**The European Union "Consultancy for Capacity Building for Habitat Improvement in the Hindu Kush" Programme**

Tajikistan/Gorno Badakshan Autonomous Oblast (GBAO), Pakistan /Northern Areas (NA) and Chitral District (NWFP)

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# Technical Working Paper ~ Number 20a

# How to Make a Thin Heat Retention Bag (Size 45 cm)


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***Abstract***

How to make a Heat Retention Bag (HRB) based on thermal insulation using two metalized reflective foils separated by fibrefill or quilting batting. The HRB can be stored flat (5 cm), taking up little kitchen space. The thermal insulation value is approximately $R_c$ = 2.0 $m^2$.K/W, being similar to 8 cm of Expanded Polystyrene (EPS). The 45 cm HRB can be used for a 4-litre cooking pot or a small pressure cooker. With a starting temperature of 100°C and a 3.5 kg mass (pot and contents), a cooking temperature of above 70°C will be maintained for approximately three hours. A 6-litre pressure cooker with water having a 6.6 kg mass and a temperature above 105°C will stay above the cooking temperature (70°C) for four hours.

***Key words:*** **hay box, heat retention bag, flat storage**

***Cover Page Photo***

*Heat Retention Bag with 4-litre pressure cooker.*
*The bag is made wide to fit a pressure cooker with a long handle.*
*The HRB closes with a plastic zipper and has a flap covering the zipper zone.*
*The hot pot stands on a thin wooden support inside the HRB.*

# INTRODUCTION

The house improvements for the Capacity Building for Habitat Improvement in de Hindu Kush (HIHK) project are focussed around the theme of health improvements. These are obtained through thermal insulation, improved water supply and better sanitation. Making the buildings more comfortable and reducing Internal Air Pollution (IAP) are important aspects linked to thermal insulation. The HIHK project is based on exchanging the best experiences in house improvements to improve the life of other people living in similar and often remote mountain regions.

The Technical Working Papers are a collection of experiences from 10 years of BACIP project development and implementation and provide practical information on how to realise beneficial solutions for the inhabitants of the mountain regions of the Himalayas.

> *The Building and Construction Improvement Programme (BACIP) finds appropriate solutions taking into consideration the local economy of its clients and entrepreneurs, as well as the available skills, tools, materials and other resources, to create affordable products to improve living conditions and livelihood.*

This Technical Working Paper #20a provides an example for making a 5 cm thin Heat Retention Bag (HRB) from reflective foils and other materials. This design was explained during cooking exercises of local rice and potato-based dishes, demonstrating that with the use of a pressure cooker and the HRB, up to 90% of the cooking energy could be saved. Without using a pressure cooker, the energy savings could still be as large as 75 to 80%.

The objective is to develop this paper further during the current HIHK project with more variations of the design and different source materials. There are many design possibilities, but good thermal insulation is the key factor for continued cooking when the cooking pot is taken off the heat source. Eventually this paper can be used for developing a curriculum in the field of cooking and energy saving.

Additional technical working papers will cover the various types of thermal insulation and technical details of the most efficient types of construction, taking into consideration cost, available local materials and level of skills.

This paper covers the general idea on how to make a thermal insulation bag for cooking:

- The bag must perform well and keep food at slow cooking temperature (70°C) for over three hours.
- The design must be easy to manufacture using local materials.
- The bag must be easy to operate with reference to inserting the pot into the bag.
- When not in use, the bag can be stored away flat, requiring little space.
- When used, it should look nice in the kitchen.

As a sequel to the capacity building of the project's core staff by the technical adviser, the project staff has to train Village Resource Persons (VRPs), such as community leaders, traders, salespersons and contractors, who will then be responsible for providing information to the clients (villagers). Only when local artisans make them and the villagers buy the house improvements without the need for intensive promotion by the project, can the HIHK project be considered a success.

