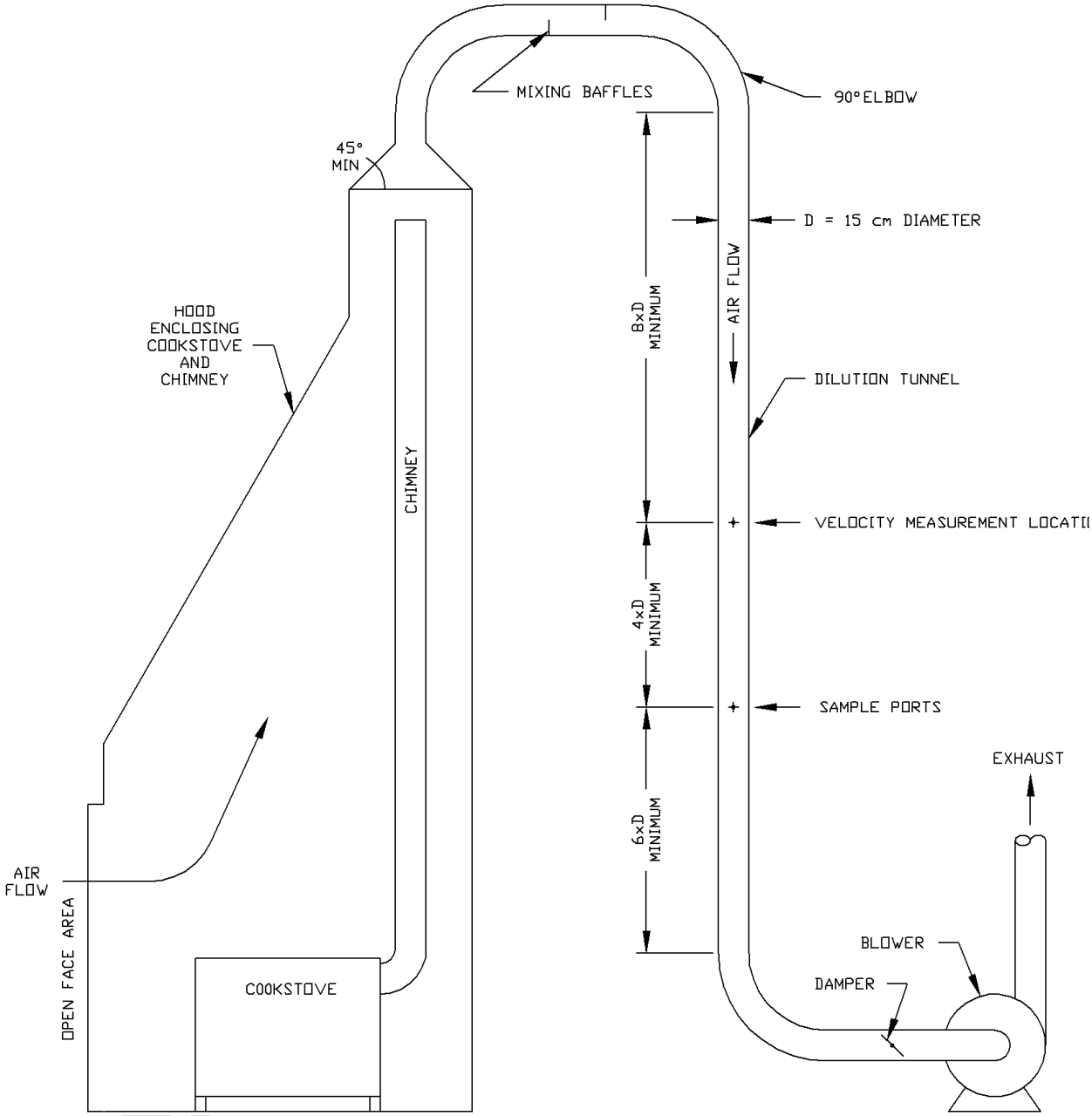

Figure C.1 — Hood and dilution tunnel apparatus for collecting total emissions from cookstoves with chimneys

