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ABSTRACT

This document was developed as a training manual for people interested in various types of appropriate technologies related to improved cookstoves. The three types of cookstoves included in the manual are earthen, ceramic, and metal (or a combination of metal and ceramic). The training sessions described deal with: (1) an orientation to the cookstove training program; (2) project documentation; (3) trainee working styles and skills inventory; (4) the fuel wood crisis and improved cookstoves; (5) appropriate education and the learning process; (6) socio-cultural and technical considerations; (7) survey and assessment; (8) stove combustion theory; (9) hypothetical stove design; (10) earthen stove design and soil analysis; (11) earthen stove construction; (12) introduction to ceramics; (13) ceramic stove design; (14) ceramic stove construction; (15) ceramic stove curing and firing; (16) project design and proposal preparation; (17) metal stove design; (18) metal stove construction; (19) cooking on cookstoves; (20) cookstove business development; (21) diagnosis and repair of cookstoves; (22) testing and monitoring cookstove performance; (23) cookstove project presentations; (24) traditional and improved cookstove banquet; and (25) training program evaluation. A glossary is included. (TW)

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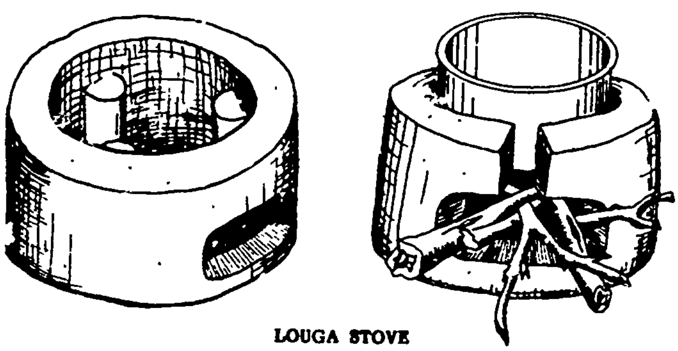
TRAINING FOR DEVELOPMENT

Improved Cookstoves

A Training Manual



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TRAINING MANUAL NO. T-40

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IMPROVED COOKSTOVE TRAINING MANUAL

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Malcolm and Lynda Lillywhite

5

INTRODUCTION TO THE TRAINING MANUAL

This training manual has been designed as a trainer's tool for use in both state side training and in-service training programs. The session listing shows which sessions are appropriate for each purpose. Trainers are encouraged to revise sessions where necessary to make them most effective in a given setting. Session sequencing should be maintained to insure that the introduction of theoretical information and construction experience are logical and build the necessary learning foundation for a successful long-term retention of the material.

Stove Application

Three basic types of cookstoves are included in this training manual: earthen, ceramic and metal (and combination metal/ceramic) cookstoves. Generally earthen stoves are designed for wood fuel and ceramic and metal stoves are designed for charcoal fuel. However, some metal stoves are also designed for use with dung, biomass residue and small diameter and length fuelwood. Cookstoves used for larger scale cooking such as restaurants or large extended families are included as well as cookstoves for general family use. Trainers should pay particular attention to the primary function and fuel recommended for a given stove before allowing trainees to modify the stove or before selecting the stove for a specific application.

Stove Testing

Considerable effort has been devoted to the evaluation and comparison of cookstove fuel comsumption characteristics. The "Testing and Monitoring Cookstove Performance" session is time consuming and must be executed with care and accuracy in order to produce useful stove comparison data. In some village training situations, this session may not be appropriate until stoves are built and have been used for several months. Simple algebra and some statistical analysis are necessary to perform stove performance calculations and this skill may only be found in institutional settings. Therefore, it is recommended that trainers examine appropriateness of the session before training begins.

Trainers

The Improved Cookstove Training Manual is designed for use by trainers with experience in cookstove technology, metal working and ceramics. As a trainer if you do not have experience, but need to offer training in one or more of these areas, obtain help from a local artisan or an outside consultant. Generally a local metal worker or ceramicist coupled with a trainer's theoretical knowledge is sufficient to conduct a workshop if this team works together to build and test sample stoves prior to the beginning of the training. Earthen construction skills are usually available through village women.

Participants

The training program should be tailored to the need and skills of the participants. If business oriented individuals, metal or ceramic artisans are the primary target, focus will include not only cookstove construction but also may include maintenance on a small scale, manufacturing, bookkeeping, marketing, etc. A training program where village women who already have earthen construction skills are the primary participants, construction and proper use of earthen cookstoves may be the primary focus. The trainer should develop this training program with these conditions in mind.

Logistics

Logistics of a cookstove training program depends primarily upon where the training will occur, the time allowed for the training and the degree to which the participants are expected to find their construction materials. If participants are expected to find metal, clay or other materials from local resources, time must be allowed for this activity. The manual as written assumes that all tools, handouts, demonstration units, construction materials and fuel are available to participants at the training site. There are definite advantages for an IST in having participants use local human and material resources, however, the additional amount of time required can range from 16-40 hours spread over a week or more.

Other logistical considerations such as feeding, housing, transporting and providing emergency medical care for trainees, and the effect of local holidays, weather, previous obligations of participants, and protocol for beginning and ending training program should be considered in setting up the primary programs and dealt with as necessary.

COOKSTOVE TRAINING PROGRAM GOALS

- To provide trainees during training with all necessary information, skills, materials, tools, and resources to prepare them to transfer their knowledge and experience to other communities.
- To enjoy the training experience, both in work and play.
- To develop through learning an understanding of the fuelwood crisis and improved cookstoves as a partial solution to the crisis.
- To improve personal and group dynamic skills.
- To be able to adapt the improved cookstove technology they have learned to new situations.

TRAINING TRACK GOALS

Improved Cookstoves

- To develop an understanding and be able to articulate the importance of considering cultural, social and technical factors before implementing an improved cookstove program.
- To design and construct cookstove(s) appropriate for the country of assignment.
- To practice using cookstoves and be able to explain how they function.
- To understand and describe the principles of cookstove testing and conduct cookstove tests.
- To understand and describe the application of cookstove testing to an improved cookstove program.
- To be able to diagnose causes of malfunctioning cookstoves.
- To provide written documentation and designs of all cookstoves used.
- To give a final presentation synthesizing data on design, construction, use and testing.
- To appreciate and articulate the interrelationship of the cookstove training with skills learned in project management, small business development and the overall training program.

IMPROVED COOKSTOVE TRAINING MANUAL
SESSION LISTING

NOTE: ( ) indicates sessions that would have been offered earlier in a SST

Session Number	Session Title	Time Required (Hrs) SST	IST
S-1	Orientation to Cookstove Training Program	-	2
S-2	Project Documentation	(3)	3
S-3	Trainee Working Styles and Skills Inventory	(2)	2
S-4	The Fuelwood Crisis and Improved Cookstoves	2	2
S-5	Appropriate Education and The Learning Process	(2 Opt)	2 Opt.
S-6	Socio-Cultural and Technical Considerations	2	2
S-7	Survey and Assessment	(2)	4
S-8	Stove Combustion Theory	3	3
S-9	Hypothetical Stove Design	2	2
S-10	Earthen Stove Design and Soil Analysis	2	2
S-11	Earthen Stove Construction	16	16
S-12	Introduction to Ceramics	2	2
S-13	Ceramic Stove Design	4	4
S-14	Ceramic Stove Construction	8	8
S-15	Ceramic Stove Curing and Firing	2	2
S-16	Project Design and Proposal Preparation	2 Opt.	2 Opt.
S-17	Metal Stove Design-Part A and Part B	4	4
S-18	Metal Stove Construction	14	14
S-19	Cooking on Cookstoves	4	4
S-20	Cookstove Business Development	(2 Opt.)	2 Opt.
S-21	Diagnosis and Repair of Cookstoves	2	2
S-22	Testing and Monitoring Cookstove Performance Part A and Part B	8	8
S-23	Cookstove Project Presentations	2	2
S-24	Traditional and Improved Cookstove Banquet	4 Opt.	4 Opt.
S-25	Training Program Evaluation	(2)	2
	Total Hours	**93**	**97**

TRAINER PLANNING AND SCHEDULING NOTES FOR IN-SERVICE TRAINING

Pre-Training

One week or earlier before training begins trainers should determine the following information:

* What traditional stoves are used for different types of cooking.
* Locate earthen stoves, if used, and obtain sample portable stoves for demonstration (if possible).
* Identify types of clay available and current methods of working with clay.
* Identify metal available, tools and ways of working with it, and a local artisan who will cooperate with the training program.
* Identify sites to make earthen stoves and obtain permission or other agreement to construct stoves.
* Become familiar with traditional cooking practices (although trainers should stress to trainees that it is their responsibility to adapt the skills they learn to local conditions).
* Order or obtain necessary tools, materials and make arrangements with local human resources to be used in training.

Trainer's Note

Good luck with your training program. It can be an enjoyable and worthwhile process if done with proper planning and preparation.

SESSION S-1 **ORIENTATION TO COOKSTOVE TRAINING PROGRAM**

TOTAL TIME: 2 Hours

OBJECTIVES:
* To open the program with formal greetings and introductions
* To present an overview of the stove program
* To determine the trainees' expectations of training
* To present the behavioral objectives and the schedule
* To tour facilities (if appropriate)

RESOURCES: Attachment S-1-1
Training Schedule

MATERIALS: Flip chart, markers, slide projector and slides (opt.)

Trainer's Note

This session is designed to introduce the training in an in-country situation. If the training is part of an on-going program, such as a stateside training, the orientation would be part of the overall program orientation. In this case, and assuming Sessions S-2 and S-3 have been executed, the training would begin with Session S-4.

PROCEDURE:

Step 1 5 Minutes
Review the objectives and the procedure to be followed.

Step 2 1 Hour
Introduce Peace Corps personnel, host country sponsoring agency staff, or current program volunteers, who can provide background information on the program. NOTE: This step can also include a slide show or a visit to a stove center.

Step 3 30 Minutes
Have trainees list what they expect out of the technical part of the training. List on flip chart.

Step 4 10 Minutes
Present the behavioral objectives and give the trainees a few minutes to read them. Answer any questions.

Step 5 15 Minutes
Present the schedule and compare it with the expectations list. If there is an expectation of training that isn't to be met, explain why.

Attachment S-1-1

IMPROVED COOKSTOVES
BEHAVIORAL OBJECTIVES

By the end of this training, all trainees will be able to perform, with a minimum level of proficiency (as determined by the trainers) the following skills:

1. Develop an understanding and be able to articulate the importance of considering cultural, social and technical factors before implementing an improved cookstove program.
2. Design and construct one earthen or ceramic and one metal stove.
3. Practice using the stoves and be able to explain how they function.
4. Understand and describe the principles of stove testing and conduct at least two "Water Boiling" Tests.
5. Understand and describe the application of stove testing to an improved cookstove program.
6. Be able to diagnose causes of malfunctioning stoves.
7. Provide written documentation and designs of all stoves.
8. Give a final presentation synthesizing data on design, construction, use and testing.
9. Appreciate and articulate the inter-relationship of the stove component with skills learned in project management and overall program sessions.

SESSION S-2 **PROJECT DOCUMENTATION**

TOTAL TIME: 3 Hours

OBJECTIVES:

* To understand the purpose and use of training program documentation
* To identify when "I" (the participant) am responsible for documentation
* To identify a variety of documentation approaches
* To experience the documentation process and its use

MATERIALS: Three-dimensional puzzles (each different), documentation format (handout), flip chart, markers, 35 mm slides or photography to demonstrate photo documentation, a watch or clock

PROCEDURE:

Step 1 30 Minutes
Discuss documentation as it relates to this training program and to the effectiveness of Peace Corps service. Hand out samples of good and poor quality cookstove documentation.

Step 2 15 Minutes
Give participants assignments for documentation.

Trainer's Note

The assignment can be as simple as asking participants to organize and coordinate their own documentation of each project to be designed and/or built during training.

Step 3 2 Hours
Practicing Documenting

a. Break the group into fours; two observers and two puzzle solvers;
b. Give each team a puzzle and an amount of time to solve the puzzle while the observers watch in silence making notes on how the puzzle is solved on paper only;
c. At the end of the time the observers take their puzzle and documentation on how to solve the puzzle to the next group;
d. Again, the same amount of time is given to the groups to solve the puzzles using the documentation only (no talking);
e. This cycle is repeated until all groups have tried all puzzles.

Trainer's Note

The object of the puzzle exercise is to see if the use of documentation and improving the documentation decreases the time to solve the puzzles.

Step 4 15 Minutes

Discuss, as a group, if the use of the documentation decreased the time required to solve the puzzles. Discuss how this same type of process can improve their Peace Corps service.

SESSION S-3 **TRAINEE WORKING STYLES AND SKILLS INVENTORY**
(Optional for In-Service Trainings)

TOTAL TIME: 2 Hours

OBJECTIVES:
* To explore different styles of working with others and assess the consequences of those styles
* To consider how one's personal, preferred style of working with others may affect one's work and how to adapt that style when necessary

RESOURCES: Attachment S-3-1 and S-3-2

Trainer's Note

This session is designed to explore a series of work case situations. The participants consider what they would do in those situations and the possible consequences of those actions.

PROCEDURES:

Step 1 5 Minutes
Introduce the session by linking this session to the theme of development. Review objectives and procedures.

Step 2 25 Minutes
Hand out Attachment S-3-1 and ask participants to go through and mark their scores on the scoring sheet. Explain that a discussion will follow.

Step 3 20 Minutes
Facilitator should lead a discussion based on the information in Attachment S-3-2.

Step 4 30 Minutes
a. Discuss two or three of the situations and for each one have participants share the reasons they scored it the way they did. For example, what people were there, what skills they have, etc. Try to discover what assumptions the participants are making.
b. For each situation, discuss and list what the consequences of their choices may be in terms of the principle of working towards eventual autonomy for the community.

c. As a group discuss:

What kind of conditions should be present for me to use this work style?	What are the advantages of this work style?	What are the disadvantages?
(Examples)		
<u>Direct Service</u> No expertise in the community	Quick payoff	Could create dependency
<u>Demonstration</u> People don't believe something is possible	Builds credibility	People may think only a volunteer can get results

Step 5 20 Minutes
Use the working style concept to analyze in-country situations

a. What preferred working style(s) would you use to describe some of the volunteers you have talked to in-country (or returned volunteers for a SST)? What evidence leads you to this conclusion? (Discuss responses to this question for 10 minutes or so, trying to get people to be as specific as possible about why they describe a volunteer in a particular way, what situation(s) that volunteer may face, and so on.)

b. Given what you know about your community and work situation, what style do you think might be most effective, at least initially?

Step 6 15 Minutes
Summing Up: generalizations and applications.
What are some of the things you can say about working with others in the community that you think are true in general? (List responses on flip chart.)

* In the specific situation of your work? In the community experiences you have had so far in training, what style would you use?
* How do you think you will be able to find out what style is the best one to use in your volunteer work when you first start on the job?
* What style is easiest for you? Why?
* What style is most difficult? Why?
* What changes do you want to work on over the next month or two that will help broaden your style range?

Step 7 5 Minutes
Refer to the goals of the session and check with the group to see to what degree the goals have been met.

Attachment S-3-1, Page 1

WORKING STYLE INVENTORY

Self-Assessment

Sixteen situations typical of those faced by Peace Corps Volunteers in the past are described here. Select the way of handling each situation which you prefer and assign the number "4" to that choice. Select your next preferred choice and assign a "3" to it. Assign a "2" to the next preferred choice and then a "1" for the least preferred choice. Assign your numerical choices directly on the scoring sheet attached to this Self-Assessment form.

This form is designed to help you assess your personal preferred style of handling situations which you are likely to face during service as a volunteer. Later, you will analyze the results yourself and will be given opportunities to try out different ways to handle similar situations.

ASSIGN A "4," "3," "2," or a "1" IN THE ORDER OF YOUR PERSONAL PREFERENCE FOR HANDLING EACH SITUATION DESCRIBED. PLACE YOUR RESPONSES DIRECTLY ON THE SCORING SHEET ATTACHED TO THIS SELF-ASSESSMENT FORM.

Situation #1

You are entering your assigned village to take over an appropriate technology project. The volunteer you are replacing has already left. The project is three years old. You have had brief discussions with village leadership and get the sense that the project is being received with mixed results. You have been asked to address a meeting of village leaders to introduce yourself. How would you prefer to handle the situation? (Respond on Scoring Sheet!)