# 1. LIST OF MATERIALS

The following materials are needed for making a Heat Retention Bag (HRB) measuring 45 cm x 60 cm. This will fit a 3.5 litre cooking pot measuring 20-22 cm in diameter and 16 cm in height, including the lid.

The depth of the bag should be minimum the diameter plus 1.5 times the pot height. The cooking pot can have handles on both sides or one large handle. A depth of 45 cm fits a cooking pot with a vertical circumference of maximum 90 cm. When the cooking pot is larger, the depth of the HRB must be larger; for example:

HRB 50 cm x 60 cm = 50 cm deep for a pot with Ø 24 cm and 17 cm high (6-7 litre).
HRB 60 cm x 60 cm = 60 cm deep for a pot with Ø 26 cm and 22 cm high (10 litre).

The size of HRB purchased/made should be based on the largest cooking pot most used.

**Materials Required for HRB**

- Decorative fabric for outer cover
- Muslin (unbleached pure cotton) for lining[1]
- Quilting (insulation) batting (1 cm thick)
- Reflective foil[2]
- Zipper (fully separating, largest teeth)
- Sewing thread
- Buttons (can make yourself)
- String or rope

*Quilting Batting*

**Material Required for Stand**

- Wooden or bamboo sticks (Ø 1 cm)
- Galvanised wire (1 mm) or nine (plasticized) paper clips
- Cellophane (scotch) tape

**Tools Required**

- Sewing machine (if unavailable, sewing by hand is possible)
- Scissors
- Measuring tape
- Sewing needle
- Straight pins
- Clothes pegs (12) to hold layers temporarily in place
- Pliers to twist the galvanised wire

Larger size bags may be more practical for most households because more pot sizes can fit into it and the thermal insulation value remains the same.

[1] The lining material may not contain plastic or other synthetic fibres as these may melt against the boiling hot cooking pot.
[2] The reflective foil is aluminum metalized plastic, such as used for packaging potato chips and chocolate, with a thickness of about 0.01 mm. Polyethylene foils are the best types. The shiny metalized surface reflects the infrared radiation. This works when there is a thin air space (5-7 mm) in front of the reflective side. The airy quilting insulation in the HRB functions as the air layer. Other materials are possible, but dense materials must be avoided because they block the radiation. The most reflective side must be towards the heat source, the inside. Aluminum foil will eventually break with a lot of handling and therefore is less suitable.

# 2. HOW TO MAKE A HEAT RETENTION BAG (HRB)

## 2.1 HRB SIZES – DIMENSIONS

The instructions are for making a 45 cm x 60 cm HRB. For other sizes, refer to the following chart. The letters (A through E) refer to the diagrams on the following pages.

| Volume Pot | 3-4 Litre Ø22 x 15 | 6-7 litre Ø24 x 17 | 9-10 litre Ø26 x 22 |
|---|---|---|---|
| Outside Bag Size | 45 x 60 | 50 x 60 | 60 x 60 |
| A | 64 cm | 64 cm | 64 cm |
| B | 115 cm | 125 cm | 145 cm |
| C | 45 cm | 50 cm | 60 cm |
| D | 120 cm | 130 cm | 150 cm |
| E | 47.5 cm | 52.5 cm | 62.5 cm |
| Outer Cover | 120 x 64 | 130 x 64 | 150 x 64 |
| Muslin | 115 x 64 | 125 x 64 | 145 x 64 |
| 2 x Quilting Batting | 110 x 70 | 120 x 70 | 140 x 70 |
| 2 x Reflective Foil | 110 x 70 | 120 x 70 | 140 x 70 |
| Zipper | 62 cm | 62 cm | 62 cm |

## 2.2 MATERIALS – TOOLS

Materials

- Decorative fabric for outer over – 120 cm x 64 cm
- Muslin (unbleached pure cotton) for lining – 115 cm x 64 cm
- Quilting (insulation) batting (1 cm thick) – 115 cm x 70 cm (2 pieces)
- Reflective foil – 110 cm x 70 cm (2 pieces)
- Zipper – 62 cm (fully separating, largest teeth)
- Sewing thread
- Buttons – 2 large, 4-5 cm (can make yourself)
- String or rope (3-5 mm thick) – 50 cm long (2 pieces)

