Appendix B
Test information

NOTES AND COMMENTS REGARDING EQUIPMENT AND INSULATION

Pots: We were using a pot covered with a blue enamel coating. This coating comes off easily and it can be assumed that in the daily use that it would also come off, potentially being consumed via the food. This pot was chosen because the handle would fold down and fit in the RHC easily.

A stainless steel pot is also available but the ones that were readily available had handles that did not fit well into a box. The handles were removed from this stainless steel pot that was in the warehouse and tested. There are several advantages to using this pot over the enamel covered pot; less expensive in financial cost, would not oxidize or lose a covering, easy to clean. The stainless steel pots are more desirable although they need to be manufactured in such a way that the handles and pot fit easily into a RHC.

Insulation: Various types of insulation were used including Styrofoam, a radiant barrier purchased in the USA, a similar product used (and available) here in Guatemala to protect the interior of cars from the sun, tuza leaves, tamal leaves, pressed wool blankets, and foam rubber (esponja) sheets. These materials varied in R-value and thickness. It is preferred to use a material that has a good insulating value, is as thin as possible, inexpensive, and readily available. Another product that could be used that fits those categories is lamb's wool.

Inner box: The inner box is an important design issue. It should be easy to clean, air tight, leak proof to prevent moisture from passing into the insulation, lightweight and inexpensive. Plastic containers work well in all categories although are not as environmentally friendly in the long term. An appropriate model, such as a garbage can or pail, may also be presently available which would keep cost low and eliminate any plastic injection initial costs.

The metal tubes that were constructed for this testing also work well but will likely oxidize over time as they are subject to moisture. There were two designs for the top and the cover that fit *into* the tube versus the cover that fit *over* the tube was a much better air tight fit. They were also inexpensive to have made.

If a similar tube could be made with aluminum it would reduce the mass. Aluminum plates are often available for low cost from printers as the plates are no longer used after the printing process. This material is easy to work, cheap in cost and easy to clean.

Outer box: The outer box can be of any material that will support the insulation between the two boxes. For this testing, we used a cardboard box, a box constructed of thin plywood, a half metal barrel, and plastic containers including a 5 gallon pail.

An outer box that is square in shape needs to have the corner spaces between the round inner box and the outer box filled with some type of material. If a round outer box is

used, then there are no corner spaces and this is not an issue. A round outer box is therefore preferred for this reason.

RECOMMENDATIONS

1. Take results of this week testing and design a RHC that will keep the inner contents to a temperature of not less than 80° C. after three hours.
2. Include at least a small amount of beans in *all* tests that run for 3 hours in the RHC.
3. Test stoves that performed well more than once to compare results.
4. Perform this test on the suggested RHCs mentioned above.
5. Perform tests in (or simulate) higher altitude areas and with beans that considered hard to cook.
6. Search for materials that appropriate for a RHC design that are easily accessible in Guatemala, work well based on the insulation and air tightness qualities, are easy to clean and care for, are reasonable in cost and are appropriate for the environment.

TESTING THE RETAINED HEAT COOKER

HARDWARE USED
5.8 liter enameled pot
Thermos Shuttle Chef
PICO TC08 data logger
Type K thermocouples
Electric hot plate
Scale
Inner linings (custom built)
Plastic buckets
Turkey bag

INSULATION TESTED
Cardboard
Styrofoam
Rubber foam
Radiant Barrier
Tuza & tamal leaves

PROCEDURE

1. Weigh the contents in the pot. Record on data sheet.
2. Start the PICO test.

3. Bring the contents of the pot to a full boil. Record the time and temperature on data sheet. When heating water with beans, note the duration of the boiling time.
4. Note the time the pot is taken off the heat source. Write on data sheet the time.
5. Put the pot in the Retained Heat Cooker (RHC).
6. Note the temperature and time (on data sheet) when the pot is in the cooker and the RHC is completely closed. Record the amount of time it takes to get the pot into the cooker.
7. Use a data logger (such as the PICO) to measure the temperatures. If a data logger is not being used, measure temperature and note time manually for set intervals for a minimum of two hours.
8. Remove the pot from the RHC.
9. Measure and record the amount of water left in the pot.

NOTES AND SPECIFICS OF EACH TEST

Results

DESCRIPTION	NAME	Minutes 90.0	Minutes 120.0	Minutes 150.0
rbcb2 with corners plugged with wool	rbcb3	89.83	87.95	86.08
same as above	rbcb3log2	88.97	87.26	85.67
Thermos Shuttle Chef bought in USA	termus	88.87	86.77	85.14
foam around plastic bucket	foam1	87.7	85.99	84.45
rbcb1 with lid	rbcb2	87.68	85.87	84.29
foam1+polyester	foam2	87.7	86.08	84.05
same as above	foam2log2	87.29	85.48	83.81
10 cm Styrofoam	st1	86.61	84.69	82.96
tuza and tamal in nixtamal bucket	tuza11	85.82	83.71	81.76
US radiant barrier	rb1	85.97	83.41	81.02
pail around grb3	pail1	84.04	81.82	79.8
Guate. rb 3layer	grb3	85.04	82.13	78.92
st1 with corners filled	st2	87.89	86.18	
rb1 in rb box	rbcb1	87.67	85.58	
plastic surrounded by tuza	tuza10	82.97		

Yellow highlighted tests were done previously.