Choices:

1. Present your approach to the project and ask for questions and advice.
2. Seek the leadership's view of the project and identify problems.
3. Ask the leaders to describe their goals for the project, as well as other pressing needs the village is facing.
4. Ask the leadership if you can sit in on this meeting and become better acquainted with village needs before addressing a meeting.

Situation #2

You have been assigned to help the largest village cooperative keep their financial records straight and to provide general management assistance to coop leaders. The cooperative is operating at a deficit, and membership is declining. You need to decide how to prioritize your time from the following choices.

Choices

5. Develop a balance sheet and income statement to analyze causes of the deficit.
6. Work with coop manager and bookkeeper to identify causes of deficit and declining membership.
7. Encourage coop leadership to call a membership meeting to discuss the causes of deficit and declining membership.
8. Observe everyday functioning of the coop and informally talk with people who belong and do not belong to the enterprise.

Situation #3

You have been assigned as a teacher in the local trade school in manual arts. A disagreement has arisen among the faculty about whether to emphasize employable skills-training or preparation for advanced training. You are about to attend a faculty meeting to discuss these issues. You are the only expatriate member of the faculty. What is your strategy?

Choices

9. Publicly state your point of view indicating a willingness to listen.
10. Meet with influential faculty and seek to influence them to your point of view.
11. Seek the advice of fellow faculty and follow it.
12. Take no position in public and attend the meeting to listen and learn.

Situation #4

You are assigned to a small vegetable cooperative project which has been underway for several years. There is very high interest in the project among the village at large. However, the local leadership has just decided all coop labor must be assigned to re-building the bridge recently flooded out during the rainy season. This is planting time for the vegetable coop. What would you do?

Choices

13. Persuade the leaders to change their priorities, at least to enable the once-a-year planting in the vegetable fields.
14. Help the leadership identify some alternatives to choosing between the vegetable crop and the bridge.
15. Help the local vegetable coop manager develop strategies to try to get the local leaders to reconsider.
16. Join in and facilitate bridge repair in an effort to complete it in time to also plant vegetable plots.

Situation #5

You are in the last six months of your tour. It is unclear whether you will be replaced by another volunteer. The local project committee is urging you to be sure to finish a gravity irrigation project before you leave. You are not sure you can complete it in the time allotted. How will you handle this pressure?

Choices

17. Try as hard as you can to complete the project.
18. Lead a planning meeting with the local project committee and staff and try to develop alternative strategies.
19. Concentrate on developing skills in local project staff to enable them to complete the project after your departure.
20. Pass the dilemma on to the local project staff leaders and encourage them to solve the problem and tell you what to do.

Situation #6

A new counterpart has been assigned to your food production project. He/she does not have the connections with local district officials which the previous counterpart had and seems unable to use connections to get needed inputs. If you do not get the needed inputs soon, serious food shortages could result at harvest time. What will you do?

Choices

21. Use your previous associations through the past counterparts to ensure the required inputs are received in time.
22. Develop strategy with new counterpart to provide introductions and contacts to enable him/her to get inputs in time.
23. Ask new counterpart to develop plan to get inputs, and critique plan.
24. Encourage new counterpart to go out and try to figure out how to get needed inputs.

Situation #7

You have taken over an agricultural production project of the "green revolution" type witn a "most promising farmer" orientation. There are two very progressive farmers using the new technologies and greatly increasing their cultivated land. Most farmers in the area have not adapted the new practices. The village leadership is predicting scarcity to starvation next year if food production is not greatly increased. Where will you focus your time?

Choices

25. On increasing food production by whatever means, including using the progressive farmers as "model" farmers for others.
26. Balanced between encouraging the progressives and working directly with more traditional farmers.
27. Organizing traditional farmers and training them in new agricultural practices.
28. Identifying why traditional farmers are not adapting new agricultural practices.

Situation #8

The village to which you have been assigned has a native bee-keeping project going and are highly motivated about it. Your assignment is a general agricultural assignment, but you happen to know quite a bit about bee-keeping and can see some ways to help improve their already successful project. They have shown no interest in using you in that way. How will you respond?

Choices

29. Speak to village and project leaders laying out some of your ideas for improving the project and suggesting change in your assignment.
30. Make a suggestion from time to time, informally, demonstrating your competence in this area.
31. Share your dilemma with your counterpart and seek his/her advice and follow it.
32. Move ahead with your assignment as planned, being alert to any future opportunities to be helpful in an informal way with the bee-keeping.

Situation #9

You are beginning the second year of your two-year teaching contract. You have been able to introduce some innovative methods, and students and fellow faculty have responded and will have begun to adapt them. Some students in particular have "blossomed" under your direction. What are your priorities for the next eight months?

Choices

33. Focus on blossoming students and bring more into the fold.
34. Organize special teacher-training seminars to broaden and deepen innovations in curriculum and teacher practices.
35. Seek opportunities to co-teach with counterparts to solidify innovations already adapted.
36. Begin planned withdrawal to lessen dependency on you for sustaining innovations adapted.

Situation #10

You are a health and nutrition specialist assigned to a community clinic with a very vague and general assignment. The needs surrounding you are overwhelming, but you don't know where to begin. The clinic director seems glad to have you, but has provided no specific direction. How will you begin?

Choices

37. Assess your strongest field and make a concrete proposition to the director to clarify your role.
38. Ask for a meeting with the director to mutually explore his/her priorities and ascertain where you can be most helpful.
39. Ask your counterpart(s) if you can observe them for a month in hope of identifying areas where your skills can complement theirs.
40. Conduct a community needs assessment and develop your role in response to community needs.

Situation #11

You are a technician assigned to a well-drilling project in a community where potable water is in short supply. You know how to dig wells and have demonstrated how to do so. However, in this culture, manual labor by men is frowned upon. They are happy to have you dig wells while they watch. What will you do?

Choices

41. Continue digging to model that manual labor is okay and, by example, influence local men to join you.
42. Meet with influential leaders and point out the necessity for potable water and its relationship with health problems in the community.
43. Meet with counterpart(s) and try to get them to help you solve the problem.
44. Stop digging wells and focus your attention on overall community needs and how you might help meet some of those needs.

Situation #12

You have been working as an athletic coach in the community and, under your direction, the community has produced outstanding teams. It is a matter of considerable pride to community leaders, and they have asked you to continue to win. You have noticed little parental involvement, however, and in order to win you have focused attention on a small number of talented youth. How will you change the situation?

Choices

45. Try to maintain your winning teams, while organizing new teams with more focus on parental involvement among new team members.
46. Call a meeting of existing and new parents and make a condition of your continued coaching, greater parental involvement all around.
47. Seek parental assistance in coaching, organize new teams, and focus your time on training new coaches.
48. Spread your "winners" among newly organized teams, minimize importance of "winning" and concentrate on parental involvement to identify new needs.

Situation #13

Your counterpart is becoming increasingly dominating during project committee meetings. As his/her confidence and skill has grown, you have gladly given more responsibility to the counterpart. But, it seems to you other committee members are becoming more withdrawn from the project. You want to build a strong project team, rather than just one strong counterpart. What should you do?

Choices

49. Raise the issue directly with the counterpart and offer to lead the next committee meeting to demonstrate participative leadership skills.
50. Provide help in planning the next meeting and make some specific suggestions to the counterpart about how to modify leadership behavior.
51. Watch for opportunities to provide feedback, ask the counterpart questions about how she/he thinks meetings are going, and reinforce participative behavior.
52. Leave the situation alone and count on the committee to call the counterpart on dominating behavior, then reinforce and offer to help.

Situation #14

You have just been assigned to a project which is a mess. Your counterpart appears to have opened a small shop for a second income and is not showing up for project work. Community leaders are unhappy because the project was begun with a lot of enthusiasm. They have asked you to take over and straighten it out. How will you proceed?

Choices

53. Take over and straighten out the project first, then deal with the counterpart problem later.
54. Confront the counterpart with his/her behavior and provide ongoing consultation until both problems are more manageable.
55. Present counterpart with pressing project problems and ask him/her to suggest solutions and plans to implement solutions.
56. Call meeting with leaders and counterparts and facilitate a problem-solving session as first step toward project reorganization.

Situation #15

You are working in a community with another volunteer. You have just become aware that the other volunteer has deeply offended the leaders because of dress-code behavior. The level of distress in the community is rising and inhibiting the success of both of your assignments. How will you handle this?

Choices

57. Speak to the other volunteer immediately and strongly suggest she/he change inappropriate behavior.
58 Consult with the other volunteer and try to understand reasons for the behavior in a mutual problem-solving manner.
59. Bring influential community leader(s) and the other volunteer together to mutually explore problem and solutions.
60. Encourage local leaders to go to volunteer on their own and offer to be available if they need help.

Situation #16

You counterpart is moderately skilled and experienced and moderately interested in your project. She/he does not see the project as advancing her/his own career. The village, however, is vitally interested in the project. How would you handle this situation?

Choices

61. Try to get counterpart reassigned, and temporarily take over direction of the project until a new person is assigned.
62. Spend time with counterpart trying to identify ways in which his/her role in the project can both meet project goals and career aspirations.
63. Work with counterpart on career goals and help her/him develop strategy for pursuing them, including leaving project if appropriate.
64. Facilitate a meeting between community leaders and counterpart to see if they can come up with a mutually satisfactory solution to the problem.

Attachment S-3-1, Page 8

SCORING SHEET

(A)	(B)	(C)	(D)
1.	2.	3.	4.
5.	6.	7.	8.
9.	10.	11.	12.
13.	14.	15.	16.
17.	18.	19.	20.
21.	22.	23.	24.
25.	26.	27.	28.
29.	30.	31.	32.
33.	34.	35.	36.
37.	38.	39.	40.
41.	42.	43.	44.
45.	46.	47.	48.
49.	50.	51.	52.
53.	54.	55.	56.
57.	58.	59.	60.
61.	62.	63.	64.
Total______	Total______	Total______	Total______

Instructions:

Enter your responses for each of the 16 situations above. Assign a "4" to your first choice, a "3" to your second choice, a "2" to your next choice, and a "1" to your last choice in each situation.

When you have responded fully to each set of choices, total the numbers vertically in each column.

Attachment S-3-2, Page 1

The inventory you have just taken presented a series of situations where you were asked to choose which way to work with the people in that situation. In fact, there is no hard and fast rule for which is the best way to work with others, and no situation is exactly like another. (For example, even though one long range goal is self-sufficiency, a situation may dictate that we choose actions that would fall in the direct service column in order to attain short term goals.) As much as possible, we need to be clear about what the situation is we are confronting and try to make a conscious choice about how to act so that we are clear about the consequences of our choices and how they affect the people with whom we work. The inventory, in general, corresponds to the "Continuum of Volunteer Helping/Work Styles" (unveil the diagram drawn out on a flipchart). Your score corresponds to one of the major work styles (the numbers in columns 1, 2, 3, and 4 follow: a = Direct Service, b = Demonstration, c = Organizing with Others, and d = Indirect Service). If you score higher in one column than in another, it indicates that you prefer to work in that mode in the situations described. Each style is described as follows.
Column A: Direct Service (summarize on a flip chart)

This is a direct approach in which the volunteer mostly does the work, gets a project organized, provides a needed service where none exists, and generally takes the initiative for making things happen. In most instances, this means that the volunteer takes responsibility for the action or project, and that a counterpart may or may not be involved — and even if involved, will look to the volunteer for action and leadership.

Column B: Demonstration

In this approach or situation, the volunteer spends most of the time demonstrating to others how to do something, but also spends a lot of time doing it him/herself. Most often the responsibility is shared with one or two counterparts. The work is a combination of direct service and training/demonstrations, often with the volunteer sharing some responsibilities with a promising local leader or an assigned counterpart.

Column C: Organizing With Others

In this system, the volunteer encourages and stimulates promising counterparts and others in the community, generally—although not always—working with people rather than directly on projects. (NOTE: Throughout this session, we use community in its most generic sense--it could be a school community, an agricultural office, or a town or section of a city.) The focus is on building leadership and helping a group or organization develop which will continue the work. The primary work is behind the scenes using influence, assisting as a resource in developing alternative solutions which the people choose or generate themselves, serving in a training capacity, occasionally serving as a role model in doing work, and so on.

Attachment S-3-2, Page 2

Column D: Indirect Service

In this approach, the volunteer responds to a range of situations and problems raised in volunteer work by helping others solve their own problems; the volunteer does not direct any of the work but concentrates on helping the people define and refine their perceived need. Help is given only on request, rarely initiated by the volunteer. The volunteer may even come and go, leaving the project to do something else and thus reinforcing the autonomy of the group. The way the volunteer works is primarily clarifying, asking questions, listening a lot, and facilitating.

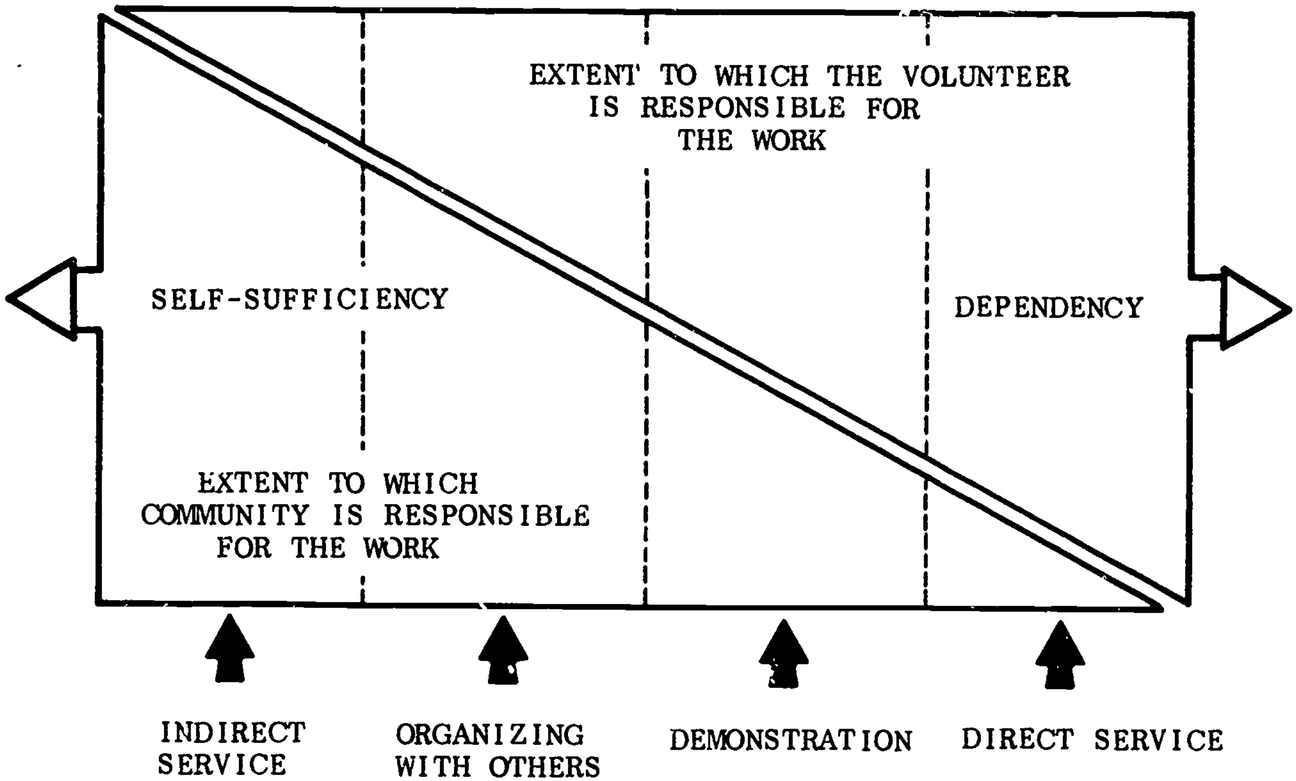
These four styles can be seen as related to stages in the development of self-sufficiency. For example, in a beginning stage, a group may never have worked together, may not have any technical resources and may not believe that it is possible to make improvements. In such a situation a volunteer may decide that the best way to get things moving is to: (a) establish credibility, (b) show people that (for example) a fat pig can be produced, and (c) salvage a bad situation. In so doing, he may decide to simply do the work himself and show the skeptical that something could be done. In this instance, the volunteer may be using a combination of "direct service" and "demonstration."

At a later stage of development as a group or project moves towards self-sufficiency, a volunteer may decide that the best way to help a group move along is to work with only the leadership in a community to help with ways to effectively plan or communicate together. In this instance, the volunteer will do nothing without a counterpart from the community. The primary task in this case would be leadership training and "organizing with others."

