Controlled Cooking Test (CCT)

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(Not currently included in Shell HEH Stove Performance Protocols)

The controlled cooking test (CCT) is designed to assess the performance of the improved stove relative to the common or traditional stoves that the improved model is meant to replace. Stoves are compared as they perform a standard cooking task that is closer to the actual cooking that local people do every day. However, the tests are designed in a way that minimizes the influence of other factors and allows for the test conditions to be reproduced.

Equipment

The equipment required to conduct a series of CCTs is similar to the equipment required to perform the WBT. In addition, a sufficient quantity of food will be needed to conduct all of the tests. This is discussed in more detail below.

- **Fuel:** A homogeneous mix of air-dried fuel wood should be procured. Sufficient wood for all of the CCTs should be obtained ahead of time. Use local input to determine the quantity of fuel required to cook a "standard meal" on a traditional stove. Assume that each stove will be tested at least 3 times and allow for some margin of error. For example, if local people report that a standard meal requires ~2.5 kg of fuel wood and three stoves are to be tested, then the full range of tests will require

  $$2.5 \frac{\text{kg}}{\text{meal}} \text{ x } 3 \text{ stoves x } 3 \frac{\text{tests}}{\text{stove}} \text{ x } 2 \text{ .}$$

  The final factor of two is included to allow for aborted tests and other contingencies. This is roughly 45 kg of wood. As in the WBT, the fuel may be divided into pre-weighed bundles to save time during testing.

- **Food and water:** Testers should be sure they have sufficient food and water for the entire range of tests. Like fuel, the food should be homogenous so that variability in food does not bias the results of the test.

- **Cooking pot(s)**: if possible, use the standard pots supplied with the testing kits. If the standard pots do not fit one or more of the stoves being tested, use the most appropriate pots and be sure to record the specifications in the Data and Calculation form. If possible, the same

type (size, shape, and material) of pots should be used to test each stove. However, unlike the WBT, **lids should be used if local cooks commonly use them**.

- **Scale:** Supplied with testing kit: (at least 6 kg capacity and 1 gram accuracy): (see note in WBT section).
- Heat resistant pad to protect scale when weighing hot charcoal.
- Wood moisture meter
- Timer.
- Thermometer (this is only for recording ambient temperature – food temperatures are not recorded in this CCT).
- Small shovel/spatula to remove charcoal from stove for weighing.
- Dust pan for transferring charcoal.
- Metal tray to hold charcoal for weighing.
- Heat resistant gloves.

CCT testing procedure

The CCT described here is meant primarily to compare the performance of an improved stove to a traditional stove in a standardized cooking task. The procedure that follows should be applied to type of stove commonly in use in the community as well as the model or models of stove being promoted. Three repetitions of the CCT for each stove that is being compared are recommended.

Example of food used in a CCT (adapted from Baldwin, 1987, p. 94)

Dish	Ingredient	Quantity (g)
Porridge	water	4000
	Millet flour	1000
Sauce:	oil	100
	meat	450
	tomatoes	300
	water	2500
	onions	70
	spices	50

1. The first step in conducting the CCT is to consult with people in the location where the stove or stoves are going to be introduced in order to choose an appropriate cooking task. This should be done well ahead of time, to ensure that sufficient food can be obtained to conduct all of the necessary tests.

    - If the stove is designed for home use, then the task should be a typical meal consisting of foods that are regularly eaten in the community. It may include one or more dishes, though foods requiring complicated preparations should be avoided in the interest of time. In addition to the type of food, the testers and community participants must also decide on the precise quantity of food that is best representative of a typical family's meal. This is critical to ensure that tests are uniform. If local measures are used, the testers should convert this into standard

measurements and record these on the Data and Calculations form. The Box below shows an example of the food used for a CCT in West Africa (from Baldwin, 1987).

- If the stove is designed for specialized applications, for example making tortillas or chapati, then the cooking task requires less input and testers must simply decide on the exact amount of food on which to base the test.

- Once a cooking task has been decided on, ensure that sufficient food is available to conduct the tests.

2. After deciding on a cooking task, the procedure should be described in as much detail as possible and recorded in a way that both stove users and testers can understand and follow. This is important to ensure that the cooking task is performed identically on each stove. If possible, include an objective measure of when the meal is "done". In other words, it is preferable to define the end of the cooking task by an observable factor like "the skins come off the beans" rather than a subjective measure like "the sauce tastes right" (VITA, 1985, CCT Procedural note 2).

After sufficient ingredients and fuel have been obtained and the steps of the cooking task are written up and well understood by all participants, the actual testing can begin. **The cooking itself should be done by a local person who is familiar with both the meal that is being cooked and the operation of the stove to be tested.** If the stove is a new design that differs significantly from traditional cooking practices, some training will probably be required before conducting the actual tests.[1] When comparing stoves with the CCT, if more than one cook is used, each cook should test each stove the same number of times, in order to remove the cook as a potential source of bias in the tests. In addition, to ensure that the testers have control over the testing environment, the tests should be conducted in a controllable setting such as a lab or workshop rather than in a private home.