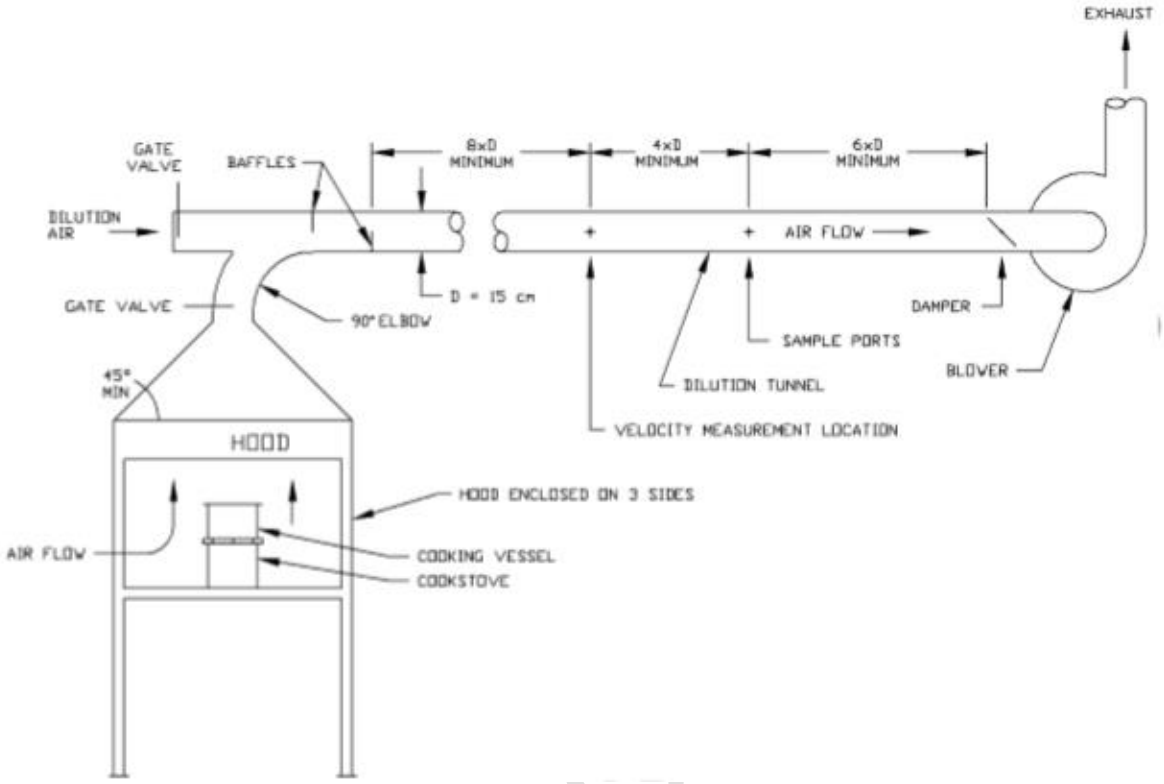

Figure C.2 — Hood and dilution tunnel apparatus for collecting emissions from cookstoves without chimneys

C.1.2 Test method

C.1.2.1 Locate the stove under the hood, and place the stove chimney just below the hood (See Figure C.1). Flue gas emitted from the stove during the test is diluted and cooled by the ambient air, and then passes through the hood, the duct, the blower, and is discharged into the atmosphere. Measure the flow velocity in the duct according to the ISO 9096.

C.1.2.2 The sampling of PM2.5 (See Figure C.3) shall be in accordance with ISO 9096, and the instruments and filter analysis procedure shall be in accordance with ISO 25597. The sampling and testing of CO procedure refer to the ISO 12039.

C.1.2.3 When ambient air is used as the dilution air, sample and analyses ambient PM2.5 and CO according to the ISO 25597 and ISO 4224 or the purpose of determining background concentrations of pollutants.