In these situations, one must consider the circumstances and the consequences and address a critical question: Is one looking for a short-term of a long-term result?

In reality, different styles or combinations of styles may be called for at different times, depending on the circumstances, the urgency of the task, what people are expecting of the volunteer, whether the project is at a beginning stage or a later stage, whether one is addressing a long-term or short-term situation, etc. Sometimes, a volunteer may need to use all four work styles on different days of the week for the same project. Whatever the style, there are consequences for the way a volunteer works.

CONTINUUM OF VOLUNTEER HELPING/WORK STYLES



SESSION S-4 **FUELWOOD CRISIS AND IMPROVED COOKSTOVES**

TOTAL TIME: 2 Hours

OBJECTIVES:

* To familiarize participants with the fuelwood crisis in the developing world
* To experiment using an open fire and/or existing cookstoves and make observations on how the devices work, i.e., advantages and disadvantages
* To provide a brief overview of different types of improved cookstoves

RESOURCES: Attachments S-4-1, S-4-2
"The Other Energy Crisis," E. Eckholm, Lorena Book, Pgs. 9-10

MATERIALS: Flip chart, markers, fuel, matches, cooking pots, water, existing stoves

PROCEDURE:

Step 1 — 5 Minutes
Introduce the objectives and procedures to be followed.

Step 2 — 10 Minutes
Facilitator gives brief introductory remarks on the fuel energy crisis in the developing world. (NOTE: Use the "Deforestation" article as a reference. In-country training can use slides or examples from local people on the availability of fuel and price difference.)

Trainer's Note

Have the trainees read "The Other Energy Crisis," in the Lorena Book before this session.

Step 3 — 20 Minutes
Brainstorm causes, impact and alternatives to the fuelwood crisis. List these suggestions on the flip chart. At the end briefly summarize the discussion.

Step 4 — 5 Minutes
Discuss the next step, which is to experiment with using an open fire and/or available cookstoves. Explain that this is an opportunity for the trainees to start familiarizing themselves with cooking methods in the developing world. Also explain that the observations they make will be used during future sessions on combustion theory and stove design. Hand out the observation sheets.

Step 5 1 Hour

Experiment with using an open fire and/or existing stoves. Record the observations. At the end of the experience clean up the work area.

Step 6 20 Minutes

Discuss the different types of stoves used and give a brief history of them. If no stoves are available locally, show slides or diagrams of different stoves from around the world. Refer to the catalog of stoves sheet.

Attachment S-4-1, Page 1

"DEFORESTATION"
From VITA News, by S. Baldwin

Loss of forest cover is a serious problem around the world, particularly in developing countries. In Nepal, for example, forested acreage has decreased from 60 percent to 19 percent in just 20 years. In Thailand, it is expected that there will be no significant forests remaining by the period 1987-1993. When Haiti won independence from France in 1804, more than 70 percent of its surface was forested. Today it is seven percent.

The environmental consequences of this deforestation are devastating. They range from the erosion of watersheds and flooding to the destruction of farmlands and desertification. And when the forests are gone, so is the firewood they supply—the primary fuel of up to 90 percent of the people in some developing countries. For the world's poor, it is becoming increasingly difficult simply to cook their food.

The FAO has estimated that, worldwide, the number of people affected by the fuelwood shortage will increase from the current one billion to nearly 2.8 billion by the year 2000. Those suffering an acute scarcity of wood fuel will increase from 100 million to over 350 million over that same period. And by the year 2000 there will be an estimated annual shortfall of 860 million cubic meters of fuelwood, more than half of the demand. Already, 150 to 400 million tons of dung are being burned annually, and for every ton of dung burned, some 50 kg of food grain production is lost.

Worldwide, over one billion cubic meters of wood are now used annually for fuel, or the energy equivalent of some two billion barrels of oil. Eighty percent of this is used for cooking, and represents most of the energy used by the world's poor.

Improved woodstoves have been widely heralded as a way to reduce the pressures on the world's forests. However, in the face of the rapid population growth in less developed countries, even a stove that reduces wood consumption by 50 percent is unlikely to slow deforestation significantly. Consider a stove that reduces wood consumption by half and that can be produced and disseminated rapidly in large quantities. If half a given population used such a stove half the time, the overall household wood savings would be just 12.5 percent. For a static population that consumes slightly more wood than can be renewably produced, this might make an important difference; but for a population with a growth rate of 2.5 percent, such savings would be overtaken in less than five years. Even if everyone used such a stove all the time—a highly unrealistic scenario—a breathing spell of only 20 years would be provided. At least in West Africa, agricultural intrusion, animal browsing, and brush forest are likely to be more important factors in deforestation than is fuelwood collection.

Although the overall impact of improved stoves on deforestation will be small, they still have several other important roles to play. Returning to the soil even part of the 150 to 400 million tons of dung now burned annually would help maintain soil quality and productivity. As deforestation progresses, such savings of biomass and dung will become even more important. In rural areas, improved stoves will also shorten the ever longer search for fuelwood. Finally improved stoves can rapidly and cost-effectively reduce an urban family's expense for cooking fuel, which in some areas is as much as one third of the family's income. For the foreseeable future, better stoves are potentially the most important energy project going for the poor of the world.

Attachment S-4-2, Page 1

OBSERVATION SHEET

Design What are major design features of your fire or stove (draft system, chimney, materials, etc.)

Starting the Fire

What problems did you encounter?

How long did it take for the fire to heat up?

Was there much smoke?

Did you use kindling?

Heating Water

How often did you add fuel?

Did the fire stay lit?

Was there much heat loss, if so where?

Was there much smoke?

Once boiling, could you easily maintain a boil?

SESSION S-5 **APPROPRIATE EDUCATION AND THE LEARNING PROCESS** (Optional)

TOTAL TIME: 2 Hours

OBJECTIVES:
* To help participants identify and examine their assumptions about the adult learning process
* To identify and discuss implications of these assumptions for Peace Corps training and future service

RESOURCES: Attachments S-5-1 and S-5-2

MATERIALS: Flip chart and markers

PROCEDURE:

Step 1 — 5 Minutes
Review objectives and rationale. Assign someone to observe the interaction of the group and someone to summarize the group discussions.

Step 2 — 10 Minutes
Ask participants to relax, close their eyes and try to visualize/imagine a past trainer, teacher or supervisor who treated them like a child. What did that person do to create those feelings?

Step 3 — 10 Minutes
Ask participants to individually complete the phrase: "Adults learn best by/when ________________." Rank these statements in order of importance.

Step 4 — 30 Minutes
Divide into 4 small groups and have participants share their answers to the above statement. Have each group list on paper each participant's most important assumption. It isn't necessary for everyone to agree to the participant's lists.

Step 5 — 30 Minutes
Post the statements and make an assumption scale under each statement.
Example:

Treated Like an Adult

Strongly Disagree	Neutral	Strongly Agree

Have participants rate each statement. Ask for clarification and examples. Discuss as a group.

Step 6 20 Minutes
Present handouts. While trainees read through them, summarize the handouts on a flip chart for the following discussion. Discuss handouts.

Step 7 10 Minutes
Wrap up: Discuss as a group the following questions: What do you expect as adult learners in this program? What non-formal education techniques and assumptions are you comfortable with?....uncomfortable with?

Step 8 5 Minutes
Summarize and review objectives.

Attachment S-5-1, Page 1

A SUMMARY OF CHARACTERISTICS OF ADULT LEARNERS

- Adults are at various stages of autonomy, and they exercise their autonomy in learning situations. The concepts about themselves directly affect their behavior and desire to learn.

- Adults have a broad base of experience upon which to draw and to share with others.

- Adults seek to learn what they have identified as important rather than what others deem important.

- Adults look to learning what can immediately be applied.

- Adults are problem-centered rather than subject-centered.

- Adults want to know if what they are asked to learn is relevant to their needs.

Attachment S-5-2, Page 1

TWO APPROACHES TO EDUCATION

KEY IDEAS	EDUCATION FOR CHILDREN	EDUCATION FOR ADULTS
1. Concept of the Learner	Generally dependent;unable to function well without constant outside control	Generally autonomous and self-directed; Usually able to function well with minimal external control
2. Role of the Educator	Provide solutions and prescriptions to problems and issues identified by educator	Help learners find own solutions to problems and issues
3. Role of the Learner's Experience	Not relevant or unimportant	Very important; rich resource for learning
4. Role of the Educator's Experience	Very Important; the most important resource for learning	Important; can be a significant resource for learning
5. Model of Learning	Prescribe, act and evaluate relative to prescription	Act, describe actions and explore alternatives
6. Key Sources of Information to Learner about Performance	Educator	Self, peers and educators
7. Source of Learner's Motivation	External rewards and punishments	Internal interests and desire to improve competencies
8. Readiness to Learn	Produced by personality and age	Develops from life tasks and roles, not a function of age
9. Time Orientation of Learner	Global future circumstances	Specific present competencies
10. Base lines for assessment and improvement	External standards/deficiencies of learner and prescriptions for how learner should behave (shouldism)	Self assessment of current competencies; self identification of existing strengths and areas for improvement (isism)

SESSION S-6 **SOCIO-CULTURAL AND TECHNICAL CONSIDERATIONS**

TOTAL TIME: 2 Hours

OBJECTIVES:

* To look at and discuss cultural and technical factors to consider before implementing an improved cookstove project
* To look at various approaches to a volunteer's role in project dissemination, with specific reference to stoves

RESOURCES: Attachments S-6-1, S-6-2, S-6-3, S-6-4

MATERIALS: Flip chart, markers

PROCEDURE:

Step 1 5 Minutes
Review session objectives and procedures.

Step 2 20 Minutes
As a group brainstorm and list factors, cultural and technical, to be considered before implementing an improved cookstove project. List these observations on a flip chart, taking the cultural factors first and then the technical ones.

Step 3 15 Minutes
Pass out Attachment S-6-1. Give trainees a few minutes to read these lists and compare them with the group's lists.

Step 4 20 Minutes
Briefly discuss different ways to approach dissemination of a new technology.

Trainer's Note

Before the session have the two articles available for the trainees to read. The trainer should draw out of the discussion these three different ways of introducing new technologies: extension, small business and show by example.

Step 5 30 Minutes
Divide into three groups and give out the case studies. Have each group develop a plan of action.

Step 6 30 Minutes
Reconvene as a large group and have each small group present their case study and plan. Discuss the different solutions.

Trainer's Note

The purpose of Steps 5 and 6 is to get the trainees to think about their approach to different types of situations, including foregoing stoves for a latrine project, if that's more suitable.

Trainer's Note

For a stateside training or an in-country technical language training, have the two articles on stove dissemination available ahead of time so the trainees have time to read them. For a two-week in service the trainer would need to summarize these articles, due to lack of lead time.

Attachment 3-6-1, Page 1

SOCIO-CULTURAL CHECKLIST

Fire: What functions does the fire have? (e.g., cooking, warmth, light, social focus)

Is smoke a problem?

Have there been incidences of burns or scalding accidents?

Is the cook exposed to too much heat?

Likes and dislikes about open fire cooking?

Fireplace: Where is the fireplace located? (indoors, outdoors, under shelter) Why? (e.g. protection from wind)

Are there seasonal variations in cooking location?

Does a different fireplace exist for special occasions or special uses?

Fuels: How is fuel acquired? (e.g. bought, traded for, collected)

Who supplies the household with fuel?

Where does fuel come from? Is it easily available?

What are fuel costs in time or money? Has this changed recently? At what rate are fuel prices, or the amount of time needed to collect fuel, increasing?

Seasonal variation in fuel supply?

Is fuel stored? How?

What fuels do urban populations use? The rich? The poor?

Likes and dislikes about available fuels.

Pots: Are pots well adapted to local cooking needs?

What are the other cooking utensils? (coffee can, wok)

Are cooking utensils locally made? Centrally manufactured? Imported?

What kinds of pots does the cook prefer?

Foods: What do people cook and eat?

What are staples? Specialty items?

Seasonal variations in foods eaten?

What is considered especially delicious?

What will ruin a meal?

How does the urban menu differ from the rural? Rich from poor?

Attachment S-6-1, Page 3

Cooking
Practices: Describe the order of cooking steps.

Is there a need for hot water? How much? At what time?

In what position do people cook? Is this their preferred cooking posture?

Are there cooking rituals?

Family: How many people live in this family? (Men? Women? Old people? Children?)

Are there freque. visitors?

How many people regularly eat together?

How large is the average family?

How is work divided in the household between the family members?

Who cooks? Who gets fuel? Be specific (e.g., two wives cook simultaneously in two kitchens)

Sex Roles: What is considered men's work or women's work around the house?

How do men and women interact? Men and Men? Women and Women?

Who works together?

Who builds houses? Granaries? Furnishings? Fireplaces?

Attachment S-6-1, Page 4

Are artisan skills limited to one sex? (e.g., pottery)

Are there exceptions to the rules?

Taboos and Rituals:	What sex role taboos are there in regard to working together, cooking and eating practices?
	What cooking and eating rituals are there? What food taboos?
	Are there fuel taboos? Material taboos? Shape taboos? Number taboos? (e.g., number 13)
Esthetics and Fun:	What colors do people like? What shapes? What adornments do they use?
	What colors, shapes or symbols do they dislike?
	To what do they give special care and attention? (e.g., living room, place of worship)
	What are important feasts? (e.g., baptisms, fairs)
Public Eating Places	What percentage of cooked food is prepared and eaten in public eating places?

Attachment S-6-1, Page 5

Statistical Information:

What proportion of the population lives in the cities? In rural areas?

At what rate are these populations increasing or decreasing?

Economic structure: where is a cash economy used? Where a barter system? Where and to what extent a mixture?

What is the distribution of wealth?

What is the rate of deforestation? Reforestation?

TECHNICAL CHECKLIST

Fire: How do people build fires? Why? Relate this to cooking practices. (e.g., small fire for simmering)

How many fires are used simultaneously?

What kind of fuel conserving practices are used? (e.g., windshields, cooking with retained heat.)

What happens to the fire and fuel after cooking?

Fireplaces: Make dimensioned drawings of the local kinds of fireplaces.

Are there indigenous stoves? Ovens? Kilns?

Fuels: What is used for kindling?

What is used for fuel? Seasonal variation?

Combustion characteristics of each fuel used. (e.g., straw burns fast and hot)

Measure fuel size, length, diameter. How much variation is there?

If the fuel is wood: what kind of wood? Is it used wet or dry?

Are there wood cutting tools?

What are the local ways of measuring fuel? What are the units? Is fuel measured by volume? By price?

How much does a local unit (e.g., "a bundle") weigh? Establish the average for each area you work in.

List possible alternative fuels. (e.g., agricultural wastes)

Pots: Make dimensioned drawings of the pots and cooking utensils.

How much variation is there in pot sizes? Do pots come in standard sizes? How exact are these sizes?

What materials are used for coking utensils? List their properties (e.g., clay pots; fragile, heat slowly).

Are lids used? If not, why not? What could be used as lids?

Are lids insulated? What could be used for insulation?

Cooking Practices: How long do commonly eaten foods take to cook? Measure, and draw up timelines.

Parameters: what foods require the shortest and longest cooking times? How long?

Note fire and heat requirements to cook different commonly eaten foods.

Measure the distance between the ground and the bottom of the cook pot.

Attachment S-6-1, Page 8

Available Materials: Local materials (e.g., sand, gravel, clay, straw, dung)

Recycled materials (e.g., old oil cans for sheet metal)

Imported materials (e.g., cement, steel)

Where are these materials available?

Are there preferred materials? Why? (e.g., people like cement because it is strong, and because it is modern.)

What other materials could be adapted to stove construction?

Skills Are there adobe and/or mud construction skills? Describe.

Are there potters? Describe their materials and technique. (e.g., how do they fire their pots? Do they use glaze? etc.)

Are there blacksmiths? Describe their technique. (e.g., is their furnace hot enough to permit welding?)

What other skills might be useful in stove construction? (e.g., are there local ways of waterproofing houses?)

Tools: What are a local mason's tools?
An adobe maker's?
A potter's?
A blacksmith's?

