

# BIOMASS STOVE SAFETY PROTOCOL GUIDELINES

The process of designing stoves should include evaluation of safety. Seeing that there was no published standardized methodology for evaluating stove safety, Nathan Johnson developed standardized stove safety protocol for his Master of Science in Mechanical Engineering thesis work at Iowa State University in 2005. His thesis examined hazards associated with cookstove use and proposed a set of safety guidelines for the evaluation of injury risk.

In February, 2012 the International Standards Organization (ISO) International Workshop Agreement (IWA) mapped the stove safety protocol to the tiers of performance.

The Global Alliance for Clean Cookstoves is developing these guidelines and the stove safety entry form to facilitate conducting the stove safety protocol. The entry form was designed to allow testers to input the required measurements. Results for each procedure as well as a final safety result and tier are calculated automatically. Another goal for this data entry format is to facilitate the integration of testing results. Text and methods used for these documents came directly from the published thesis.

Below, guidelines for the ten safety evaluation procedures for household biofuel cookstoves are outlined. These guidelines are meant to be used in conjunction with the entry form which can be printed for use in the field or entered directly into the spreadsheet for automatic calculations. Simple equipment needed the procedures are also described.

## **Equipment Required:**

- Cookstove
- Cooking pot
- Fuel used with the stove
- Tape measure or ruler
- Calculator (optional- most calculations automatic if using the excel data entry sheet)
- Cloth, rag, or some form of loose clothing
- Chalk
- Thermometer
- Hand-held infrared (IR) thermocouple

## **1. SHARP EDGES AND POINTS**

**Overview:** Sharp edges and points present on a cookstove can cut flesh or entangle clothes and overturn the stove. Consequently exterior surfaces of a cookstove should not catch or tear any article of clothing or cut hands during normal use. The stove does not need to be lit for this evaluation.

**Equipment:** Cloth, rag, or loose clothing

**Procedure:**

Note: stone or clay stoves may provide resistance to the material being run over the surface, but this should not be deemed unsatisfactory unless the stove moves or the rag becomes completely snagged.

- a) Rub cloth gently over the entire exterior surface of the cookstove to find areas that catch or tear the cloth.
- b) Note number of times cloth catches / tears and write this value in the Entry Form under “Number of catches/tears” for Procedure 1. Take care to only count each snagging spot once.

## 2. COOKSTOVE TIPPING

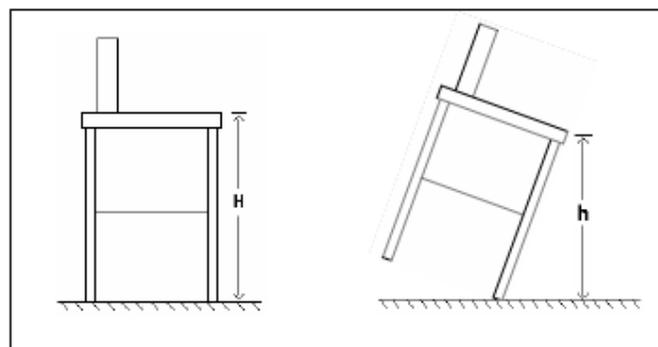
**Overview:** It is important that a cookstove be stable enough to maintain an upright orientation when in operation. Otherwise, burning or boiling contents could spill onto surrounding persons or materials. Therefore cookstoves should come back to rest upright after being slightly tipped from their regular resting position. Testing for this hazard is performed only if the cookstove is not considerably heavy nor secured to the ground or wall. The number of runs conducted is equal to the number of legs or corners on the base of the cookstove because it is not always clear where the center of gravity is located. If tipping toward the direction of a fuel entry point is not possible, avoid that direction and use multiple other tipping directions for the procedure. Measurements should be taken with care because the change in height may be small.

**Equipment:** Fuel, ruler/tape measure

**Procedure:**

Note: Write in “Best” rating for immobile stoves on the Entry Form for RESULT 2

- a) Set stove on flat surface and load with fuel but do not ignite.
- b) All cookstove covers and/or utensils are left in their normal positions during the Procedure.
- c) With the stove stable and upright, measure the height of the tallest point (in cm) on the side you will tip towards, place this value into “Starting Height” in the Entry Form for Procedure 2.
- d) Slowly tip cookstove to the chosen side until the stove is able to tip over on its own (when the center of gravity is directly above the point of contact with the ground).
- e) Hold stove tilted where it can overturn and measure the new height of the same point chosen in part ‘c’, place value into the Entry Form for “Tipped Height” for Procedure 2.
- f) Repeat process for as many runs as there are legs on the stove (or four times for a circular base) and record values in the Entry Form.