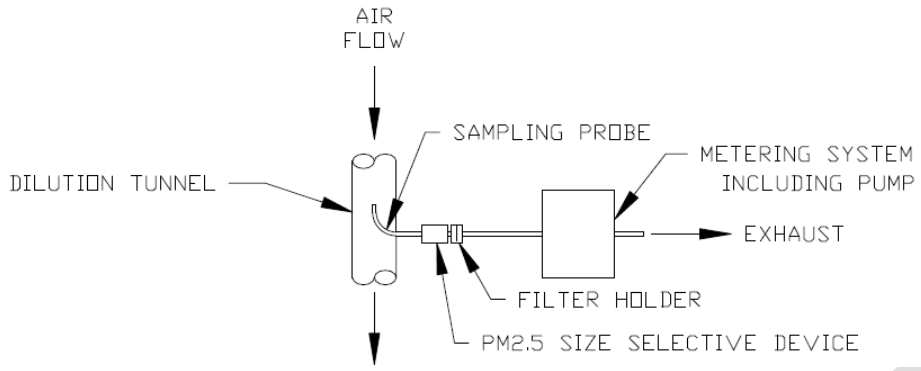

Figure.C.3 — $PM_{2.5}$ sampling test

C.1.3 Test steps

C.1.3.1 Locate the stove below the hood, turn on the blower, measure the flow rate and adjust the valves to be sure that all emissions are captured and the flow rate is no less than 5 m/s.

C.1.3.2 Start to sample both PM2.5 and CO at the same time point as the fire is ignited. When the test in B.4 stops, end the sampling and turn off the blower.

C.2 Calculation of Emission Factors

C.2.1 The emission factor, $EF_{PM2.5}$, expressed as milligrams per megajoules (mg/MJ), shall be calculated as follows:

$$EF_{PM2.5} = \frac{M_{PM2.5}}{Q_1} \times 1000$$

$$M_{PM2.5} = \frac{V_t}{V_s} \times M_s$$

$$M_s = \left(\frac{M'_s}{V_s} - \rho_{PM2.5}\right) \times V_s$$

Where;

$EFPM_{2.5}$ - $PM_{2.5}$ emission factor, mg/MJ;

$MPM_{2.5}$ - the mass of PM2.5 emitted during the sampling period, mg;

V_t - volume of total exhaust in the dilution tunnel during the sampling period, m3;

V_s - Volume of gas sampled during the sampling period, m3;

M - The mass of PM2.5 collected on the filter corrected for background, mg (if the dilution air passes through the High Efficiency Particulate Absorber (HEPA), and PM is removed efficiently, the correction is not necessary);

M's - the mass of PM2.5 collected on the filter, mg;

$\rho PM_{2.5}$ - the concentration of PM2.5 in ambient air, mg/m^3

C.2.2 The emission factor, EF_{CO}, expressed as milligrams per mega joules (mg/MJ), shall be calculated as follows:

$$EFco = \frac{(\rho'co - \rho co) \times V_t}{Q_1}$$

Where:

EFco - CO emission factor, g/MJ

ρ'co - the concentration of CO in the dilution tunnel, mg/m^3

ρco - the concentration of CO in the ambient air, mg/m^3

C.3 Testing repeats

Repeat the test at least three times using the same method. Average the results for thermal efficiency and emission factors as the final reported value.

ANNEX D

(NORMATIVE)

SAFETY TESTS AND SCORING TABLES

D.1 Sharp edges and points test

D.1.1 Equipment

Piece of cloth, rag, or loose clothing

D.1.2 Procedure

A piece of cotton cloth shall be rubbed gently over the entire exterior surface of the cookstove to find areas that catch or tear the cloth.

The safety rating for this hazard shall be determined by adding together the number of times the cloth becomes caught or entangled. The sum shall then be applied to the metric in Table D.1.

Table D.1 - Scoring system for sharp edges and points test

Number of catches	Rating	Score
None	Best	4
One or two	Good	3
Three	Fair	2
Four or more	Poor	1

D.2 Cook stove tipping test

D.2.1 Equipment:

D.2.1.1 Fuel

D.2.1.2 Ruler / tape measure

D.2.1.3 Calculator

D.2.2 Procedure

D.2.2.1 Set stove on flat surface and load with fuel but do not ignite.

D.2.2.2 Pick a side to tip towards and measure the height of its tallest point and record it as a standing height, H (see Figure D 1). Slowly tip cookstove in the outward direction from the side chosen until the stove begins to tip on its own.

NOTE for the case of firewood stoves in which fuel is fed from the side and protrudes outside, do not tip the stove from that side.