Tools

- Sewing machine (if unavailable, sewing by hand is possible)
- Scissors
- Measuring tape
- Sewing needle
- Straight pins
- Clothes pegs (12) to hold layers temporarily in place

## 2.3 INSTRUCTIONS

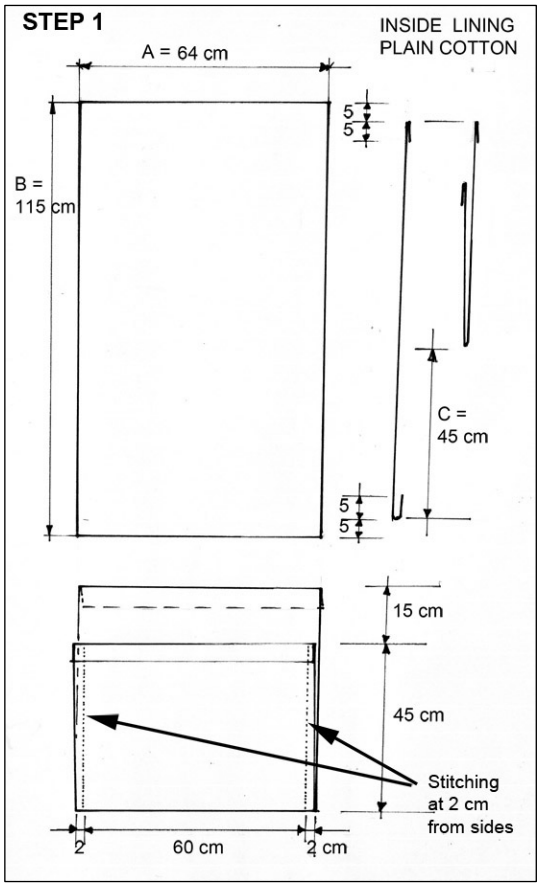
Lining (Step 1)

(1) Cut the muslin (unbleached cotton) to the indicated size.

(2) Fold and iron each 64 cm end for 5 cm – wrong sides together.

(3) Fold one end upwards, right sides together, until it measures 45 cm. The single fabric end (flap) will measure 15 cm.

(4) Stitch a 2 cm wide seam on each side, up to the opening fold, making an envelope.




Decorative Outer Cover (Step 2)

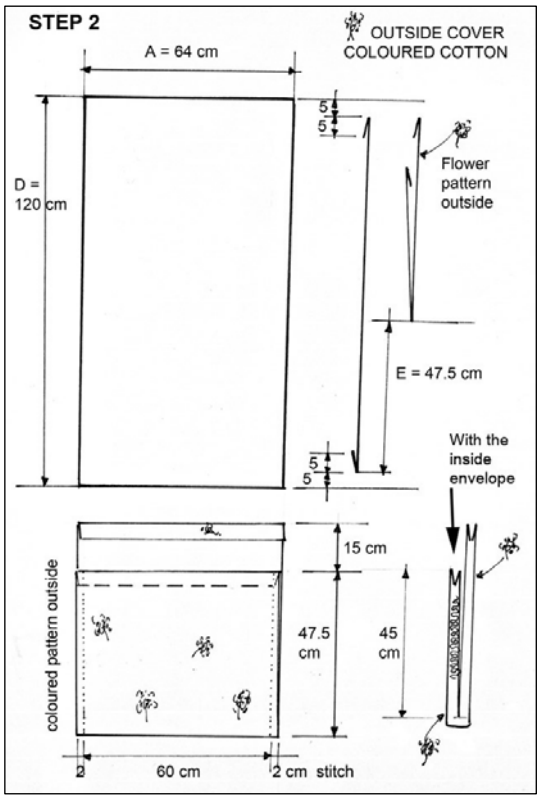
(5) Cut the decorative outer cover fabric to the indicated size.