What tools and utensils could be adapted to stove construction? (e.g., machete can be used as metal cutter)

Attachment S-6-2, Page 1

EXCERPTS FROM "INTERMEDIATE TECHNOLOGY TRANSFER AND CULTURAL APPROPRIATENESS: THE CASE OF WOODBURNING COOKSTOVES IN UPPER VOLTA"

by Jonathan B. Tucker

Problems of Acceptance

Even if cookstoves can be made cheap enough to be within the reach of the poor, they will not necessarily be accepted by large numbers of people. As Nicolas Jéquier has pointed out, introducing new technologies into such deep-rooted human behaviors as food preparation and nutrition is an extremely complex task because it impinges on "spheres of human activity that are inherently very stable and that tend to be greatly influenced by traditions, ethical norms, religion, and taboos."

In a number of countries where improved cookstoves have been introduced, the stoves were at first widely adopted by the people. Two or three years later, however, when the extension agents returned, they found that the stoves were not being used; people were storing wood on them and using an open fire instead. A recent study of woodstoves by the National Academy of Sciences came to the disheartening conclusion that in no area where efficient cookstoves have been introduced has there been a significant, long-term improvement in fuel savings.

Why has this seemingly sensible effort failed so far to achieve its goals? Surprisingly, whether or not the stoves save a significant amount of wood does not seem to be the most important factor in their acceptance by villagers. Even if the stoves are efficient, the amount of wood they save is usually not dramatic, and it may take quite a while for the villagers to detect the reduced costs or labor. Hence they must like the stoves for reasons other than fuel conservation per se. Indeed, status or aesthetic appeal may outweight purely economic motives in some cases. For example, in Upper Volta people prefer cement stoves to banco (mud) stoves because of their appearance, even though banco is cheaper, more efficient, and easier to build. Experience has also shown that stoves are not accepted by housewives if they fail to take into account such factors as cooking methods (types of pots used, types of dishes cooked, cooking time, and type of wood employed), and cultural rules associated with cooking.

Nevertheless, most failures of acceptance appear to result from a rational calculation of <u>benefits foregone</u> in adopting the new technology. Western stove designers often overlook the fact that the traditional fireplace serves an entire complex of functions within its setting in addition to cooking food. If these extended or latent functions are not met by the new stove or provided by some alternate means, the technology is not likely to be accepted permanently.

Attachment S-6-2, Page 2

As described above, the main benefits of cookstoves is that they reduce wood consumption (if used correctly), eliminate smoke and its associated health hazards, prevent burns and scalds often suffered by the cook and her children, and pose less of a fire hazard. What, then, are the advantages of an open hearth that are foregone by the adoption of a cookstove?

The first drawback of cookstoves is their lack of flexibility. Whereas the three-stone hearth is portable, the massive lorena stove is fixed in one spot inside the house and cannot be moved. This factor is particularly significant in areas where cooking outdoors is traditionally favored during certain times of year. For example, women in southern India take pride in their kitchens and do all their cooking inside, but women in northern India prefer to move the cooking fire indoors or outdoors according to the season or convenience. As a result, these women object to the non-portability of efficient cookstoves. Moreover, in countries such as Upper Volta where polygamy is practiced, the two to four wives in each household can each have their own fireplace, but must share the same cookstove. The open fire is also more flexible in that women can use pots of any size, whereas the cookstove has holes of fixed size that may not fit the available pots.

A second drawback of cookstoves is their fuel requirement. Although the stove does save time and effort expended in the search for fuel by being more efficient, it is necessary to chop the wood into much smaller pieces in order to fit them into the stove, a process that is both laborious and time consuming. An open fire is also easier to light or to rekindle than the closed fire inside the stove.

Furthermore, there may be problems of construction and maintenance. Because cookstove design is fairly critical, it is not very tolerant of construction errors. For example, if the firebox is built too high, the stove may burn more than less wood. In addition, although improved stoves work well in the laboratory, out in the field things tend to go wrong. After a while the flues get clogged with soot or pieces of food, reducing the draft and causing smoke to back up out the front of the stove. The problem is that the users do not think to clean out the flue, even if they have participated in building the stove and understand how it works. One solution to this problem might be to establish maintenance crews that go around and clean stoves.

Finally, some people become disenchanted with cookstoves when the appearance of the stove worsens with continued use, particularly if aesthetics were a primary motive for adoption. For example, small cracks often appear in the surface of the stove after several months. Although these cracks have no effect on the functioning of the stove, villagers may conclude that the stove has broken and stop using it.

Design and Promotion of Stove Technology

Due to variation in local needs and cooking practices, the design of cookstoves must be adapted to the specific circumstances prevailing in nearly every village. The designer, before attempting to adapt or disseminate the technology, must therefore determine the technical and social aspects of current methods of food preparation and cooking. In this process, user participation is essential. The information can best be obtained by doing a detailed survey among the villagers of their cooking practices, cultural rules associated with cooking, fuel usage, and the diffusion of innovation in the community.

Most importantly, women should be encouraged to participate in the design and installation of cookstoves, so that the stoves are compatible with their needs and cultural preferences. For example, a number of architectural features, such as the height of the stove and the positioning and size of the pot holes, can be modified according to the user's request. Women in some cultures prefer to squat while cooking, whereas in other cultures they stand. (In Guatemala, however, where squatting is traditional, the women opted for waist-high stoves so that they would be able to stand. Although a lower stove requires fewer materials to build, a waist-high stove is more convenient to use and is safer if small children are present.) Since acceptance may depend on how much the cook feels involved in the decision-making process about her stove, this type of cooperative interaction is essential. In general, community participation in design and extension of cookstoves gives better results than a more "top-down" approach.

A key factor in the success or failure of a new technology is the way it is promoted. Because the population of Upper Volta is diverse, it seems likely that a range of both stove models and promotion techniques will be required to achieve the maximum possible diffusion of the technology. The designer also has to take political factors into account, such as the need to secure the approval of elites and the possible existence of interest groups that oppose the innovation. For example, local entrepreneurs who sell wood at high prices may profit from the fuel shortage, and hence may resist the introduction of more fuel-efficient stoves.

The first step in the promotion process is to determine how the stoves should be produced and distributed. Should they be constructed in the home, produced by industry for sale, or donated free of charge to the people? Often the appropriate mode of dissemination can be determined by sociocultural conditions. For example, Lorena stoves tend to be large and stationary, whereas manufactured stoves are relatively small and portable. The latter are clearly preferable when the population is mobile, or for city dwellers who must cook outside for reasons of space and health.

The next step is the training of large numbers of extension agents to bring the technology to the people. Because there is a severe shortage of skilled manpower in Africa, extensive training programs will be necessary if cookstove dissemination is to become self-sustaining after the handful of foreign consultants leave the country.

Although stove-extension training programs have been established in a number of Sahel countries, a major failing is that male participants have tended to dominate them, even though women are the primary users of the stoves. Indeed, women are rarely involved in extension work and almost never participate in the actual construction of the stove in the home. The main reason for this is a strong cultural awareness of sex roles in the Sahel countries. In Senegal, for example, attempts have been made to train women as extension agents. Although some women did participate, they insisted on waiting until male extension agents were also trained.

As suggested by the large number of acceptance failures of new technologies, the extension process is a difficult one. It must overcome a basic conservatism among rural people with regard to innovation that is entirely rational in view of the serious risks incumbent upon failure. In general, villagers are unwilling to change their traditional methods of food preparation unless a new technology is introduced that does not do violence to their sociocultural values and is perceived as being preferable to their present cooking arrangements. According to Ki-Zerbo, Voltaic villagers want to see how well the cookstoves work before deciding to adopt them. They may also entertain unrealistic fears about the technology, such as the belief that fires may erupt if the stoves are incorrectly employed. In view of such fears, it is essential to demonstrate the stoves, educate the villagers about their workings, and provide clear instructions concerning their use.

One problem with demonstrating the stoves is that they are basically an "invisible" technology, hidden away in the privacy of a family's kitchen. it is therefore difficult to promote the technology through the demonstration effect. One possible way around this, however, would be to provide efficient cookstoves for the cooking of fancy foods on sale in the village market. (In most areas, propane-gas stoves are used for this purpose.)

Modifications

The local people should be given the opportunity to modify the technology once it is in place, provided that the changes do not impair the fuel-efficiency of the stove. Experience in Guatemala has shown that villagers themselves often initiate the most appropriate adaptations, since they are naturally best attuned to their own needs. For example, Guatemalan Lorena Stoves examined after a year of use were found to have a large number of ingenious modifications, sometimes added by the builder and often by the owner. Typical additions included an external damper system, a sloping flue, a concrete bridge to prevent cracking, and a coating of clay-cement mix applied to the stove surface for improved appearance and durability. Ways should be found to test these adaptations and list them so that they can become widely available. The basic stove design must also have enough flexibility in it to allow for modifications and alternations by local craftsmen without significantly reducing its operational efficiency.

In addition to the dissemination of fuel-efficient cookstoves, other changes in food preparation techniques may be necessary if firewood consumption is to be reduced to sustainable levels. There is some evidence that villagers will modify their eating and cooking habits when fuel is scarce. For example, African women will soak legumes to reduce cooking time, or bake food in hot ashes instead of boiling it. In Upper Volta, people have started to eat rice instead of millet, even though rice is less nutritious and is not a traditional West African food. Part of the reason is that rice takes less time to cook. (It is also more productive per acre of cultivated land.)

Another way of reducing fuelwood consumption in Upper Volta would be to establish a food-processing industry at the village level that could render food-grains softer and faster to cook. For example, solar stoves might be used to steam newly harvested rice, removing the oils so that the rice lasts longer and is easier to hull. It might even be possible to process rice or millet on a village-industry basis to create a form of "minute rice" or instant hot cereal that does not require much fuel to prepare.

To sum up, development strategists have perhaps placed excessive faith in improved cookstoves as a panacea for deforestation. The problems with the technology are two-fold: it requires near-complete diffusion throughout the rural population to produce a significant reduction in wood use, and its acceptance is contingent on numerous complex sociocultural factors that may vary down to the village level. It therefore seems unwise to rely on cookstoves as a primary solution to the firewood crisis. Instead, improved cookstoves should be integrated with other programs aimed at satisfying basic human needs, and redesigned in such a way as to approximate the diverse benefits provided by the open hearth, without its drawbacks.

Attachment S-6-3, Page 1

STOVE DISSEMINATION

By Sam Baldwin

In large-scale dissemination of stoves, three rather disparate viewpoints must be considered—the donor, the urban dweller, and the rural dweller. These may also be thought of as the macro view, the micro cash economy, and the micro subsistence economy.

For the donor, the trade-offs of stove programs versus alternative fuel supplies must first be compared. One alternative is the fuelwood plantation. Plantations can cost $700–$800 per hectare to plant and have upkeep costs of ten percent of that per year in order to produce perhaps five cubic meters of wood annually. This is roughly half the annual wood needs of a family of 15. On the other hand, two improved stoves costing $5 with lifetimes of two years—a cost less than four percent of the annual maintenance costs of the plantation alone—could reduce this family's fuel consumption by the same amount.

A second alternative is to introduce fossil fuels to meet cooking needs. Even when subsidized, such efforts have so far shown limited success.

A subsidy of 50 percent, for example, would be needed to make butane gas cost competitive in daily use. In addition, the capital investment to buy a gas bottle and stove poses a considerable barrier to the low income urban poor.

If a stove program is to be launched, the donor must decide how and to what extent it will support stove dissemination activities. In the case of the lightweight stoves there are several potential savings. First, because of their rapid production and central quality control, lightweight stoves intrinsically require less donor support than massive site-built stoves. Secondly, because of their high thermal performance, lightweight stoves provide good feedback to the user (for example, too large a fire will quickly burn the food), which may reduce the need for extension activities to train users. Finally, the lightweight stoves can become established in the existing commercial sector as some traditional stoves already have, eventually eliminating the need for donor support.

For the moment, however, there is a need for donor support for stove activities. Designs must be optimized, production lines fine tuned, and publicity campaigns launched as for the marketing of any product.

The view of the urban dweller is similarly supportive of stoves. For many urban dwellers who buy fuel, the economics of these lightweight improved stoves would seem very encouraging. In addition, their portability is appealing to the urban renter. Although field testing is not yet complete, initial indications are, in fact, positive. In a follow-up of some 60 stoves distributed in preliminary tests in Upper Volta, all the stoves were used regularly and all the users were willing to purchase them. Longer and more detailed tests are now underway in Niger, Upper Volta, and Mali. In the first public exposition in which various lightweight and massive stoves were displayed side by side in Upper Volt, 282 lightweight models were sold in two weeks compared to just 67 massive concrete stoves and two massive mud stoves that had been the focus of several years of extensive publicity. It is important to note the great appeal of the metal stoves and the virtual absence of appeal of the mud stoves.

Market activities, now beginning in Upper Volta and soon to be followed in Mali, Mauritania, Niger, and Senegal, will demonstrate to what extent these stoves can become commercial successes in urban and eventually in rural areas.

The viewpoint of the rural dweller is considerably different from that of the urban dweller. In rural areas, wood fuel is not normally part of the cash economy (except to the extent that it is collected for sale in nearby urban areas). Instead, women and children collect fuel. Prevalent attitudes toward the value of women's work pose a considerable barrier to the marketing of a manufactured stove. Under such conditions a site-built massive stove may be more easily disseminated. Although even the best massive stove, such as the one-pot chimneyless banco stove, do not perform as well as comparable manufactured stoves, if they can be more widely disseminated they may provide important overall fuel economies nonetheless. Tests to compare the field performance and marketability of massive stoves versus manufactured stoves are now underway in rural Mali and planned for rural Senegal.

Sociological problems may still arise in these stove programs. In West Africa, hired cooks usually have the right to the charcoal remaining at the end of cooking on a wood stove. Further, in many areas, people use the charcoal produced in a wood fire to heat water for tea. High performance stoves produce little charcoal, which may be a hindrance. Other problems can sometimes be solved with rather minor modifications to the stove. For example, the national dish of Upper Volta requires vigorous stirring, under which lightweight stoves were sometimes unstable. Field tests indicate that the addition of $0.15 worth of materials to stabilize the pots appears to have solved the problem.

Improved stoves show tremendous potential to ease the expense and effort of getting cooking fuels for the world's poor and to reduce the consumption of biomass needed to maintain soil productivity. However, whether or not such improved stoves can be disseminated on a large scale depends on whether or not their increased efficiency is worth their increased cost and reduced flexibility. There will likely be a local and dynamic response - changing as conditions change. Use of the existing market system should prove relatively quickly whether or not these advantages outweigh the disadvantages at any given time in any given area. Work now in progress in West Africa should provide at least some of these answers.

Attachment S-6-4, Page 1

CASE STUDIES

1. You have been placed in a village of 1500 as a community development volunteer with the Ministry of Rural Development. Your immediate supervisor is in the county capital, 40 miles away. There is an electrical generator in the area, it runs when there is fuel. Some people have also piped in water to their houses, though most use huge barrels to catch water from rainfall. It is a tropical area, mostly subsistence agriculture. Rice is the main crop followed by beans and corn. Most of the cooking and heating for household use is done with wood. A traditional stove consisting of a U-shaped cement structure about 1' high is used. The wood is put into the middle of the U and a metal plate is rested on top. Thus a women can cook several things at the same time (i.e., tortillas, hot water and stew). Bananas, oranges and pineapple are grown, but not on a large scale. Most people have at least a grade school education. About half the village has latrines.

2. You have done 2 months of Renewable Energy Technology Training in the states and have been assigned to a regional capital, a town of 60,000 people. You work with the local Department of Forestry and are to set up a stove center and develop a prototype stove. The people cook almost entirely with wood in rural areas and half use wood and half use charcoal in the regional capital. Rural people use the three-stone fire and urban charcoal users have a charcoal stove made of fired clay. The area is rain forest with rice the primary crop. Women cook in separate buildings made of clay with thatched roofs.

3. You have been assigned to the National Renewable Energy Research Centre in the capitol to set up a stove testing and monitoring program. There is a stove dissemination program in operation and it has been going on for two years. Another Peace Corps Volunteer is the national coordinator and there are 20 nationals currently working to teach people in rural and urban areas how to make clay stoves for use with both charcoal and wood. To date no serious attempt has been made to test the efficiency of the models being introduced.

SESSION S-7 **SURVEY AND ASSESSMENT**

TOTAL TIME: 4 Hours

OBJECTIVES:
* To discuss and develop different types of surveys
* To practice surveying and analyze the results
* To discuss the process of developing and conducting a survey

RESOURCES: Assessing Rural Needs: A Manual for Practitioners
ACCION/AITEC
Attachments S-7-1, S-7-2, S-7-3, S-7-4
Peace Corps Rural Energy Survey

MATERIALS: Flip chart, markers, notebooks, pencils

PROCEDURE:

Step 1 5 Minutes
Review the objectives and procedure to be followed

Step 2 25 Minutes
Review different types of surveys.