**Figure 1. Diagram of height measurements for Cookstove Tipping Procedure 2.**

Note: Starting Height (H) is measured prior to tilt, Tipped Height (h) is measured after tilt.

### 3. CONTAINMENT OF FUEL

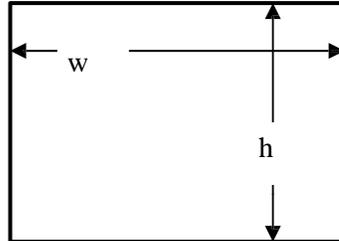
**Overview:** Burning fuel may be expelled from a combustion chamber or spilled when a stove becomes overturned. This can cause burns to the eyes and may also set fire to surrounding materials or construction. Therefore flaming fuel should rarely fall from the cookstove when it is overturned and embers/burning fuel should have little chance of being expelled from the combustion chamber.

**Equipment:** Fuel, cookpot, ruler / tape measure, calculator (optional)

**Procedure:**

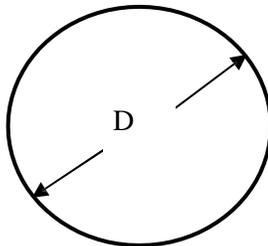
- a) The cookstove should still be stocked with fuel from the previous procedure but not ignited.
- b) Place a cookpot (one that is normally used with this stove) onto the burner surface.
- c) Visually inspect to find exposed areas that fuel can be seen through (often around the sides of the pot or through the fuel loading chamber)
- d) Measure the area of the Exposed Areas. If gaps are roughly square, you may enter one side length in the “cm” column of the Entry Form for Procedure 3 and the Area will be calculated automatically. If the gaps are not square, calculate the Area by using the formulas below. Choose the appropriate formula based on the shape of the gap. If you calculate the areas using the formulas below, enter them directly into “Area (cm)” column of the Entry Form for Procedure 3.

Square:



$$\text{Area} = w * h$$

Circle:



$$\text{Area} = \pi * D^2 / 4$$

where  $\pi = 3.1416$

### 4. OBSTRUCTIONS NEAR COOKING SURFACE

**Overview:** Areas surrounding the cooking surface should 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.

Typically, these obstructions include handles perpendicular to the griddle that are used for removing the cooking surface during cookstove maintenance. A ruler or tape measure is used to find the difference in height of the cooking surface to the height of any protrusions closely surrounding it.

**Equipment:** Ruler/ tape measure

**Procedure:**

Note: Write in “Good” for stoves with a skirt for RESULT 4.

- a) Inspect cookstove for skirt – pot sits partially into a near cylindrical extension to the combustion chamber. Do not perform if skirt is present. (write in “Good” for Result 4)
- b) Measure the “Height of Cooking Surface” and record Entry Form for Procedure 4.
- c) For each obstruction or protrusion closely surrounding the cooking surface, measure the “Height of Obstruction” in cm and record on the Entry Form for Procedure 4. (This can include small but solid obstructions such as handles perpendicular to the griddle)

**5. SURFACE TEMPERATURE;**

**6. HEAT TRANSFER TO THE ENVIRONMENT;**

**7. HANDLE TEMPERATURE**

**Overview:** For procedures 5, 6, and 7 the ambient air temperature (C°) is used as a reference point to allow comparison to the stove and surrounding area temperatures.

**Procedure 5** is employed with the intention that burns should not occur if the cookstove surface is touched for a short duration. The importance of this test is apparent since children have a tendency to touch cookstoves and women are likely to come into contact with stove surfaces during normal use. Since children are more sensitive to heat than adults, lower surfaces temperatures are suggested for heights within accidental touch of a child (0.9m or less). Conversely, adults are assumed to be susceptible to accidental contact at heights below that of 1.5m. Therefore heights above this are considered out of reach from accidental contact and are not tested. The most deficient rating based on material, temperature, and location is used to determine the likelihood for a person to avoid burns when touching a cookstove.

**Procedure 6** is employed with the knowledge that large amounts of heat transmission to surroundings may ignite combustibles or construction in the area of the cookstoves. Therefore cookstoves should not cause elevated temperatures on surrounding surfaces in the environment. The following procedures are 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”. Alternate procedures are provided for stoves that are designed to be attached to the floor or wall.

**Procedure 7** is meant to measure parts of the cookstove that need to be touched during regular operation. Temperatures should not reach a level where use can cause harm either directly or indirectly. Components where excessive temperatures may occur, yet need to be handled during regular use, include doors for combustion chambers and handles to regulate the flow of gas/liquid.

**Equipment:** Fuel, igniter, chalk, ruler/tape measure, hand-held thermocouple

**Procedure:**

Note: For Procedure 7: Stoves that do not have any components which need to be touched during stove use receive a rating of “Best” in this category. Write in “Best” for RESULT 7.