(6) Fold and iron each 64 cm end for 5 cm – wrong sides together.

Insulation Material

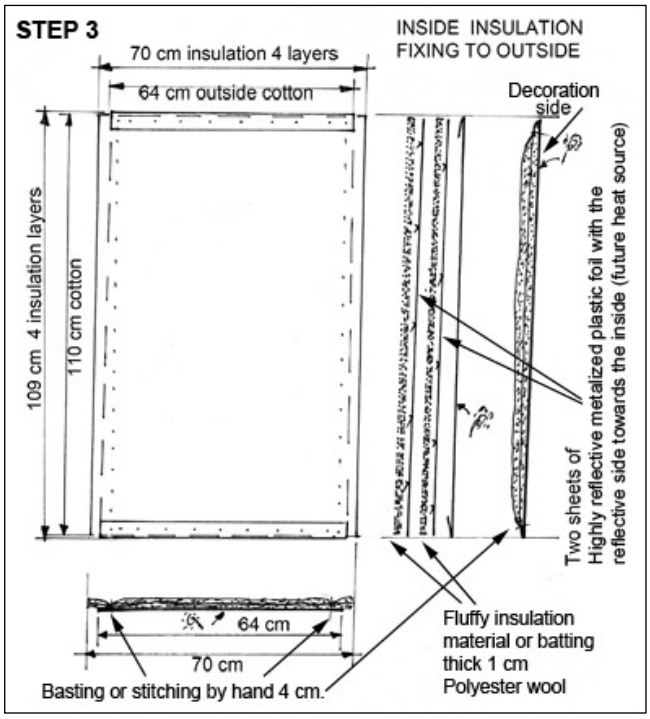
(7) Cut 2 pieces of reflective foil to the indicated size. The reflective foil is 6 cm wider than the outer cover fabric and fits under the 5 cm folds at the ends to reduce bulk.

(8) Cut 2 pieces of quilting batting to the indicated size.



Assembly (Step 3)


*The assembly order:*
*outer cover fabric, foil one, batting, foil two, batting and lining.*




(9) Lay the outer cover fabric (wrong side facing upwards) on a flat surface.

(10) Assemble the layers as follows, fitting them under the folded ends of the outer cover fabric:
- Reflective foil (reflective side facing upwards)
- Quilting batting
- Second reflective foil (reflective side facing upwards)
- Second quilting batting

(11) Hold the 5 layers together in position using clothes pegs and baste with long stitches (by hand) to hold all the layers together. This will make it easier to machine stitch. Remove the clothes pegs.

*Note: The layers of foil and basting will be trimmed later to the width of the decorative outer cover. The five layers need to be stitched together with the zipper in one go. The inner lining will be attached later.*

(12) Separate the zipper. With the half zipper facing upwards (towards the right side of the fabric), centre it (equal distance from both ends) along one of the folded ends. Baste the zipper in place by hand. Stitch the zipper and the materials all together.

(13) Turn over and trim the batting/foil equal to the decorative outer cover fabric.

(14) With the right sides together (outer cover sides), fold the side with the zipper 45 cm upwards and stitch a 2 cm seam on each side, making an envelope. The seam should come precisely to the ends of the zipper to avoid a space and loss of heat.

(15) Turn the bag right side out (insulation batting is now on the inside).

(16) Insert the lining envelope with the wrong sides (unfinished seams) together. The side seams of the lining should fit exactly to the ends of the half zipper. If not, adjust the width (seams) of the lining – bigger or smaller. Otherwise, it will be difficult to stitch.

(17) Position the 5 cm folded end of the lining on top of the half zipper, pin the lining in place. Test the zipper to ensure the lining is not too close, preventing the zipper from closing. Stitch the lining to the half zipper.