Trainer's Note

For general information gathering or specific needs (fuel type and cost, current stoves used, etc.) trainer can refer to the attached sample surveys or Assessing Rural Needs.

Step 3 30 Minutes
Divide into groups of two to three participants and begin developing questionnaires. Different areas that can be investigated are: marketing of an existing stove; fuel use/cost; or cooking practices

Step 4 1 Hour 30 Minutes
Conduct the survey (depending on the training site, the survey may require more time)

Step 5 30 Minutes
Reassemble and have each group compile and summarize their information

Step 6 45 Minutes
Have each group give a five minute presentation

Step 7 15 Minutes
Discuss how the surveying process went with reference to: approaches that worked, problems, approaches tried, but changed.

Attachment S-7-1, Page 1

QUESTIONNAIRE DEVELOPED BY THE "Programme Cuisinieres Ban Ak Suuf" CERER, Dakar Senegal

Key: CH = Control Household

1H = First Household

Surveyor____________

Date____________

CH	1H	2H	3H	4H

Village 1 neighborhood____________

Last name and first name of head of family:____________ __ ____________

Ethnic Group ____________

Principle activity of the head of the household:

Number of wives:________ Number of Children________

\# of Children 0-3 yrs______

Number of people eating in the household:________

Money making activities done by the wife (wives):

Personal fields _____ Pottery _____

Gardening _____ Weaving _____

Small Commerce ___ Hairdressing _____

Others ______________________

1. Who prepares the family meals? Head of House____ Child____

   Parent ____ Maid ____

   Sex: M__ F__ Age ____

2. When there are several wives how do they divide meal preparation?

Attachment S-7-1, Page 2

3. Where do they cook:

		Dry Season	Rainy Season	Why
In the entrance way				
In an open air courtyard	in the shade			
	in the sun			
In the courtyard under a shelter				
In a cooking hut				
In the family dwelling				

4. Do co-wives use a common kitchen?

   If no, list the number of and uses for the different kitchens.

5. What do they cook on?

   3 rocks

   Metal stove (give local name)

   Others

   How long has this method been used?

6. For the metal stove, is it necessary to frequently repair or replace it?

   How much does one cost?

7. For improved cookstoves, did the cook participate in the construction or placement of her stove?

   If yes, list what the woman did:

Attachment S-7-1, Page 3

8. What fuel does the cook use to prepare the meals?

9. Who provides the family with fuel?

	Dry Season	Rainy Season	Men	Women	Children
Wood					
Millet Stalks					
Peanut Shells					
Cow Manure					
Charcoal					
Kerosene					
Gas-bottled					
Others					

10. What price does the cook pay for fuel?

a. How far does she go to find fuel? ____________

How long does it take? ____________

How many times per week? ____________

b. How much is spent on buying fuel?

_____/day _____/week _____/month

_____/kilogram _____/liter _____/bottle

11. In reference to the fuels used by the cook:

— which is least expensive? ____________

— which one cooks the fastest and with the least bother? ____________

— which does the cook prefer and why? ____________

Attachment S-7-1, Page 4

12. What bothers the cook most when she cooks:

— the heat

— the smoke

— the constant attention to the fire and the cooking pot

— the bent-over cooking position

— others

13. How does the cook start the fire?

Does she use straw?_____ Kindling?_____ Paper?_____ Kerosene?_____

Does she fan the fire to make it burn faster?____________________

What does she use to fan it?____________________________________

14. What does she do with the cinder and ashes once she is finished cooking?

Attachment S-7-2, Page 1

EARTHEN COOKSTOVE

CH	1H	2H	3H	4H	5H

Surveyor:____________________ Village:____________________

Date: ____________________ Region:____________________

Model Dimensions in cm.

C1	H h_1 h_2 h_3		D d		L			
C2	H1 H2 h_1 h_2 h_3 h_4		d1 d2 d3 d4		L1 L2 L			

Attachment S-7-2, Page 2

COOKING POTS USED DURING THE TEST

CH	1H	2H	3H	4H

Surveyor: ______________ Village: ______________

Date: ______________ Region: ______________

Model | Dimensions in cm.

M1	H D		M3	H D	
M2	H1 H2 D		M4	H1 H2 D	

Other Models: (design and dimensions)

HOUSEHOLD COOKING SURVEY FORM

Breakfast/Lunch/Dinner

Additional Information on
the Control Household (CH)

Surveyor________________

Date ________________

Village________________

Region________________

	Starting the Fire		Reducing the Fire		Opening the Cooking Pot			Is there burnt food at the bottom of the pot?	After Cooking the Meal does the cook put another pot on the fire? Why?
	Hour	Length of time	Hour	Length of time	Hour	Length of time	Why?		
MON									
TUES									
WED									
THURS									
FRI									
SAT									
SUN									

Attachment S-7-3, Page 1

HOUSEHOLD COOKING SURVEY FORM

Breakfast/Lunch/Dinner

Surveyor__________ ____ Village________________

| CH | 1H | 2H | 3H | 4H |

Date ______________ Region________________

# of People	Type of Meal	How much was Prepared	Length of Cooking Time	Type of Fuel Name/ Dimensions	initial Amount	Amount Left/ not used & cinders/ashes	OBSERVATIONS
MON							
TUES							
WED							
THURS							
FRI							
SAT							
SUN							

Attachment S-7-3, Page 2

Attachment S-7- 4, Page 1

VILLAGE ENERGY SURVEY FORM

Village: ____________________

Date. ____________________

TRADITIONAL FUEL

1. What traditional fuels are used by the villagers?

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Firewood				
Charcoal				
Dung				
Agricultural residue				
Candles				
Other ____________________				

2. What traditional fuels are sold in the village?

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Firewood				
Charcoal				
Dung				
Agricultural residue				
Candles				
Other ____________________				

3. On the average, what distance do villagers have to travel to obtain firewood?

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Firewood is not used				
Less than 1 kilometer				
1-5 kilometers				
6-10 kilometers				
More than 10 kilometers				

Attachment S-7-4, Page 2

Village: ____________________

Date: ____________________

COMMERCIAL FUEL

4. What commercial fuels are used in the village?

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Gasoline				
Kerosene				
Propane				
Diesel fuel				
Other ____________________				

5. What fuels are sold in the village?

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Gasoline				
Kerosene				
Propane				
Diesel fuel				
Other ____________________				

6. What is the cost for each of these fuels? Specify the unit by which the fuel is sold.

Unit	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Gasoline ______________				
Kerosene ______________				
Propane ______________				
Diesel fuel ___________				
Other ____________________				

7. If they are not sold in the village, how far do villagers have to go to obtain them (in kilometers)?

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Gasoline				
Kerosene				
Propane				
Diesel fuel				
Other ____________________				

Village: ____________________

Date: ____________________

8. During the reporting period, how would you describe the availability of each of these fuels in the village? Place the number corresponding to the most accurate response in the appropriate box.

   1. Always available
   2. Almost always available
   3. Occasionally available
   4. Seldom available
   5. Never available

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Firewood				
Charcoal				
Dung				
Agricultural residue				
Candles				
Gasoline				
Kerosene				
Electricity				
Propane				
Other ____________				

TIME PERIOD

9. During this reporting period, what have the weather conditions been?

Mild/rainy				
Hot/dry				
Hot/rainy				
Mild/dry				

Village: ____________________

Date: ____________________

TRADITIONAL FUELS

10. How are traditional fuels sold — by bundle, by kilo, by liter, by piece, etc. Please describe.

11. What is the price of each of the traditional fuels? Specify the value by unit sold in U.S. dollars — for example. "A bundle of firewood weighing approximately 20 kilograms costs $.53."

12. Describe the location of the sources of firewood in the area, e.g., distances from village, size of wooded area, type of area — Savannah, forest, etc.

13. What types (species) of trees are found in the area? Are all types used for firewood? What parts of the trees are collected? Is the wood that is collected used green or is it dried first? What is the predominant species of trees used? What is the preferred species?

Attachment S-7-4, Page 5

Village:____________________

Date: ____________________

AVAILABILITY OF FUELS

14. Which fuels do villagers see as most crucial to meeting daily needs? Why?

15. If particular fuels were not available at various times during this quarter, please explain why.

16. Have villagers made efforts and/or recommendations to alleviate problems due to fuel scarcity or unavailability? Specify the nature of any such efforts.

17. If some fuel pric have risen faster than others, describe which ones and, if you can, why.

Attachment S-7-4, Page 6

Village: ____________________

Date: ____________________

18. Are there fuels used in the village that were not used 10 years ago? Please describe. For what purposes are they used?

19. Would villagers prefer to use different fuels than they are presently using to meet their daily needs? Which ones? Why?

TIME PERIOD

20. What is the average monthly temperature for the early morning? Noontime? Late evening? What are the ranges of temperature, day — night?

SESSION S-8 **STOVE COMBUSTION THEORY**

TOTAL TIME: 3 Hours

OBJECTIVES:
* To discuss the five basic cooking methods.
* To learn the basic principles of combustion and heat transfer, using observations made in Session 4 and by experimentation.
* To discuss the effects of combustion on the design of improved cookstoves, considering different building materials, fuels and cooking methods.
* To examine and evaluate several different cookstoves.

RESOURCES: "Stove Design," S. Baldwin, VITA News, January, 1984
Cookstove Handbook, TATA Research Institute
Modern Stoves for All, pgs. 12-18
Wood Conserving Cookstoves, VITA/ITDG, pgs. 9-19, 29-5?
Attachments S-8-1 through S-8-4

MATERIALS: Flip chart and markers, sample stoves and slides, if possible, and reflective, absorptive and insulating materials

PROCEDURE:

Step 1 — 5 Minutes
Review objectives and procedures.

Step 2 — 30 Minutes
Ask the trainees to refer to Session #4 and the observation sheet. Brainstorm a list on how heat is transferred.

NOTE: After the opening discussion refer to Modern Stoves for All, pgs. 12-13 and Wood Conserving Cookstoves, pgs. 9-15 to explain combustion.

Trainer's Note

Have trainees read these assignments before the session.

Step 3 — 25 Minutes
Brainstorm a list of stove parts and discuss how each part affects combustion. Look at the differences between metal and earthen, ceramic stoves.

Trainer's Note

Use Modern Stoves, pgs. 15-18 and Wood Conserving Cookstoves, pgs. 15-19 as references.

Step 4 40 Minutes
Introduce the modes of heat transfer: radiation, conduction and convection, using handouts and sample materials which exhibit these properties. Expose these materials to a fire, and demonstrate the principals by having participants feel the different phenomenon.

Step 5 10 Minutes
Have the trainees brainstorm and compare a list of the advantages and disadvantages of earthen, ceramic and metal stoves based on the principles of combustion and cooking methods used.

Step 6 30 Minutes
Break up into three groups: metal, ceramic and earthen, and assist the groups in developing a conceptual design of each type of stove identifying important factors and parts of each stove type. Discuss ways to make stoves more efficient.

Trainer's Note

Use Wood Conserving Cookstoves, pgs. 29-54 as a reference. Use Stove Catalogue and Individual Stove handouts, stove scenario sheet attachments.

Step 7 30 Minutes
Have groups report back.

Step 8 10 Minutes
Review objectives and highlight examples that meet the objectives which were discussed during the session.

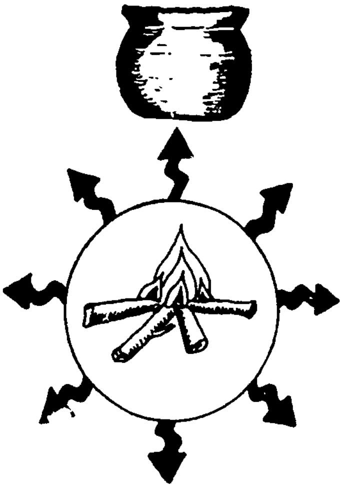
Trainer's Note

In order to present this session in a manner that does not lose the non-technical participants, begin the session with a discussion using examples which all trainees are familiar with and progress slowly to Step #4, at which time most of the combustion theory should be presented in a thermodynamic format. The trainer can expect some non-technical participants to experience frustration during this session and must be prepared to reinforce the technical principles using alternative examples. Having participants analyze an operating stove may help clarify heat transfer concepts.

Trainer's Note

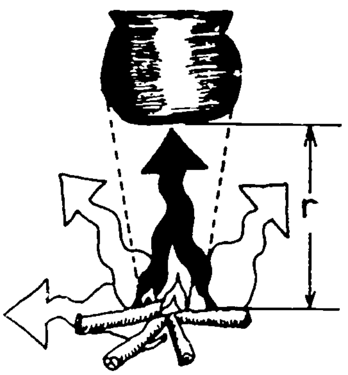
Take a break after Step #4 if schedule is maintained.

MODES OF HEAT TRANSFER

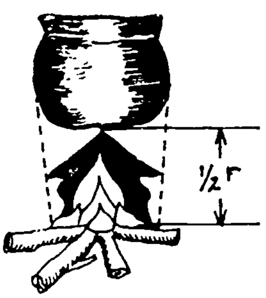


RADIATION

Radiant energy is emitted from all objects and does not become perceptible heat until absorbed on the surface of another object. It is a form of electromagnetic energy as is light, and they are both transmitted by wave-like action through air. Movement of air, "convection", has no effect on the energy emitted from the object. Radiation is the primary method of heat transport for charcoal fuels.



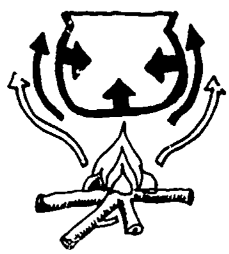
Radiation is emitted equally in all directions and travels in a line of sight or straight line. An object moved twice as close to a radiant heat source (e.g., a fire) receives four times as much radiation. (The intensity of radiative heat is inversely proportional to the square of the distance "r" between the source emitter and the receiver).



Radiation increases dramatically with temperature. If the differences in absolute temperature between an object and its environment is doubled, radiant heat transfer will be increased by approximately sixteen times. (The radiant heat surface transfer increases as the fourth power of the temperature of the emitter).

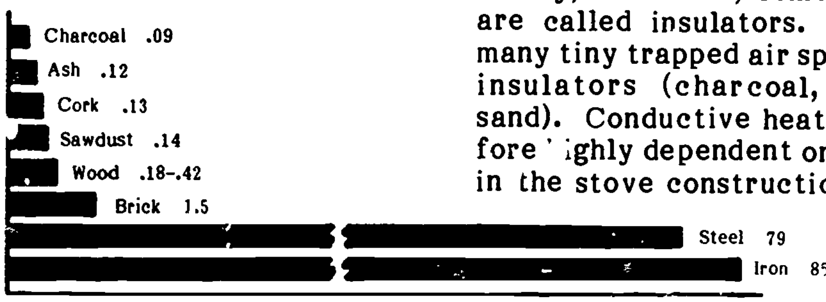
Attachment S-8-1, Page 2

MODES OF HEAT TRANSFER



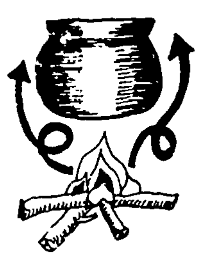
CONDUCTION

Conduction is defined as the movement of heat through solid materials by molecular action. Heat flows rapidly through good conductors like steel or aluminum (metal). Materials which conduct heat slowly, like wood, cement, clay and sand are called insulators. Substances with many tiny trapped air spaces are very good insulators (charcoal, sawdust, straw, sand). Conductive heat losses are therefore ' ighly dependent on the material used in the stove construction and its design.



THERMAL CONDUCTIVITY

CONVECTION



Convection is defined as the transfer of heat by the .ovement of a viscous media (e.g., a gas or liquid) and is the primary method of heat transfer of wood, dung and peat fuels (not charcoal). For example, when air is heated it rises and is replaced at the heat source by cooler air. The continued rising of hot air that is displaced by cooler air is called an open convective loop. This type of heat transfer is called natural convection and occurs because the buoyancy of the heated air is greater than cooler air since it becomes less dense as it expands. Heat carried away from hot objects by mechanically induced air currents (e.g., fans) is called forced convection, or advection. In nature forced convection is when a breeze causes hot air to move with the prevailing current.