D.2.2.3 Hold stove tilted where it can overturn and measure new height, h (see Figure D 1).

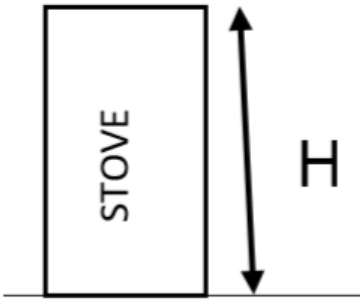

Figure D.1a) — Measurement of H

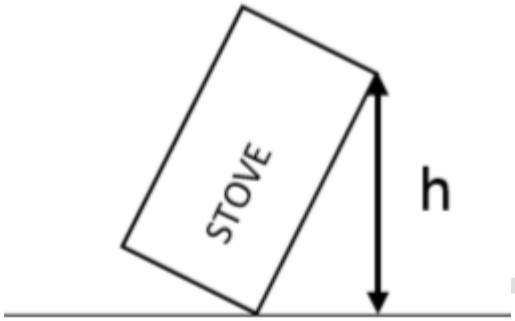

Figure D.1b) — Measurement of h

Figure D.1 — Showing how to measure stove standing height and tipped height

D.2.2.4 Calculate the ratio, R as per equation

$$R = h/H$$

D.2.2.5 Repeat process as many times as there are legs on the stove (or four times for a circular base).
D.2.2.6 Apply the result to table D.2

Note If the stove is fixed in position it automatically gets the best rating.

Table D.2 — Scoring system for cookstove tipping test

Maximum ratio (R)	Rating	Score
≤ 0.940	Best	4
0.940<R≤ 0.961	Good	3
0.961<R≤ 0.978	Fair	2
R≥0.978	Poor	1

D.3 Containment of fuel test

This test provides a method for determining the likelihood for stoves to release burning fuel whether standing upright or after being overturned. Enclosure of the combustion chamber or fuel canister is important to restrict the uncontrolled movement of fuel during use.

D.3.1 Equipment

D.3.1.1 Fuel
D.3.1.2 Ruler / tape measure
D.3.1.3 bCookpot

D.3.2 Procedure

D.3.2.1 Stock the cookstove with fuel but do not ignite.
D.3.2.2 Place the cooking pot onto the cooking surface.
D.3.2.3 Visually observe the gaps through which fuel can be seen.
D.3.2.4 Measure these gaps to determine their approximate areas.
D.3.2.5 Calculate the sum of these approximate areas.
D.3.2.6 Use the summation of area, A, to find the rating according to Table D.3.

Table D.3 — Scoring system for containment of fuel test

Area exposed (A) (cm^2)	**Rating**	**Score**
A ≤ 50	Best	4
50 < A ≤ 150	Good	3
150 < A ≤ 250	Fair	2
A > 250	Poor	1

D.4 Obstructions near cooking surface test

D.4.1 Equipment

Ruler / tape measure

D.4.2 procedure

D.4.2.1 Inspect the cookstove for presence of the skirt (see Figure D.2); do not perform the test if skirt is present.

D.4.2.2 Measure height difference between the cooking surface and obstructions surrounding the cooking surface.

D.4.2.3 Use the largest height difference, D, to find the rating according to Table D.4

Note Stoves with skirts get good rating

Table D.4 — Scoring system for obstructions near cooking surface test

Maximum height difference (D) Cm	**Rating**	**Score**
D ≤ 1	Best	4
1 > D ≥ 2.5 or cook stove with skirt	Good	3
2.5 > D ≥ 4	Fair	2
D > 4	Poor	1

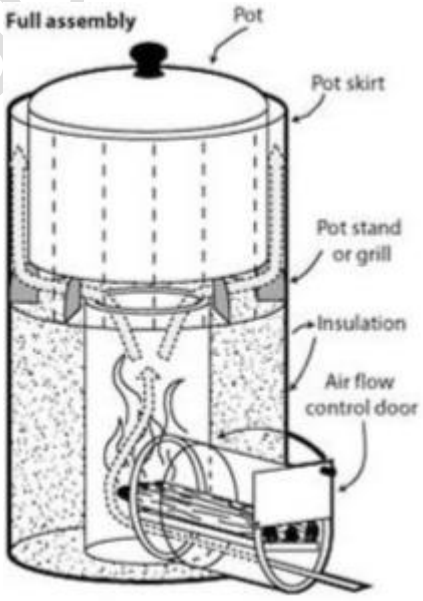

Figure D.2 - schematic diagram of a stove with a skirt

D.5 Surface temperature test

D.5.1 Introduction

This test is employed with the intention that burns should not occur if the cook stove surface is touched for a short duration. This short duration is the time it takes for the body to react after touching something warm.