(18) To finish the flap on the inside, fold the outer cover fabric inwards on all three sides. Fold the lining material inwards over the 5 layers on all three sides. Pin together. Place the two closing strings in between the outer cover and lining, about 2 cm from each end. Stitch the outer cover and lining together.

*The strings of the HRB pictured right are too close to each other. They should be positioned further apart, closer to the outer edges, for better closing. See photo following page.*

(19) Position the other half of the zipper onto the lining. Pin in position and control closing and opening. Stitch the half zipper in place. Turn the extended zipper end under for a neat finish.

(20) Sew on two big buttons (for closing the bag with the string).

# 3. HOW TO MAKE A WOODEN STAND

The wooden stand is necessary to create an air layer between the pot and reflective foils.

## 3.1 MATERIALS – TOOLS

Materials

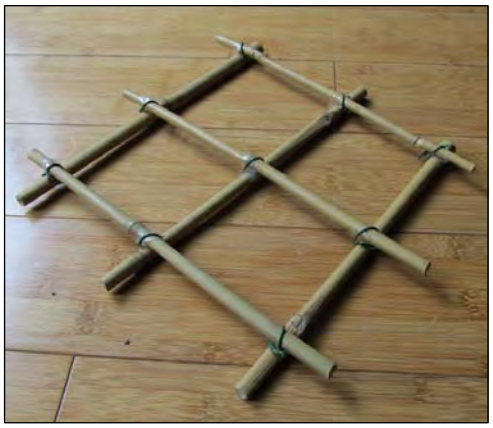
- Wooden or bamboo sticks (Ø 1 cm) – 1 meter (2 pieces)
- Galvanised wire (1 mm) – 1 meter or nine (plasticized) paper clips
- Cellophane (scotch) tape – small roll (for temporarily fixing the sticks in position)

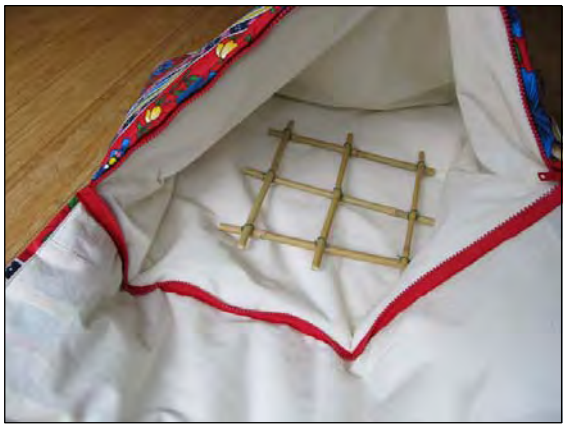
Tools

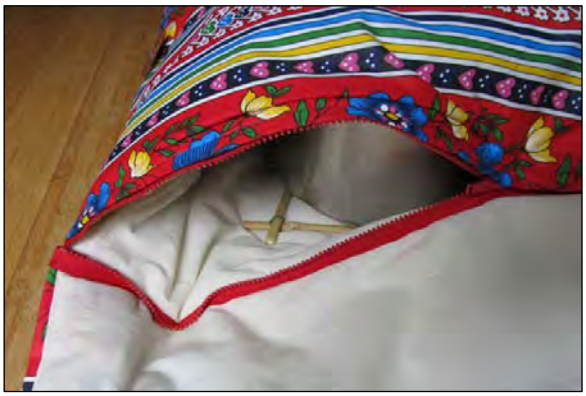
- Scissor to cut wooden/bamboo sticks
- Pliers to twist the galvanised wire

## 3.2 ASSEMBLY

(1) Cut the wooden/bamboo sticks into 6 pieces, each 25 cm in length.
(2) Bind the sticks together as in the photo with the cellophane tape.
(3) Cut the galvanised wire into 9 pieces, each 8-10 cm in length. Make a long U-shape of the wire and stick it diagonally over each two sticks.
(4) Using pliers, twist the two ends of the wire tightly and bend the wire ends back so they do not stick out.