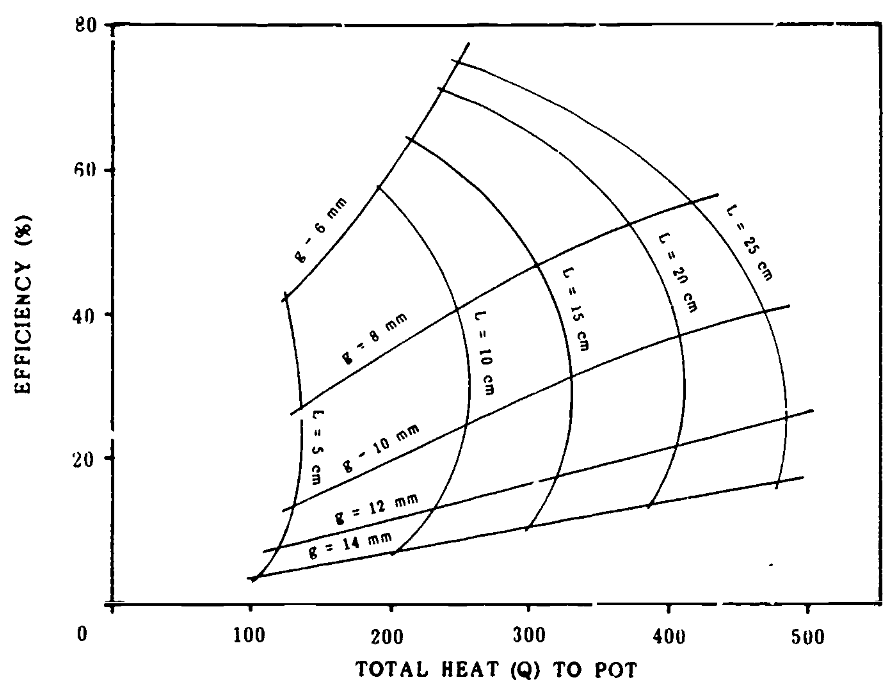
Air heated by combustion or by contact with the flames of a fire will rise in still air transferring its en 'rgy to the surfaces it contacts (e.g., stone wall, pot). Energy not transferred in this manner is lost to the atmosphere. Therefore, the efficiency of a wood fuel stove depends greatly on the efficient movement of heated air within the stove.

Attachment S-8-1, Page 3

CONVECTIVE HEAT TRANSFER

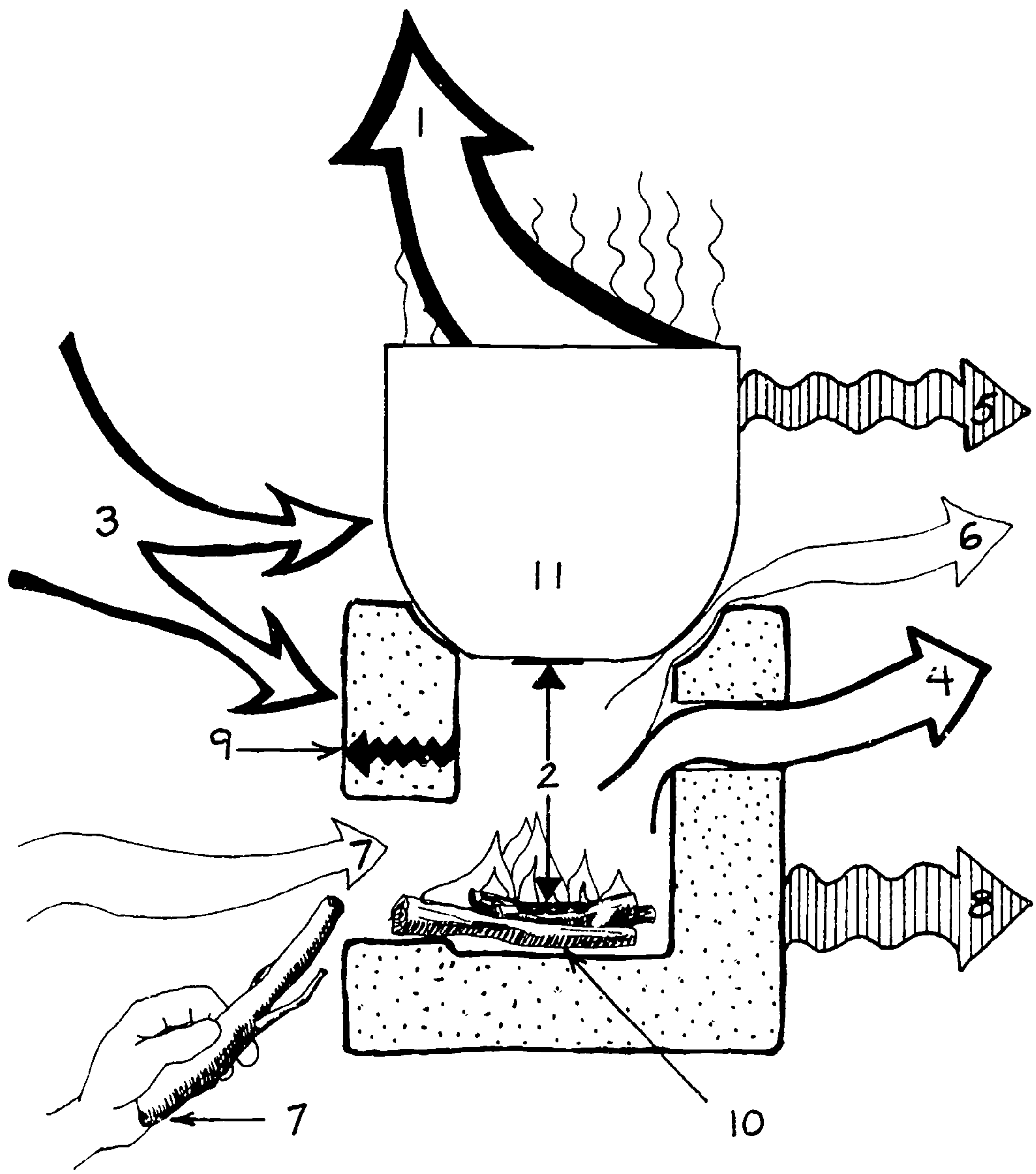
Increasing convective heat transfer from the hot gases to the pot is the single most important way to improve a stove's performance. An open fire exposed to the wind can be extremely wasteful. As soon as the fire is put inside a kitchen or a protected area, its efficiency increases dramatically by approximately 17 percent. To increase efficiency further, it is nesessary to expose the entire surface of the pot to the hot gases, forcing the gases against the sides of the pot. If the walls are built around the pot we ask how close they must be to improve stove performance significantly — 10 cm? 1 cm? 1mm? At 10 cm, there is no appreciable forcing of hot gases against the wall. At 1 mm, there is not enough room for the smoke to pass, and the fire dies. Experiments and calculations indicate an optimum value in the range of 4 to 8 mm, depending on the size and shape of the pot. It is preferable to keep this gap as small as possible without choking the fire or having too much smoke escape out the door.

In the graph below we see that the efficiency of convective heat transfer increases very radidly with the pot to wall gap "g" and only slowly with the channel length "L". It is also important to note that one may often have a trade-off between the efficiency and the heating rate. Long narrow gaps can have very high efficiencies but low heating rates compared to wider gaps. This means that a compromise must sometimes be made between fuel consumption and the patience of the user in bringing a pot to a boil. In addition, the sensitivity of the efficiency of the pot to wall gap requires precise control of dimensions -possible only through mass production-and the careful matching of stove to pots.



Attachment S-8-1, Page 4

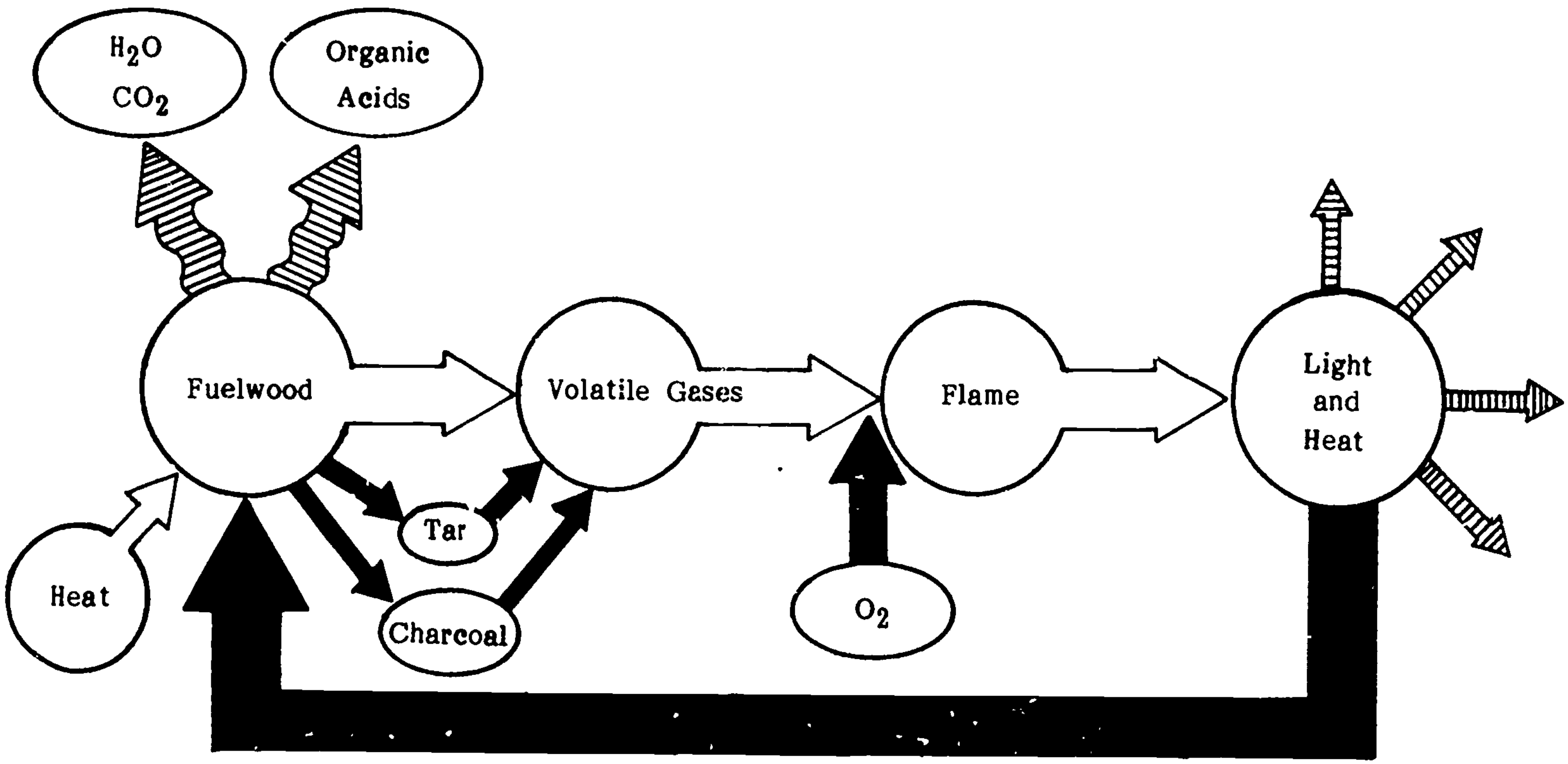
COOKSTOVE HEAT LOSS DIAGRAM



Heat Loss Parameters in order of Declining Importance
for the Generalized Stove Situation

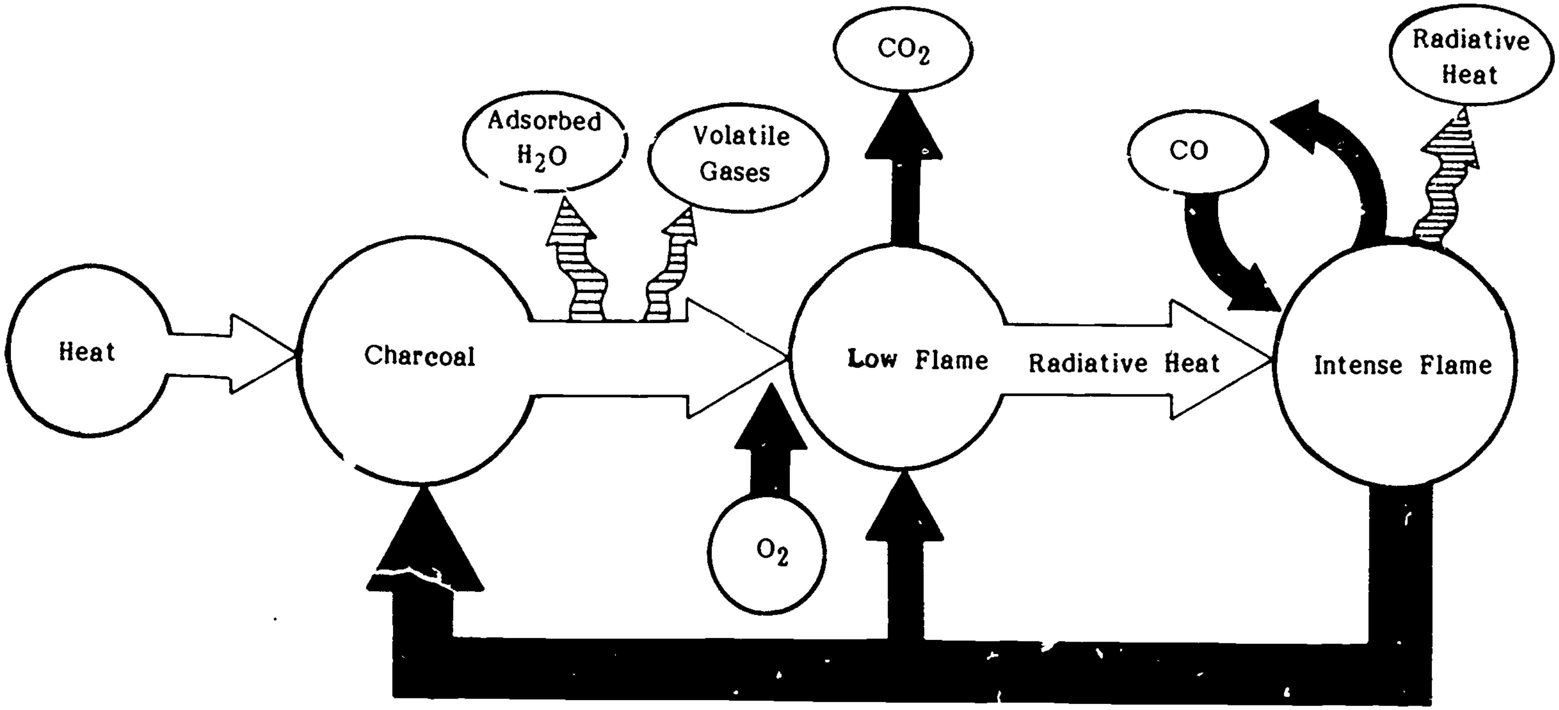
1. Evaporation
2. Distance From Fuel to Pot
3. Convective Loss from Wind
4. Unburned Volatile Gases
5. Radiation from Pot
6. Poor Seal at Pot/Stove Interface
7. Cool Combustion Air or Fuel
8. Radiation From Stove
9. Conduction Through Stove
10. Wet Wood
11. Pot Contents

DIAGRAM OF THE WOOD COMBUSTION PROCESS



Combustion Phase	← Dehydration →	← Decomposition →	← Primary - Secondary Combustion →
Temperature Range °C / °F	100 / 212	150 / 300; 225 / 440	300 / 570; 400 / 750
Observations	Cool Grey/Brown Smoke	Lighter Hotter Smoke With Odor	Peak Combustion Turbulent Flame - Little Smoke or Odor

