

Updated Water Boiling Test (WBT)

This test provides the stove designer with reliable information about the performance of wood burning stove models. The test consists of three phases that determine the stove's ability to:

- (1) bring water to a boil from a cold start;
- (2) bring water to a boil when the stove is hot; and,
- (3) maintain the water at simmering temperatures.

It is used to evaluate a series of stoves as they are being developed. The test cannot be used to compare stoves from different places because the different pots and wood used change the results.

The test is a simplified version of the University of California Berkeley (UCB)/Shell Foundation revision of the 1985 VITA International Standard Water Boiling Test. The wood used for boiling and simmering, and the time to boil are found by simple subtraction. All calculation can be done by hand in the field.

By using a standard pot, taking into account the moisture content of the wood, steam generated and other factors the complete UCB/Shell Foundation Water Boiling Test makes comparison of stoves from different places possible.

Before starting the tests...

1. **Collect at least 30 kg of air-dried fuel for each stove to be tested in order to ensure that there is enough fuel to complete three tests for each stove. Massive multi-pot stoves may require more fuel. Use equally dry wood that is the same size. Do not use green wood.**

2. Put 5 liters of water in the testing pot and bring it to a rolling boil. Make sure that the fire is very powerful, and that the water is furiously boiling! Use an accurate digital thermometer, accurate to 1/10 of a degree, to measure the local boiling temperature. Put the thermometer probe in the center of the testing pot, 5 cm above the pot bottom. **Record** the local boiling point on the data sheet (see page 34).

3. Do the tests in a place that is completely protected from the wind.
4. Record all results on the data sheet.

Equipment used for the In Field Water Boiling Test:

- Scale of at least 6 kg capacity and 1 gram accuracy
- Heat resistant pad to protect scale
- Digital thermometer, accurate to 1/10 of a degree, with thermocouple probes that can be in liquids
- Timer
- Testing pot(s)
- Wood fixture for holding thermometer probe in water
- Small shovel/spatula to remove charcoal from stove
- Tongs for handling charcoal
- Dust pan for transferring charcoal
- Metal tray to hold charcoal for weighing
- Heat resistant gloves
- 3 bundles of air-dried fuel wood. One, used for simmering, weighs around 5 kgs. The other two bundles, used for cold and hot start boiling, weigh about 2 kgs each.

Beginning of Test

- a. **Record** the air temperature.
- b. **Record** weight of commonly used pot without lid. If more than one pot is used, record the weight of each pot. If the weights differ, be sure not to confuse the pots as the test proceeds. **Do not use pot lids** for this, or any other phase of the WBT.
- c. **Record** weight of container for charcoal.
- d. Prepare 2 bundles of fuel wood that weigh about 2 kgs each for the cold and hot start high power tests. Prepare 1 bundle of fuel wood that weighs about 5 kgs to be used in the simmering test. Use sticks of wood roughly the same size for all tests. **Record** approximate dimensions of the fuel wood. Weigh and **Record** weights in spaces marked # on the attached data sheet. Identify each bundle and keep them separate.

High Power (Cold Start) Phase:

The stove should be at room temperature.

1. Fill each pot with 5 L of clean water (-20°). **Record** the weight of pot(s) plus the water.
2. Using the wooden fixtures, place a thermometer probe in each pot so that water temperature may be measured in the center, 5 cm from the bottom. Make sure a digital thermometer is used. **Record** water temperatures.
3. **Record** the weight of the starting materials. Always use the same amount and material.
4. Start the fire using the wood from the first 2 kg bundle.
5. Once the fire has caught, start the timer and **Record** "0". If using a watch **Record** the starting time. Bring the first pot rapidly to a boil without being excessively wasteful of fuel.

6. When the water in the first pot reaches the local boiling temperature as shown by the digital thermometer, rapidly do the following:
 - a. **Record** the time at which the water in the primary pot (Pot # 1) reaches the local boiling point of water. **Record** the water temperature for other pots as well.
 - b. Remove all wood from the stove and put out the flames. Knock all loose charcoal from the ends of the wood into the tray for weighing charcoal.
 - c. Weigh the unburned wood from the stove together with the remaining wood from the pre-weighed bundle. **Record** the result.
 - d. Weigh each pot, with its water. **Record** weight.
 - e. Remove all the charcoal from the stove, place it with the charcoal that was knocked off the sticks and weigh it. **Record** the weight of the charcoal and container.

This completes the high power (cold start) phase. Continue without pause to the high power (hot start) portion of the test. Do not allow the stove to cool.

High Power (Hot Start) Phase

1. Refill the pot(s) with 5 L of fresh cold water. Weigh pot(s) (with water) and measure the initial water temperatures; **Record** both measurements.
2. Start the fire using kindling and wood from the second 2 kg bundle. **Record** weight of any additional starting materials.
3. **Record** the time when the fire starts and bring the first pot rapidly to a boil without being excessively wasteful of fuel.
4. **Record** the time at which the first pot reaches the local boiling point. **Record** the temperature of all pots.

5. After reaching the boiling temperature, rapidly do the following:
 - a. Remove all wood from the stove and knock off any loose charcoal into the charcoal container. Weigh the wood removed from the stove, together with the unused wood from the second bundle. **Record** the result.
 - b. Weigh each pot, with its water and **Record** these weights.
6. Leave the charcoal in the stove as you continue quickly into the simmering test.

Without pause, proceed directly with the simmering test.

Low Power (Simmering) Test

This phase is designed to test the ability of the stove to simmer water using as little wood as possible.

The boiling water is quickly replaced on the stove and the fire is rekindled using the charcoal and fresh wood. Then the water is simmered for 45 minutes at about 3 degrees below boiling.

Only the primary pot will be tested for simmering performance.

Start of Low Power test:

1. **Record** the weight of the new bundle of fuel.
2. While the water is still near boiling, weigh the pot (with water). **Record** weight. **Record** temperature.
3. Rekindle the fire using kindling and wood from the weighed bundle. **Record** the weight of any additional starting materials. Replace the pot on the stove and **Record** the start time when the fire starts.

It is Ok if the simmering temperature varies up and down, but

1. **The tester must try to keep the simmering water as close as possible to 3 degrees C below the local boiling point.**
 2. **The test is invalid if the temperature in the pot drops more than 6 degrees C below the boiling temperature.**
 3. **The tester should not further split the wood into smaller pieces to try to reduce power.**
4. **Record** the time. For the next 45 minutes maintain the fire at a level that keeps the water temperature as close as possible to 3°C below the boiling point.
 5. After 45 minutes rapidly do the following:
 - a. **Record** the finish time of the test (this should be 45 minutes).
 - b. **Record** the temperature of the water at end of test.
 - c. Remove all wood from the stove and knock any loose charcoal into the charcoal weighing pan. Weigh the remaining wood, including the unused wood from the preweighed bundle. **Record** the weight of wood.
 - d. Weigh the pot with the remaining water. **Record** the weight.
 - e. Extract all remaining charcoal from the stove and weigh it (including charcoal which was knocked off the sticks). **Record** the weight of pan plus charcoal.

This completes the full water boiling test. The full test should be done at least three times for each stove for accurate results.