When the pot support is mass-produced, making an assembly jig will save time.

# 4. TESTING

**The Heat Retention Bag is as good as its thermal insulation value.**

The highly reflective foil with a thin air space in front has a thermal insulation value of about $R_c$ = 0.8 $m^2$.K/W. Two foils with the quilting batting and cover fabric will bring the thermal insulation value up to about $R_c$ = 2.0 $m^2$.K/W. This value is the same as obtained with 8 cm thick Expanded Polystyrene (EPS) or stone wool insulation.

The thin wooden/bamboo stand for the pot ensures that the pot does not press directly onto the lining, but creates the required air space on top of the reflective foil.

Since for most food types cooking stops at 60-65°C, the quality of the HRB is determined by the length of time the temperature stays above 70°C. In high mountain areas, the boiling temperature of water becomes lower with higher altitude.

| Altitude above Sea Level | Boiling Temperature Celsius | Boiling Temperature Fahrenheit |
|---|---|---|
| Sea level = 0 m | 100.0° | 212° |
| 2000 ft = 601 m | 97.7° | 208° |
| 5000 ft = 1524 m | 95.0° | 203° |
| 7500 ft = 2286 m | 92.2° | 198° |
| 10,000 ft = 3048 m | 90.0° | 194° |

People living at an altitude of 1500 m already need to consider a 5°C lower boiling temperature for food preparation. When placing the hot pot with food in the HRB, the pot temperature is about 5°C lower than at sea level and drops earlier to 70°C.

## 4.1 INSTRUMENTS FOR TESTING

- Two electronic thermometers/timers with a cable. One was used first inside the pot when bringing the water to a boil (sea level 100°C) and then later placed on top of the pot inside the HRB; the other was placed under the pot support inside the HRB.

- An infrared temperature measuring instrument. The instrument used has two lasers that cross and indicate the area of the spot measuring. The spot measuring is realised on the outside of the HRB, each time exactly on the same spot.

Three spots were selected:
(1) Near the zipper as a possible heat leakage area.
(2) Outside, directly above the cooking pot.
(3) On the side of the HRB.