DIAGRAM OF CHARCOAL COMBUSTION PROCESS

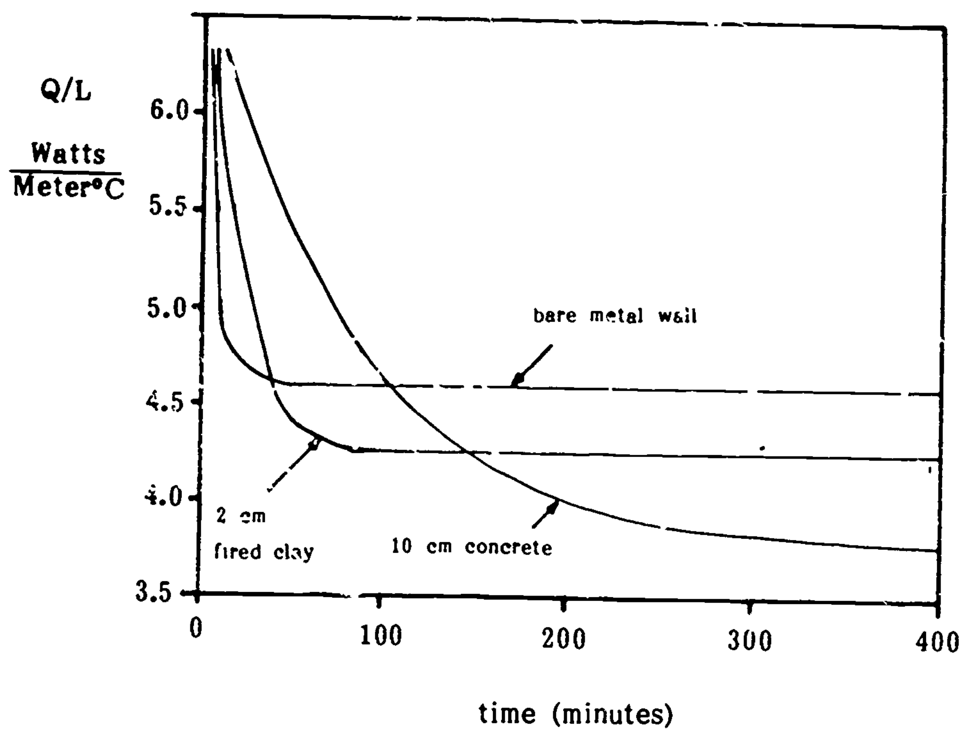


Combustion Phases	← Fuel Heat Up →	← Primary Combustion →	← Secondary Combustion →
Temperature °C	500	700	1000
Temperature °F	950	1300	1850
Observations	Smoke/Odor from Fuel	White Ash Forms; Intense Radiative Heat; Stove Limits	Not Occur In Cookstoves; Radiative Heat Increases

Attachment S-8-3, Page 1

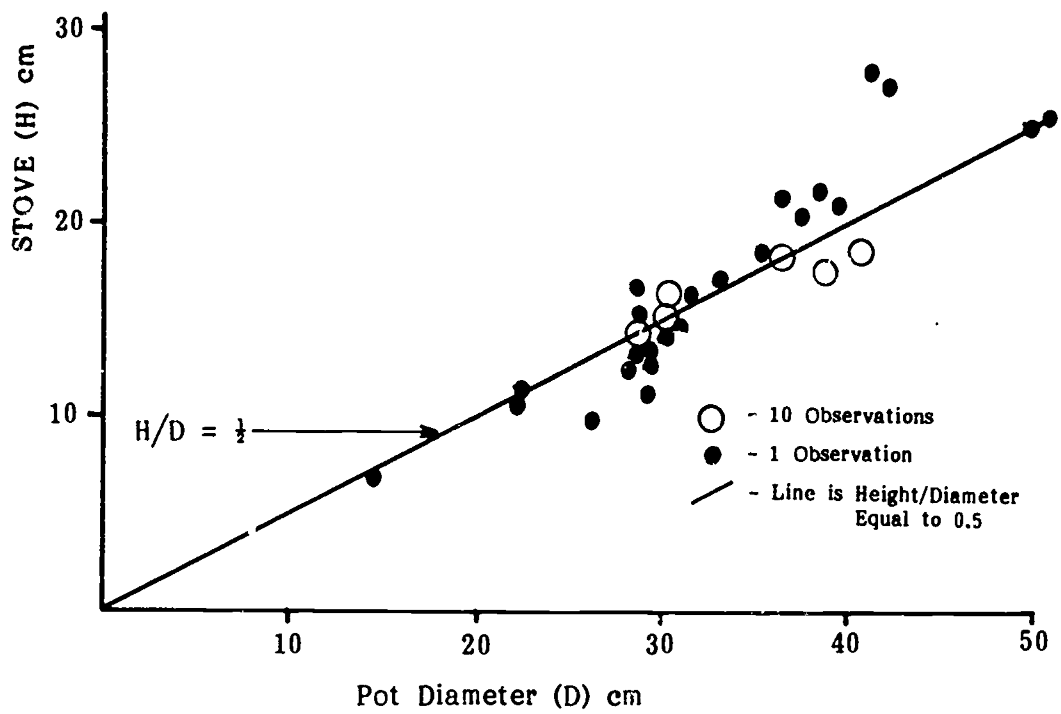
HEAT LOSS INTO AND THROUGH STOVE WALLS

(Stove Diameter is 20 cm)



Attachment S-8-3, Page 2

RATIO OF STOVE HEIGHT TO POT DIAMETER FOR A WIDE RANGE OF TRADITIONAL STOVES



Attachment S-8-4, Page 1

STOVE DESIGN RULES OF THUMB

Fuel:

Different fuels exhibit different combustion and heat transfer characteristics and different energy values.

Fuel	Primary Method of Heat Transfer	BTU/Lb Energy Value Range
Wood	Convection	7,400 - 8,600
Charcoal	Radiation Convection, Phase I	1,200 - 1,400
Dung	Radiation, Phase II Convection, Phase I	3,800
Kerosene	Convection	19,200

Fuel	Distance for Pot (cm)	Thickness of Fuel (cm)
Wood	8 - 18 (variable)	7 diameter
Charcoal	2 - 5	3 - 6
Dung	4 - 7	12 - 20
Kerosene	4 - 6	N.A.

SESSION S-9 **HYPOTHETICAL STOVE DESIGN**

TOTAL TIME: 2 Hours

OBJECTIVES:
* To look at the importance of user involvement in stove design
* To practice designing and presenting improved cookstoves

RESOURCES: Attachments S-9-1, S-9-2

MATERIALS: Flip chart, markers and props for a role play (i.e., dress, cooking pots, etc.), handouts

PROCEDURES:

Step 1 — 5 Minutes
Introduce the objectives and procedures.

Step 2 — 30 Minutes
Explain that the staff will be role playing the part of cookstove users. Divide the trainees into groups and give them 10 minutes to develop questions they wish to ask. They will use the answers as a basis for designing a stove. The role play will last 10 minutes and at the end, each group will summarize their results.

Trainer's Note

Included are three different situational role plays. These can be used or others substituted.

Step 3 — 30 Minutes
Practice designing stoves by using the information from the role play. Emphasize that this is not an exercise in frustration, but a first opportunity to design a stove.

Step 4 — 30 Minutes
Present the designs and discuss different options.

Step 5 — 25 Minutes
Conclude the session by handing out Attachment S-9-2 and discussing how to use it in the design process.

Attachment S-9-1, Page 1

HYPOTHETICAL DESIGN SITUATION #1

Semi-urban area. Dry, arid climate with 3-month rainy season. Most of the year cooking is done on the patio outside the cooking hut. When it rains, the cook moves inside. Charcoal is the primary source of fuel. It costs $.05 a kilo. A metal stove is used to cook on. Rice and sauce is the noon and evening meal. Sometimes the rice and sauce are cooked together, sometimes separately. Breakfast is coffee and bread. The current stove costs $2.00 and lasts a year and a half. An average of 8 people eat each meal.

HYPOTHETICAL DESIGN SITUATION #2

Tropical rain forest. There is a 4-month rainy season. Cooking is done year round in a clay-walled structure with palm bough roof. There is usually a doorway that is open and 2-3 very small openings for ventilation. There is a shelf above the fire on which rice is stored. The smoke from the fire helps to keep insects away. Wood is the primary source of fuel. Wood is readily available and is fairly large. The morning meal is coffee and leftover rice. The noon and evening meals consist of rice and fish. They are cooked separately and sometimes a leaf sauce is also prepared. The rice and sauce are cooked in 10-15" diameter aluminum pots and the fish is cooked in a round bottomed clay pot 8" in diameter. The fish is fried in hot oil. An average of 10 people eat each meal.

HYPOTHETICAL DESIGN SITUATION #3

Sub-tropical, humid area with an average rainfall of 150 cm. per year. It rains year round. Cooking is done inside in a designated "kitchen area" using a three-stone fire. Fuel used for cooking and heating purposes is exclusively wood. The morning and evening meals are fried tortillas served with hot tea or boiled milk. The tortillas are cooked in a large frying pan, the milk boiled in a large sauce pan and the tea heated in a very large teapot. The mid-day meal is always cooked in a very large pot and consists of either beans and rice or beans and noodles. Fires are used to heat the kitchen during the 3-month long winters. An average of 6 people eat each meal.

Attachment S-9-2, Page 1

FOOD AND COOKING PRACTICES

Taken from: <u>Helping People in Poor Countries Develop Improved Cookstove Programs,</u> GATE

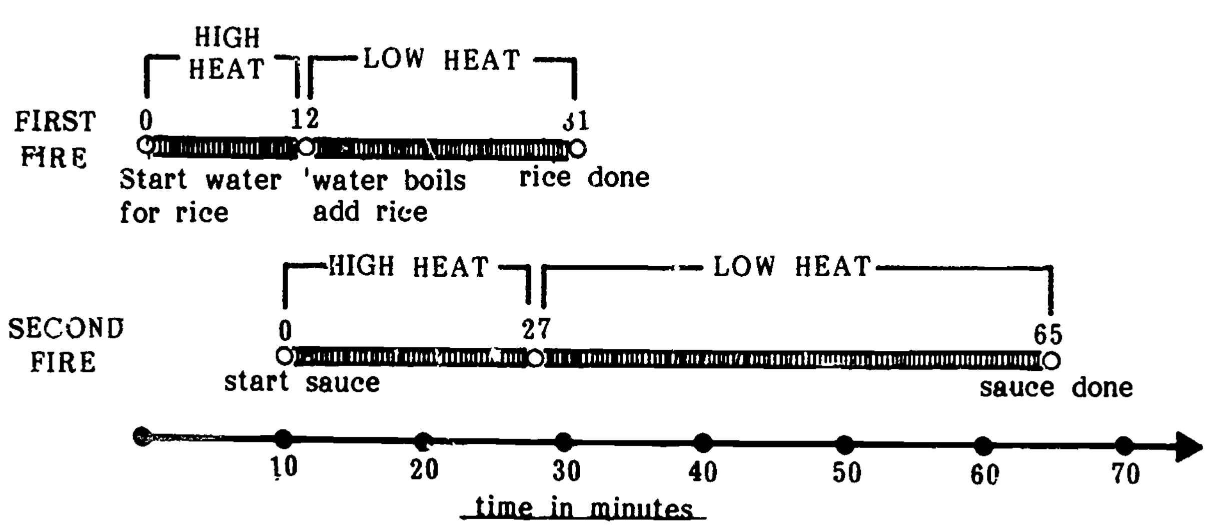
When investigating culinary traditions, explore the range of foods, when they are prepared in the community and in individual households. When is the morning meal cooked? When is it eaten? What is eaten for other meals, snacks, special occasions? What is never eaten? Note staple foods as well as specialty items, baby food and medicines. Treats and foods sold on the street are worthy of special attention; a stove that can prepare these favorites may be more likely to become popular.

It is also important to find out what will ruin a meal and design stoves accordingly. It may me unthinkable to serve a mushy grain or tepid food. A Guatemalan sand/clay stove became thoroughly unpopular in one area because it had a habit of producing sandy tortillas - the local materials had not been properly analyzed to see if they were suitable.

You should become thoroughly familiar with the preparation of common foods. Remember that these are not necessarily the foods you are being served; it is the custom in many cultures to prepare a special dish for a guest. If you were invited to an American home you might well get the impression that all Americans eat barbequed steak and that cooking is done on a charcoal grill by the men. Where local etiquette permits it, learn how to prepare the staples in the traditional manner. This will teach you the important order of cooking steps, how much heat or stirring is needed to cook without burning, and any special tricks to ensure that the dish will be just right. A stove design must fit these local cooking needs very closely.

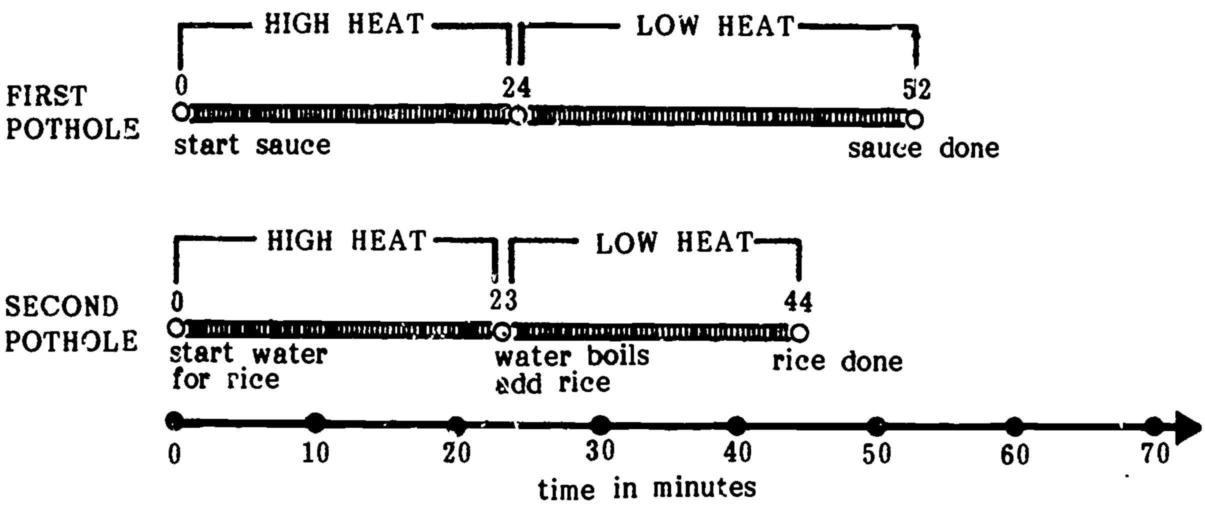
Measure how long each dish takes to cook, and note what heating level is required.

Cooking Timeline #1



Cooking Timeline #1 and #2 are examples of timelines you might observe somewhere in West Africa, but for different pot sizes. Note that the rice requires a much shorter cooking time than the sauce. Would the cook like the rice and the sauce to finish at the same time, while using only one fire? If so, a two-pot stove could be developed that places the sauce pot over the fire box and the rice pot next in line. In this way, the rice water heats up slowly while the sauce begins cooking and both will be done at about the same time.

Cooking Timeline #2



What is warm water used for in the area? How much of it is needed daily, and at what times of the day? Are there seasonal variations? Even in the tropics, large quantities of hot water are sometimes used for bathing, consuming huge amounts of wood. A multi-pot stove, for example, might be designed to include a permanent hot water vessel to ensure a ready supply of hot water, heated without having to light a separate fire.

If cooking is done on an open fire, the cook will most likely squat, stoop or sit on a low stool. Find out if this is the preferred cooking position, or would standing make the task more comfortable? A stove does not have to be at ground level; it can accommodate individual or cultural preferences.

How large and heavy are the pots? In West Africa, where families are large, the biggest pots are 60 cm in diameter. Care should be taken in determining the best height for a stove that is to accommodate very big pots. If the stove is too high, it may be difficult to lift a pot full of food. The stove could also have additional surface area so food could be served without having to set the pot on the floor.

SESSION S-10 **EARTHEN STOVE DESIGN AND SOIL ANALYSIS**

TOTAL TIME: 2 Hours

OBJECTIVES:

* To review the rules of thumb and their effects on stove design
* To design a clay cookstove based on knowledge of the country or region where the trainee is to be assigned
* To discuss soils and understand the characteristics of good mixes
* To make three test bricks using different clay/sand ratios

RESOURCES: Soils Testing Rules of Thumb and Construction Sequence sections, Lorena Book, pgs. 20-50
Wood Conserving Cookstoves, pgs 50-53
Attachments S-10-1, S-10-2

MATERIALS: Paper, pencils, clay, sand, water, buckets, shovels, trowels, screen for shifting, blocks for base, wooden form for block making

PROCEDURES:

Step 1 5 Minutes
Review objectives and procedures.

Step 2 15 Minutes
Review rules of thumb and construction sequence. (Refer to the above listed references).

Step 3 40 Minutes
Design a stove, in groups of no more than 5 people. It is a good idea to have the trainees think about these designs in advance.

Step 4 15 Minutes
Discuss soils testing using the information in Attachment S-10-2. Briefly discuss different types of soils and the properties needed for a good stove mix. Discuss where clay is usually found.