3. Record local conditions as instructed on the Data and Calculation form.

4. Weigh the predetermined ingredients and do all of the preparations (washing, peeling, cutting, etc) as described by the cooking directions recorded in step 2 above. To save time, for non-perishable food, the preparation can be done in bulk, so that food for all of the tests is prepared at once.

[1] Of course, if a great deal of training is required in order for a local user to "master" the use of the stove, then the stove-testers should probably reconsider that particular stove design.

5. Start with a pre-weighed bundle of fuel that is roughly double the amount that local people consider necessary to complete the cooking task. Record the weight in the appropriate place on the Data and Calculation form.

6. Starting with a cool stove, allow the cook(s) to light the fire in a way that reflects local practices. Start the timer and record the time on the Data and Calculation form.

7. While the cook performs the cooking task, record any relevant observations and comments that the cook makes (for example, difficulties that they encounter, excessive heat, smoke, instability of the stove or pot, etc).

8. When the task is finished, record the time in the Data and Calculation form (see the comments on determining when the task is complete in step 2 above).

9. Remove the pot(s) of food from the stove and weigh each pot with its food on the balance. Record the weight in grams on the Data and Calculation form.

10. Remove the unburned wood from the fire and extinguish it. Knock the charcoal from the ends of the unburned wood. Weigh the unburned wood from the stove with the remaining wood from the original bundle. Place all of the charcoal in the designated tray and weigh this too. Record both measurements on the Data and Calculation form.

11. The test is now complete – you may now enjoy the food that was cooked or proceed by testing the next stove – each stove should be tested at least 3 times.

Note: this procedure only requires the use of **one standardized cooking task**. However, stove testers are encouraged to develop a CCT for several different cooking tasks – particularly if the communities where the stove is being promoted cook meals that are equally popular, but differ significantly in their specific cooking requirements (for example, one task that involves slow boiling and another task that involves frying).

Analysis

After each test, transfer data from the Data and Calculation forms into the software. Once three tests for each stove are complete, the software provides a value of specific consumption and total cooking for each individual test as well as an average of three tests for each stove. Once CCTs for two stoves are completed, the software will compare the results and test for statistical significance. In addition, any qualitative observations made during each test should be noted. Each data form contains space for qualitative observations to be recorded and summarized on the "Results" page.

Analysis of the CCT

The calculations produced by the Data and Calculation form are somewhat more straightforward than the calculations for the WBT. They are explained in Appendix 5.

Appendix 5

Analysis of the CCT

Variables

As in the WBT, there are a number of variables that are directly measured. These include environmental variables and physical test parameters. The environmental variables may vary slightly from one test to another, but should be nearly constant. The physical test parameters should be constant for all tests.

Environmental variables:

Wind conditions

Air temperature

Physical test parameters:

Variable	Label
Avg dimensions of wood (centimeters)	--
Wood moisture content (% - wet basis)	m
Empty weight of Pot # 1 (grams)	P1
Empty weight of Pot # 2 (grams)	P2
Empty weight of Pot # 3 (grams)	P3
Empty weight of Pot # 4 (grams)	P4
Weight of container for char (grams)	k
Local boiling point of water (°C)	T_b

Measurements and Calculations

Upon finishing the test, a number of measurements are taken. These include:

Initial weight of fuelwood (wet basis) (grams)	f_i
Final weight of fuelwood (wet basis) (grams)	f_f
Weight of charcoal with container (grams)	c_c
The weight of each pot with cooked food (grams)	Pj_f (j is an index for the cooking pot ranging from 1–4 depending on the number of pots used for cooking)
Start and finish times of cooking (minutes)	t_i and t_f

These measurements are then used to calculate the following indicators of stove performance:

Total weight of food cooked (W_f) – this is the final weight of all food cooked; it is simply calculated by subtracting the weight of the empty pots from the pots and food after the cooking task is complete:

$$W_f = \sum_{j=1}^{4} (Pj_f - Pj)$$ where j is an index for each pot (up to four).

Weight of char remaining (Δc_c) – the mass of charcoal from within the stove, including the char removed from the ends of the unburned fuel that is extinguished just at the end of the cooking task. This is found by simple subtraction:

$$\Delta c_c = c_c - k$$

Equivalent dry wood consumed (f_d) – This is defined as for the WBT, adjusting for the amount of wood that was burned in order to account for two factors: (1) the wood that must be burned in order to vaporize moisture in the wood and (2) the amount of char remaining unburned after the cooking task is complete. The calculation is done in the following way:

$$f_d = (f_f - f_i) * (1 - (1.12 * m)) - 1.5 * \Delta c_c$$

Specific fuel consumption (SC) – This is the principal indicator of stove performance for the CCT. It tells the tester the quantity of fuel required to cook a given amount of food for the "standard cooking task". It is calculated as a simple ratio of fuel to food:

$$SC = \frac{f_d}{W_f} * 1000$$

Notice this is reported in grams of fuel per *kilogram* food cooked, whereas W_f is reported in *grams*. Thus a factor of 1000 is included in the calculation.

Total cooking time (Δt) – This is also an important indicator of stove performance in the CCT. Depending on local conditions and individual preferences, stove users may value this indicator more or less than the fuel consumption indicator. This is calculated as a simple clock difference:

$$\Delta t = t_f - t_i$$