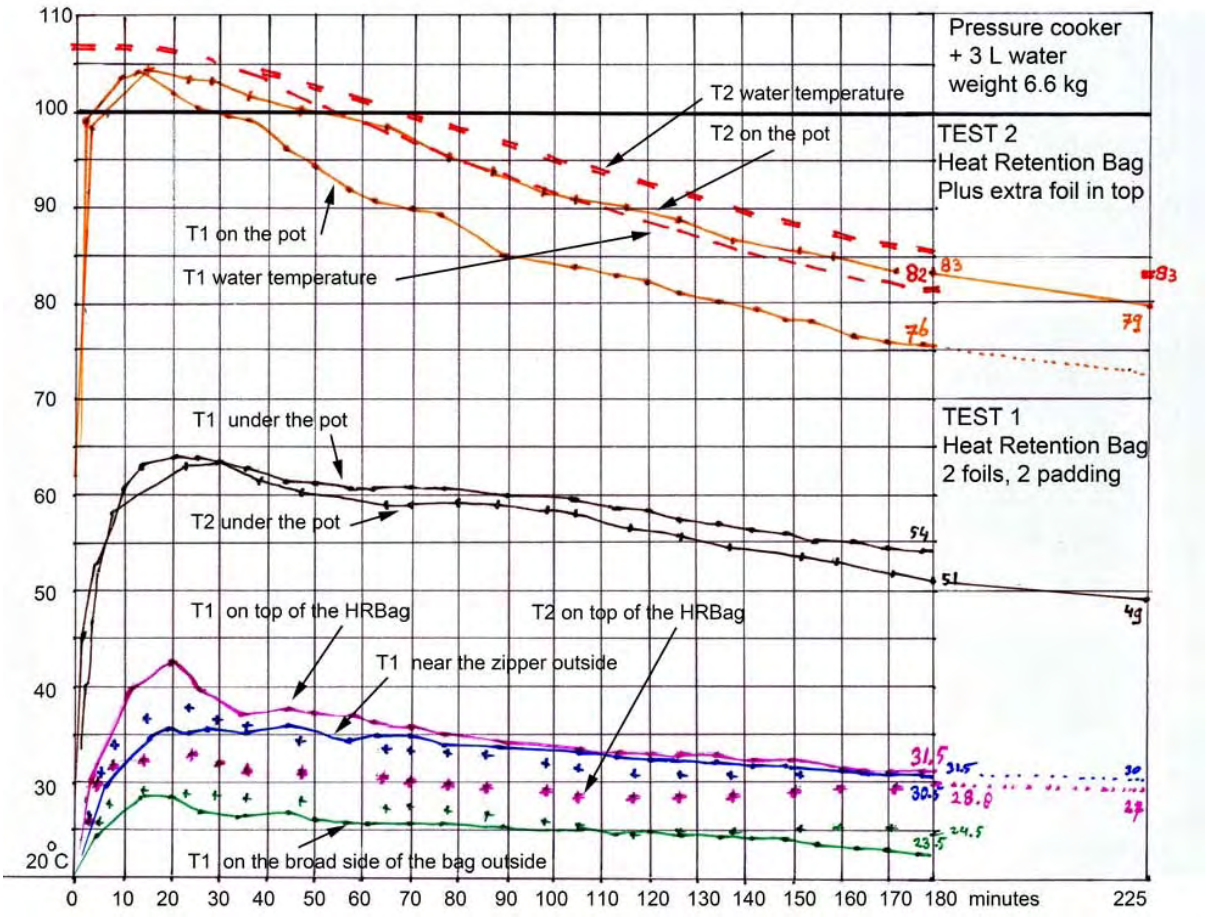
## 4.2 TESTING DIAGRAM

The following chart shows the result of two tests with the mass of the pressure cooker and content (water) of 6.6 kg, and an estimated starting temperature of 110°C.

**Test 1** was with two reflective foils separated with two layers of quilting batting of 1 cm thickness. There was a 40°C reducing to 20°C difference between the temperatures inside the bag, under and above the pot. The bottom temperature gauge was placed under the wooden support.

The orange top line indicates the temperature directly above the cooking pot, being about the same as the water temperature. After three hours, the temperature dropped to 82°C, while after 2¾ hours (225 minutes) the temperature was almost 80°C. The temperature on the outside (top) of the HRB dropped from 40°C to 35°C.[3]

**Test 2** was with an additional reflective foil inside the HRB, above the pot. The orange top line indicates the temperature on top of the pot and the double line (red) indicates the estimated temperature of the water. After three hours, the temperature dropped to 83°C, while the temperature after 2¾ hours was about 80°C. The outside temperature on top of the HRB was about 5°C lower with the extra foil, confirming less heat loss with the three foils on the upper side.