D.5.2 Equipment

D.5.2.1 Fuel

D.5.2.2 Igniter

D.5.2.3 Chalk

D.5.2.4 Ruler/tape measure

D.5.2.5 Hand-held thermocouple

D.5.2.6 Cookpot

D.5.3 Procedure

D.5.3.1 Chalk 8 cm x 8 cm grid onto the cookstove. For horizontal marking the measurement shall start from the top of the cookstove.

D.5.3.2 Mark the grid intersections with a letter or number.

D.5.3.3 Operate the cookstove at full output for 1 h before starting the measurement of temperature, with the cooking pot containing water placed over it.

D.5.3.4 Measure ambient air temperature.

D.5.3.5 Measure and record temperature at grid intersections every after 10 min until a nearly constant surface temperature is attained.

D.5.3.6 Compute and record the temperature difference, T between air temperature and the highest recorded value of each intersection in D.5.3.5.

D.5.3.7 Use the maximum value of T in D.5.3.6 to find the rating according to Table D.5.

Table D.5 — Scoring system for surface temperature test

Difference between maximum temperature and air temperature (T)	Rating	Score
T ≤ 35	Best	4
35 < T ≤ 45	Good	3
45< T ≤ 50	Fair	2
T > 50	Poor	1

D.1.6 Heat transfer to the environment test

D.6.1 Equipment

Large amounts of heat transmission to surroundings may ignite combustibles or construction in the area of the cook stove. Therefore, cook stoves should not cause elevated temperatures on surrounding surfaces in the environment

D.6.2 Equipment

D.6.2.1 Fuel
D.6.2.2 Igniter
D.6.2.3 Chalk
D.6.2.4 Ruler/tape measure
D.6.2.5 Hand-held thermocouple

D.6.3 Procedure

D.6.3.1 This procedure is used if the cookstove is placed within 10 cm of a combustible or has a combustion chamber less than 5 cm in height from the ground. If the stove is located outside these bounds it receives a rating of Best.

NOTE For cookstoves that are designed to be attached to the floor or wall, the procedures of this test should be omitted. Instead the highest surface temperatures on the stove near where (5 cm from the wall or floor) it attaches to the ground or wall are used for evaluation in this test.

D.6.3.2 Place the cookstove in its normal operating location and orientation.

D.6.3.3 Sketch an outline of the cookstove on the ground when looking from above.

D.6.3.4 Sketch an outline of the cookstove on the wall while looking at the cookstove from the side, towards the wall.

D.6.3.5 Remove the cookstove and draw 8 cm x 8 cm approximate squares in a horizontal- vertical grid inside the outlines on the floor and wall.

D.6.3.6 Return the cookstove to its normal operating location and orientation.

D.6.3.7 Measure ambient air temperature.

D.6.3.8 Operate the cookstove at full output for 1 h before starting the measurement of temperature, with the cooking pot containing water placed over it

D.6.3.9 Move the cookstove away to take temperature measurements for up to one minute at grid intersections on the floor and the wall,

D.6.3.10 Return the cookstove for at least five minutes.

D.6.3.11 Compute the temperatures difference, t, of the wall or floor with that of the ambient air

D.6.3.12 Repeat steps D.6.3.6 and D.6.3.11 until all the grid intersections have been measured.

D.6.3.13 Use the maximum value of t in D.6.3.12 to find the rating according to Table D.6.