- a) Make sure the stove is shaded during the evaluation.
- b) Take air temperature and record on the Entry Form just under the “5. SURFACE TEMPERATURE” box.
- c) Chalk extra thick lines at 0.9m and 1.5m onto cookstove, if the stove reaches that height measured from the ground.
- d) Chalk 8 x 8 cm grid onto cookstove surface below the 0.9m line, and between the 0.9m and 1.5m lines if applicable.
- e) Chalk a grid within an outline of the cookstove on the floor if within 5 cm of undercarriage, and within an outline of cookstove onto the wall if it sits within 10 cm from the wall, while continuing the grid 16 cm higher up the wall above the top of the cookstove.
- f) Ignite fuel and wait until cookstove has reached max temp (~20 min) before proceeding, adding fuel when necessary.
- g) Take data temperatures using the thermocouple at each grid intersections:
- h) Start with the Wall and Floor measurements by moving the cookstove away to take measurements for up to one minute, then return the cookstove for at least five minutes, taking Surface temperature and Handle temperature while waiting. Repeat step “h” until all data points have been checked.
  - a. No more than one minute should transpire when taking data with the stove moved away from its original position. After the data taking period, the cookstove is placed back in its original position for a period of no less than three minutes to give time for surfaces to warm back up.
- i) If stove is mounted to floor or wall, take supplementary wall and floor temperatures by using cookstove surface temperature near where it attaches to floor and/or wall.
- j) Record each temperature in the Entry Form for their corresponding Surface (Below/ Above Child Line and Metallic or Non-Metallic), Floor and Wall, and Handle Temperature (Metallic or Non-Metallic) for Procedure 5, 6 and 7.
- k) Repeat h) through j) up to five times.

## 8. CHIMNEY SHIELDING

**Overview:** 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. To prevent these injuries, insulation can be placed around the chimney, or a cage may be utilized to “shield” people from accidental contact.

Testing for this hazard occurs in two steps. First, the ambient air and chimney surface temperature are taken and applied in Procedure 5 “Surface Temperature” to determine that safety rating. If that rating is unacceptable for the designer or user, a shield can be employed to increase safety from dangerous chimney contact. Procedure 8 then evaluates the chimney shield for the risk of contact. Since chimneys

are nearly always made from a uniform pattern for reduced cost, only one (largest if there are multiple) “gap” in the shielding needs be measured.

**Equipment:** ruler/ tape measure

**Procedure:**

(Note: Write in “Best” rating for stoves without chimneys for RESULT 8)

- a) If the chimney has no protective shielding, write the worst rating from RESULT 5 (Surface Temperature) in the RESULT 8 box.
- b) If the chimney has protective covering, inspect it for any open holes.
- c) Measure the area of any open holes or gaps in the chimney and record in the Entry Form. If the holes are in a square shape you can measure the length of the hole across and input that in “Hole Size (cm across)” box in the Entry Form. If the holes are other shapes, calculate the area using the formulas in Procedure 3 above and input in the “Hole Area (cm<sup>2</sup>)” box.

## 9. FLAMES SURROUNDING COOKPOT

**Overview:** Flames touching the cookpot should be concealed and not able to come into contact with hands or clothing. Large amounts of flames around the cookpot can easily ignite clothes or produce severe burns to the hands and other parts of the body.

**Equipment:** cookpot

**Procedure:**

- a) Keep cookstove fully ablaze from previous Procedures.
- b) Place cookpot into cooking position.
- c) Observe the amount of uncovered flames surrounding the cookpot and record a description in the observations box on the Entry Form. These should be based on the four possible descriptions for each rating given on the Entry Form.
- d) Cookstoves that fully enclose all flames (such as stoves that use a griddle) receive a rating of “Best” because there is no danger from a stray flame.
- e) Select the rating that most closely describes your observation in the drop down menu in the RESULT 9 box or write in.

## 10. FLAMES EXITING FUEL CHAMBER, CANISTER, OR PIPES

**Overview:** Flames or fuel should not protrude from any fuel loading area, storage container, or flow-pipes during use. Uncontrolled flames that exit these areas very easily ignite clothes and burn nearby children and adults. Furthermore, flames or fuel exiting fuel canisters or pipes, as with liquid/gas stoves, show fuel leaks and pose great risk.

**Equipment:** None

**Procedure:**

- a) Remove cookpot from stove.
- b) Keep cookstove fully ablaze from previous procedures.
- c) Visually inspect the amount, if any, of flames coming out of the fuel chamber, canister, or pipes.
- d) Record your observations of whether or not flames protrude in the Entry Form.
- e) Select the rating that most closely describes your observations in the RESULT 10 box. Rating “Poor” if you observe flames protruding and “Best” if flames are contained.