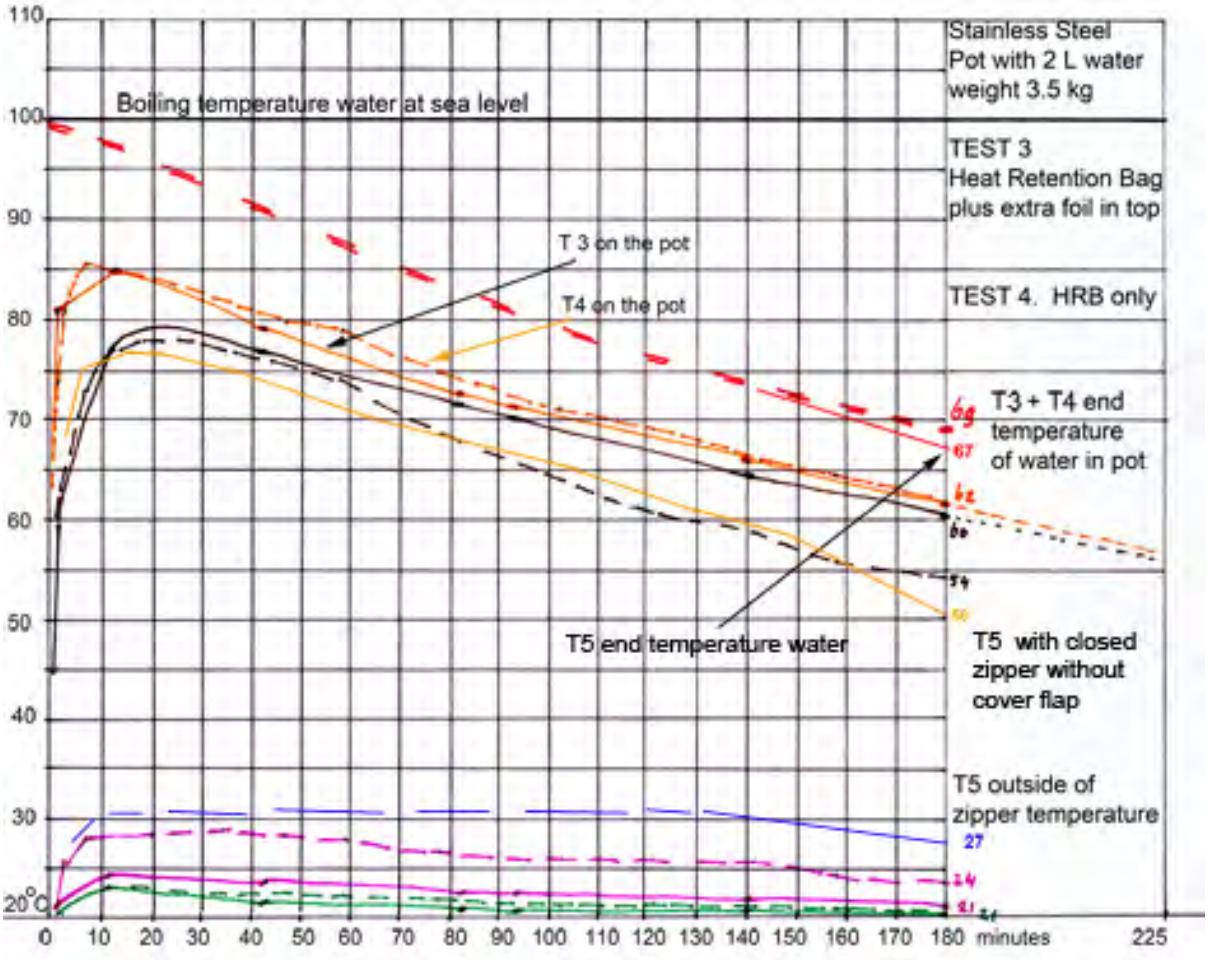

[3] The small fluctuations in the lines are caused by rounding off the minutes.

*The Two Temperature Controls*

*The top figure on the timer is the running time in hours and minutes. The bottom left figures are the bottom and top temperatures inside the HRB.*

*The outside temperatures were taken with the infrared temperature-measuring instrument.*

**Tests 3, 4 and 5** were realized with a small ordinary cooking pot having a total mass of only 3.5 kg, including the water. The smaller mass caused a larger (faster) temperature drop. The water temperature after three hours was almost 70°C, while after 2¾ hours the temperature had dropped below 65°C (the lowest temperature for slow cooking). For higher altitudes, both figures will be lower due to the lower temperature of the cooking pot when placed in the HRB.

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One of the objectives of the Technical Working Papers is that they are developed according to the local needs for information in the project regions. Depending on the feedback information obtained from the users, the content can be adjusted and extended to make it better understandable.

The users are therefore requested to communicate their comments to the project staff. Subsequently the project staff can communicate their observations to the author, after which a new version of the document can be developed.

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