TEST RB1log1

Insulation and equipment: Radiant barrier only, the type purchased in the USA and brought to Guatemala. RB1 was constructed of a metal tube A fabricated at a metal shop to fit a 5.8 liter metal, enameled pot that was purchased from the market. The metal tube represents the inner box and was fitted with a friction fit cover to the inside. The metal tube was insulated with a radiant barrier which was purchased in the USA, has an estimated R-value of R8, and is approximately 1 cm thick. It is similar in design to a product used in cars to protect the sun from entering the windshield and protect the interior. The top of the pot was insulated with two layers of foam rubber (esponja), each layer 5 cm thick. R-value for foam rubber is unknown. See photo of insulated tube.

In this test, the sensor that was attached to the side of the pot unknowingly came detached from the pot and therefore resulted in very strange readings compared with past tests.

TEST RBCB1

Insulation: radiant barrier described above plus cardboard. RBCB1is exactly as the metal tube described above and placed in a box with the four sides and bottom insulated with 5 cm of cardboard. Cardboard sheets were cut and stacked on each other to a thickness of approximately 5 cm. No cover was added and nothing was installed in the

four gaps that create a triangular open space at each of the corners. The outer box was constructed of ¼" particle board with minimal R-value. See photo.
log1
Problems with grounding this log didn't get to the RHC
log2
Test used this log.

TEST RBCB2
Insulation and equipment: same as RBCB1 but with a foam rubber cover placed over the top of the box to cover the triangular shaped openings. The openings were left empty with no insulation added. The foam rubber is 5 cm thick, exact R-value unknown. This is also the third layer of foam rubber over the top of the metal tube (15 cm in total).

TEST RBCB3
Insulation and equipment: same as RBCB2 but the corners were filled with pressed wool blanket material. In this test, beans were cooked. The beans were soaked overnight. This was done in Pot A (two tests were run simultaneously). The beans weighed 983 grams dry and 2058 grams wet when weighed the next day. The total weight of the pot, cover, beans and extra water was 5920 grams.

Beans transferred at 1620 in the RHC at 1700. The temperature on the thermocouple was 94 C, however it was boiling (the thermocouple was sitting on the beans). Beans boiled over and therefore the beans were not boiled for any length of time as is suggested when cooking beans.

Opening time was 10900.

RESULTS: The pot was opened after 2.5 hours with a temperature of 86 C. The Guatemalan team from Santa Avelina was here to observe the opening and the beans were almost done but not quite fully. They agreed that the type of bean we used was a hard bean.

TEST CB1
Insulation and equipment: Metal tube A in cardboard box made of plywood, corners filled pressed wool. The metal tube has *no radiant barrier* on the outer side of the tube, that is no tapasol (de Guatemala) or no USA purchased radiant barrier material. Beans included in the test.

REPEAT OF RBCB3 (LOG 2)
Insulation and equipment used: Same as previous RBCB3 but no beans included in this test.

TEST GRB3
Insulation and equipment: Similar to RB1 but the radiant barrier was comprised of a material that is available in Guatemala. Metal tube A with 3 layers of tapasol, the

Guatemalan purchased radiant barrier on the top, sides and bottom. A small amount of beans were also included in this test.

During the test, we had a grounding problem but it was all before the pot went into the RHC so does not affect the curve of the test.

There was a noticeable difference in the bean results between FOAM1 and GRB3. The beans from this test were not completely cooked and were less done than the previous test. Some of the beans could be split in two whole parts.

TEST ST1
Insulation and equipment: Inner part was metal tube B, surrounded by 5 cm of Styrofoam insulation on the bottom and all sides. The corners were filled with the part of the corn plant that covers the grains (tuza). The metal top B is closed with two layers of foam rubber, each 5 cm thick and a metal top B that fits *over* the flanged top. The two layers of foam represented insulation between the pot and the metal cover. There was no insulation between the metal top and the closed cardboard box. In other words, the metal top was visible. It was noted that this could be a heat loss area. As a PICO probe was not installed on this part of the pot, another thermocouple was used. At 6700 seconds, the temperature read 48 C. indicating that there was heat loss in this area. The outer box is a double layered cardboard box.

Another aspect of this test is that the metal tube is larger in diameter than the RBCB metal tube. The gap between the pot is also larger, perhaps 3 cm versus 1 cm.

This was a water test only, no beans were cooked as it was the first test done with a new pot and it was recommended that it be heated prior to use for food.

TEST ST2
Insulation and equipment: Same as ST1 but the pot was placed in a heat resistant turkey bag.

TEST TUZA10
Insulation and equipment: Thermos pot (purchased in the USA) inside a Penta Pure filter plastic pail for an inner box and with tuza insulation in between another plastic pail. Between the plastic buckets there was a 5 cm gap on the upper sides, 4 cm gap on the lower side portion, 7 cm on the bottom and 6 cm on the top.

FOAM1
Insulation and equipment: Penta Pure filter white pail inside the plastic blue garbage bin with 5 cm of foam rubber on the sides and top, with 2 cm of pressed wool on the bottom. The pot was the Thermos brand pot. No radiant barrier. Beans were also included in this test.

During the test, we had a grounding problem but it was all before the pot went into the RHC so does not affect the curve of the test.

The beans were almost all the way cooked after 2.5 hours, however all office staff noted that they were not quite done. Falta poco.

TEST FOAM2 (Log 1)
Insulation and equipment: FOAM1 + Mylar radiant barrier that Richard brought. Thermos brand pot used. Beans included in test. Opened after 2.5 hours. Beans were close but not completely cooked. Some beans could still distinguish the two parts as whole.

TEST FOAM2 (Log 2)
Insulation and equipment: FOAM2 with beans and left overnight to determine if a longer RHC time would cook the beans thoroughly.

REPEAT OF RBCB3 (LOG 2)
Insulation and equipment used: Same as previous RBCB3. 300g of beans were included in the total weight of 5509.