Table D.6 - Scoring system for heat transfer to the environment test

Surface	Difference between maximum temperature and air temperature *T*	Rating	Score
Floor	T ≤ 45	Best	4
	45 < T ≤ 55	Good	3
	55 < T ≤ 65	Fair	2
	T > 65	Poor	1
Wall	T ≤ 60	Best	4
	60 < T ≤ 70	Good	3
	70 < T ≤ 80	Fair	2
	T > 80	Poor	1

D.7 Handle temperature test

D.7.1 Equipment

D.7.1.1 Fuel
D.7.1.2 Igniter
D.7.1.3 Chalk
D.7.1.4 Ruler/tape measure
D.7.1.5 Hand-held thermocouple/infra-red thermometer
D.7.1.6 Cookpot of appropriate size according to manufacturer's instructions

D.7.2 Procedure

D.7.2.1 Operate the cookstove at full output for 1 h before starting the measurement of temperature, with the cooking pot containing water placed over it.
D.7.2.2 Measure ambient air temperature.
D.7.2.3 Measure and record the temperature of all the parts of cookstove which may be necessary to touch during its operation every after 10 min until equilibrium is reached.
NOTE While measuring the temperature the thermometer shall be covered with a felt pad or aluminium foil and kept in contact with that part for a sufficient period of time until the maximum temperature is reached.
D.7.2.4 Compute and record the temperature difference, T between air temperature and the recorded value in D.7.2.3.
D.7.2.5 Use the maximum value of T in D.7.2.4 to find the rating according to Table D.7.

Table D.7 — Scoring system for handle temperature test

Difference between maximum temperature and air temperature (T)	Rating	Score
T ≤ 32	Best	4
32 < T ≤ 38	Good	3
38 < T ≤ 44	Fair	2
T > 44	Poor	1

D.8 Chimney test

D.8.1 Chimneys can become extremely hot during use and easily cause burns. The high temperatures present on a chimney are from hot flue gases leaving the stove, often creating higher temperatures on the chimney than anywhere else on the stove.

D.8.2 The ambient air and chimney surface temperature shall be taken and assessed in accordance with D.5.

D.8.3 If a shield is being used, measure the average area, A, of the gaps.

D.8.4 Use the value obtained in D.8.3 to find the rating according to Table D.8.

Table D.8 — Scoring system for chimney shielding test

Hole area (A) (cm^2)	Rating*	Score
A ≤ 10	Best	4
10 < A ≤ 50	Good	3
50 < A ≤ 150	Fair	2
A > 150	Poor	1
***Stoves without a chimney are scored best**		

D.9 Flames surrounding cooking vessel test

During this test the stove shall be loaded with fuel and fully ablaze. The typical cookpot for the stove shall be placed in its normal operating position to simulate how the stove is most often used. Amounts of uncovered flames surrounding the cookpot shall be observed and applied to the metric given in Table D.9.

Table D.9 - Scoring system for flames surrounding cooking vessel test

Amount of uncovered flames touching cooking vessel	Rating	Score
None	Best	4
Less than 4 cm up the sides of cooking vessel, not handles	Good	3
Most of cooking vessel, not handles	Fair	2
Entire cooking vessel and/or handles	Poor	1

D.10 Flames exiting fuel chamber test

D.10.1 With the cookstove fully ablaze and a cooking pot on top, visually inspect the amount, if any, of flames coming out of the fuel chamber, canister, or pipes and record if flames do or do not protrude.

D.10.2 Rate the result according to Table D.10.

Table D.10 - Scoring system for flames exiting fuel chamber test

Occurrence	Rating	Score
Frames are contained	Best	4
Frames protrude	Poor	1

D.11 Overall safety score

To calculate the overall safety score, the score from each of the 10 procedures is multiplied by a weighting factor based on Table D.11, and then summed for a total score:

Table D.11 - Overall safety scoring system

Procedure	Parameter*	Weight
1	Sharp edges	1.5
2	Tipping	3
3	Containment of fuel	2.5
4	Obstructions near cooking surface	2
5	Surface temperature	2
6	Heat transfer to the environment	2.5
7	Handle temperature	2
8	Chimney	2.5
9	Flames surrounding cooking vessel	3
10	Flames exiting fuel chamber	4
**For any stove to pass the safety test, the minimum rating in each parameter shall be Good except for D.3, D.4 and D.8 which shall be at least fair.		

For procedures with multiple values, the minimum value is used to calculate the overall score. The total point score will be between 25 and 100.

ANNEX E

(NORMATIVE)

DURABILITY TESTS AND SCORING

E.1 Introduction

This test involves a simplified assessment of stove durability based on an inspection after thermal and safety tests as well as a quenching test.

E.2 Visual examination after thermal performance and safety tests

Durability assessment of the cook stove shall be made by inspecting its state after thermal performance, emissions and safety tests. These shall be compared to it's the state prior to testing. If durability test is to be conducted, without the other tests, then the stove shall be inspected after it has been in operation at maximum power for six hours with a cooking pot on top.

A detailed visual inspection of the cook stove shall be conducted, including documentation with photographs. Observations should be recorded on a data sheet. Whenever possible, a ruler should be included in photographs. Any signs of defects such as instability, discoloration, cracks, twisted metal, broken components, warping etc. shall be noted.

The scoring system for the quenching test is provided in, Table E.1.

Table E.1 - Scoring system for inspection

Level	Examples	Risk factor	Score
No Change	N/A	+0	10
Minor	Discoloration, minor abrasion, etc	+1	8
Mijor	Cracks < 2 cm in length, twisted metal, etc.	+3	4
Critical	Broken components, cracks > 2 cm in length, cloudy/hazy reflectors or glass, etc	+5	0

E.3 Quenching test

E.3.1 Equipment

E.3.1.1 Representative fuel enough for 5 h of operation

E.3.1.2 High temperature safety gloves and protective sleeves

E.3.1.3 Safety glasses

E.3.1.4 Cooking vessel with a diameter that is 20% less than the diameter of the cooking

E.3.1.5 Ruler

E.3.1.6 Water container or pitcher appropriate for pouring.

E.3.2 Procedure

E.3.2.1 Prior to testing, a detailed visual inspection of the cookstove should be conducted, including documentation with photographs. Observations should be recorded on a data sheet. Whenever possible, a ruler should be included in photographs, as a point of reference.
E.3.2.2 Fill a cooking vessel with water to within 10 mm of the brim. The cookstove should be run for 1 h. If cookstove power can be controlled, then the cookstove should be run at the maximum possible firepower.
E.3.2.3 Fill the pot to the brim and then quickly pour an additional amount of water into the cooking vessel, causing overflow of water into the cookstove.
E.3.2.4 Allow at least 16 h for the cookstove to dry completely.
E.3.2.5 Repeat steps E.3.2.2 to E.3.2.4 four times, for a total of five tests.
E.3.2.6 Post-testing observations and photographs should be taken and noted on the data sheet.
NOTE It is understood that some cookstove manufacturers specify the firepower for optimum performance. However, for this test the cookstove is operated at its maximum firepower, to model a worse- case scenario.
WARNING The tester should wear safety glasses, high temperature safety gloves and protective sleeves.
WARNING There is a risk of water overflowing the container and/or hot cookstove components. Extreme caution should be taken while conducting these tests.

E.3.3 Scoring

The scoring system for the quenching test is provided in Table E.2.

Table E.2 — Scoring system for quenching test

Level	Examples	Factor Score	Score
No change	N/A	+0	10
Minor	Discoloration or cracks < 2 cm in length	+1	8
Major	Warped components or cracks > 2 cm in length	+3	4
Critical	Broken or missing components, cloudy or hazy reflectors or glass, etc.	+5	0
NOTE The score is obtained by multiplying by 2 and subtracting the risk factor from 10. The formula used is 10 - 2 x (Risk factor)			

E.3.4 Overall durability score

To calculate the overall durability score, the score from each of the 2 procedures is multiplied by a weighting factor based on Table E.3, and then summed for a total score.

Table E.3 - Overall durability scoring system

Procedure	Weight
1	3
2	7

ANNEX F

(NORMATIVE)

FEATURES FOR VISUAL INSPECTION

Name and type of the stove:		Inspector:
Product identity:		Inspection site:
Manufacturer:		Date:
Feature	**Condition***	**Comment**
Cooking surface		
Liner		
Body (metal cladding)		
Handles		
Stands		
Pot rests		
Doors		
Air holes (if any)		
Combustion chamber		
Shelf		
Chimney		
Others		
* Condition shall either be G – Good, B – Broken, or C – Cracked/Scratched		