Step 5 15 Minutes
Do the pencil test, the shine test and the fired clay ball test to demonstrate how to determine if there is sufficient clay in the soil to use for making stoves.

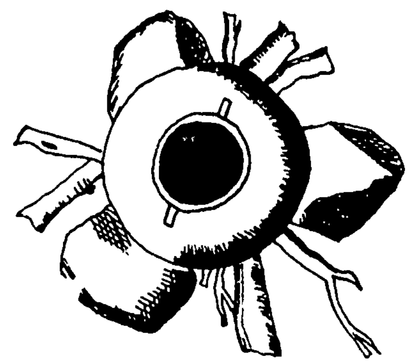
Step 6 30 Minutes
Make test bricks using different clays and different clay/sand ratios (i.e., 1:2, all clay, 1:4). Make bricks about 15 cm wide x 25 cm long x 10 cm high. A form can be made of wood. Let the bricks dry in the sun.

Trainer's Note

Explain that this is not an exact science, just an initial test. Too much clay and the brick will crack. Too much sand and it will be flaky. Check bricks at the start of the construction session.

Attachment S-10-1, Page 1

TRADITIONAL THREE STONE OPEN FIRE



PARTS

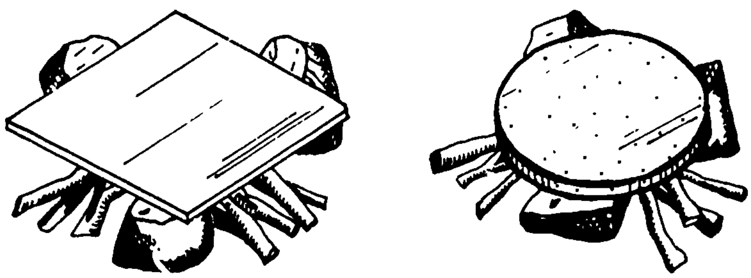
Three Large Stones and a Cooking Pot

Stove Scenario

Origin:	Throughout Third World
Construc. Materials:	Stones
Efficiency Range:	3-6% (Measured)
Primary Fuel:	Wood
Cost Index:	0
Skill Index:	0
Use:	Household cooking
Primary Heat Transport:	Convection, radiation from rocks

Attachment S-10-1, Page 2

TRADITIONAL CLAY/DUNG DOKA AND METAL DOKA



PARTS

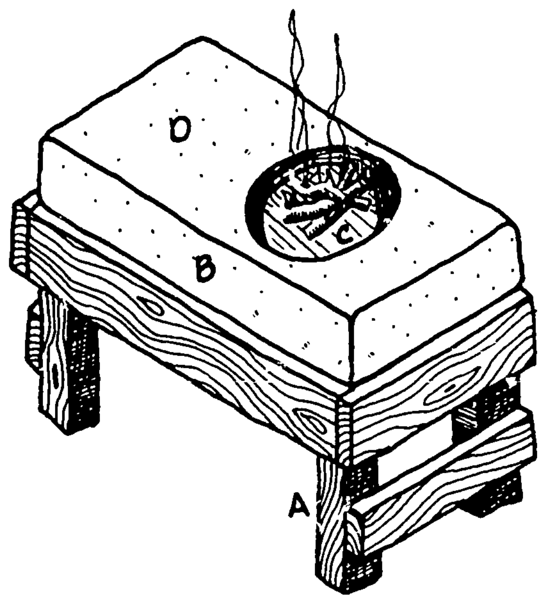
A single piece of iron plate 4 mm x 40 x 40 cm
A baked clay/dung 40 cm diameter 1-2 cm thick cooking plate

Stove Scenario

Origin:	Islamic World (Sudan)
Construc. Materials:	Clay/Dung or metal
Efficiency Range:	7% (estimated)
Primary Fuel:	Camel or goat dung
Cost Index:	1 (clay/dung), 7 (metal)
Skill Index:	2 (clay/dung), 7 (metal)
Use:	Cooking fried bread, e.g., Kisra
Primary Heat Transport:	Conduction

Attachment S-10-1, Page 3

TRADITIONAL LATIN AMERICAN HEARTH



PARTS

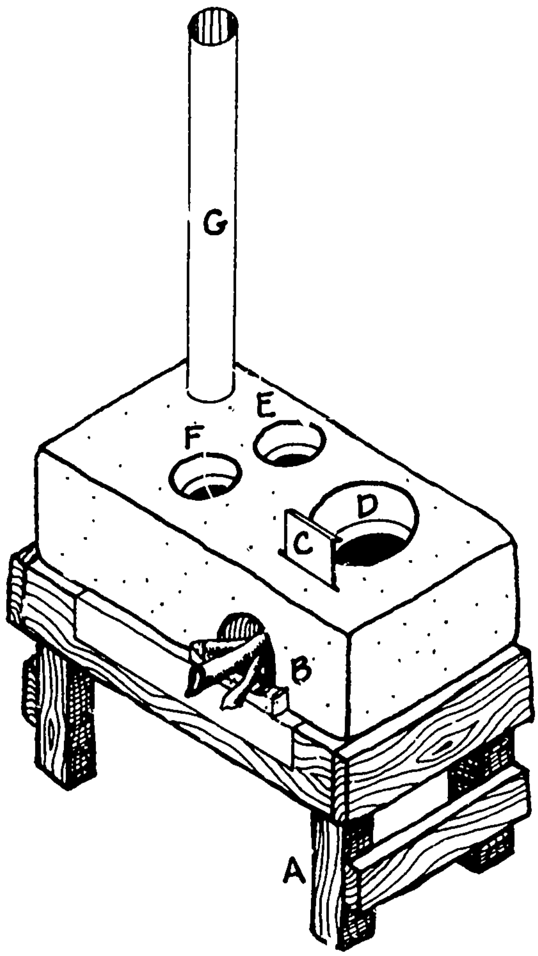
A. Wood Base to Elevate Hearth
B. Clay/Sand Hearth
C. Fire Pit
D. Working Surface

Stove Scenario

Origin:	Central American Indians
Construc. Materials	Wood, clay and sand
Primary Fuel:	Wood
Cost Index:	3
Skill Index:	3
Use:	General household cooking
Primary Heat Transfer:	Convection, radiation from hearth

Attachment S-10-1, Page 4

IMPROVED LATIN AMERICAN HEARTH STOVE



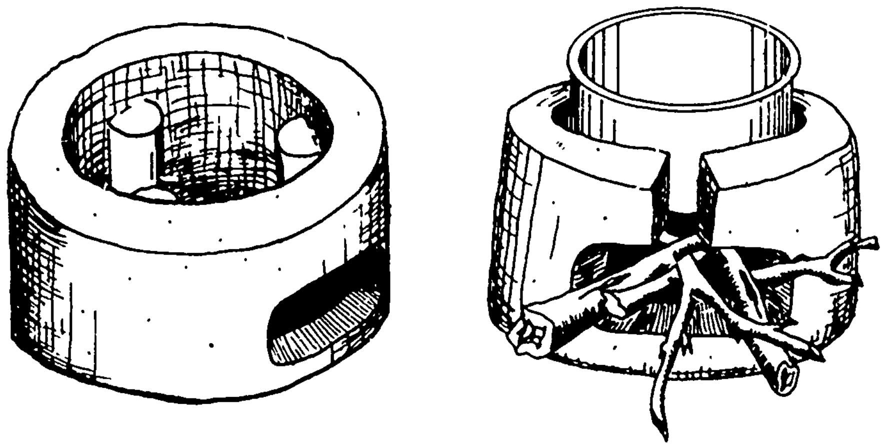
A. Wood Base for elevation
B. Fuel Feed Access
C. Damper
D. 1st Pot Hole
E. 2nd Pot Hole
F. 3rd Pot Hole
G. Metal Pipe Chimney

Stove Scenario

Origin:	Central America
Construc. Materials:	Wood base, clay/sand
Efficiency Range:	8-14%
Primary Fuel:	Wood
Cost Index:	4
Skill Index:	4
Use:	Household cooking (permanent indoor structure)
Primary Heat Transport:	Convection

Attachment S-10-1, Page 5

LOUGA STOVE



PARTS

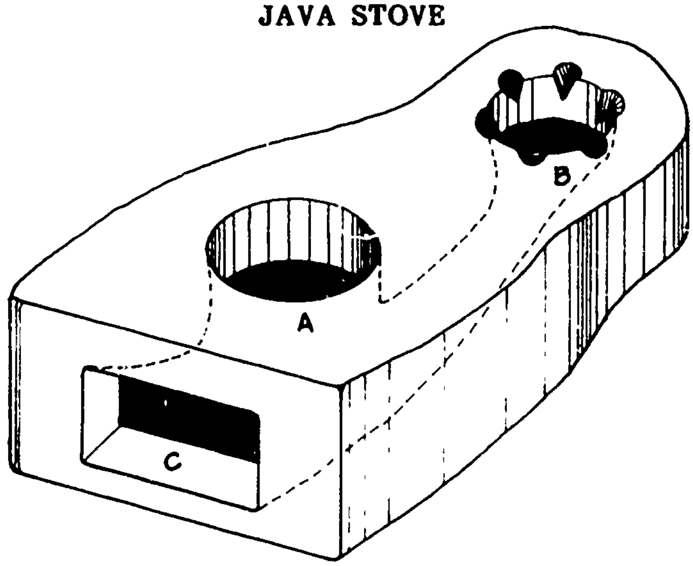
A. One pot hole permanent earthen structure with or without expansion gap

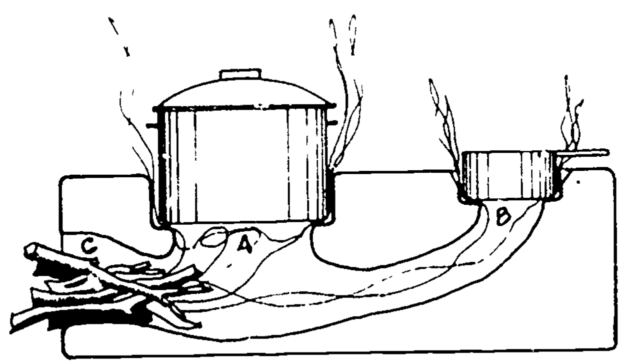
Stove Scenario

Origin:	Presently used in West Africa
Construc. Materials	Sand/Clay mix
Efficiency Range:	13-32%
Primary Fuel:	Woodsticks, millet stalks
Cost Index:	1
Skill Index:	2
Use:	Household cooking
Primary Heat Transfer:	Convection

Attachment S-10-1, Page 6

JAVA STOVE





PARTS

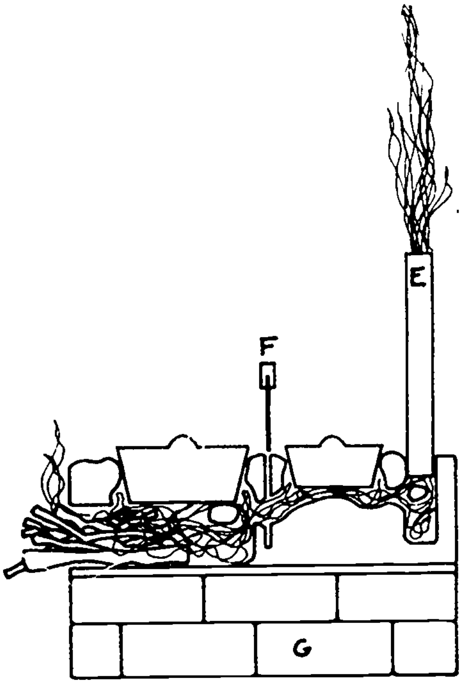
A. First Pot Hole
B. Second Elevated Pot Hole with Smoke Vents
C. Fuel Supply Access with Optional Damper

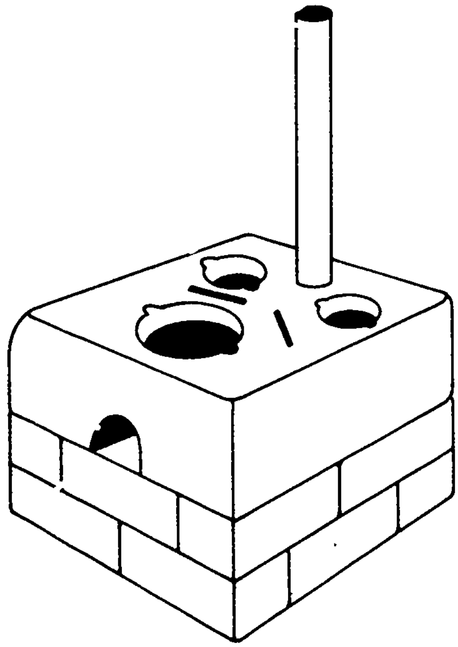
Stove Scenario

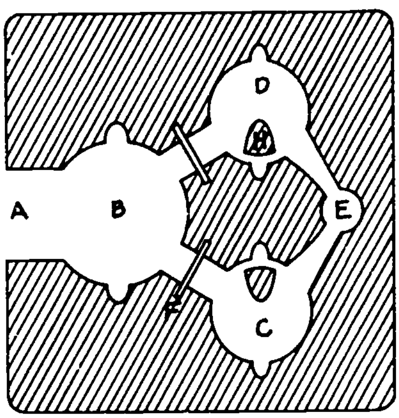
Origin:	Indonesia, used in West Africa
Construc. Materials:	Clay/Sand mix
Efficiency Range:	10-16%
Primary Fuel:	Woodsticks
Cost Index:	1
Skill Index:	3
Use:	Household cooking (permanent structure)
Primary Heat Transfer:	Convection

Attachment S-10-1, Page 7

IMPROVED LORENA STOVE







PARTS

A. Fuel Feed Access
B. Primary or 1st Pot Hole
C. Secondary Pot Hole
D. Secondary Pot Hole
E. Metal Pipe Chimney
F. Dampers
G. Stove Base
H. Baffles

Stove Scenario

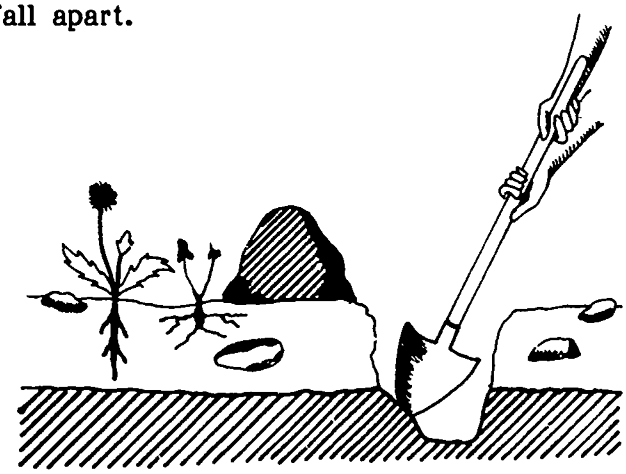
Origin:	Central America, recently West Africa
Construc. Materials:	Brick base, clay/sand
Efficiency Range:	8-14%
Primary Fuel:	Wood
Cost Index:	3
Skill Index:	4
Use:	Household cooking
Primary Heat Transfer:	Convection

Attachment S-10-2, Page 1

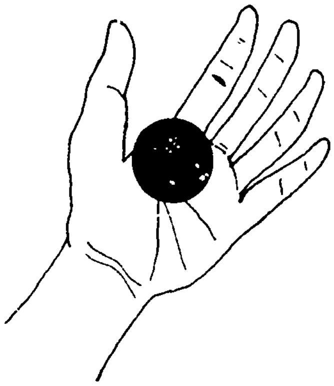
EARTHEN STOVES — CHOOSING THE MIXTURE

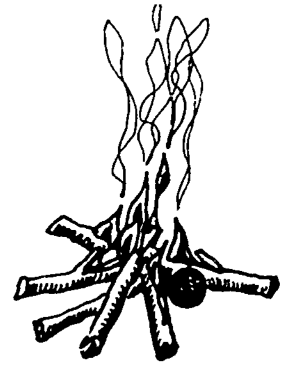
The correct soil mix for earthen stove construction is very important. The desirable clay/sand mixture is mostly sand. Clay particles expand and contract, so you want sand particles, which are rigid, to surround them. In turn, the clay binds the sand together. Too much clay and the stove will crack. Too much sand and it will flake and fall apart.

The best places to look for clay are near rivers or streams, rice fields, and depressions that hold water during rainy seasons. The most effective way to find clay sources is to ask the local people. Dig down below the surface. Pure clay is not necessary. Any clay soil will do if it contains little silt and passes the following tests.

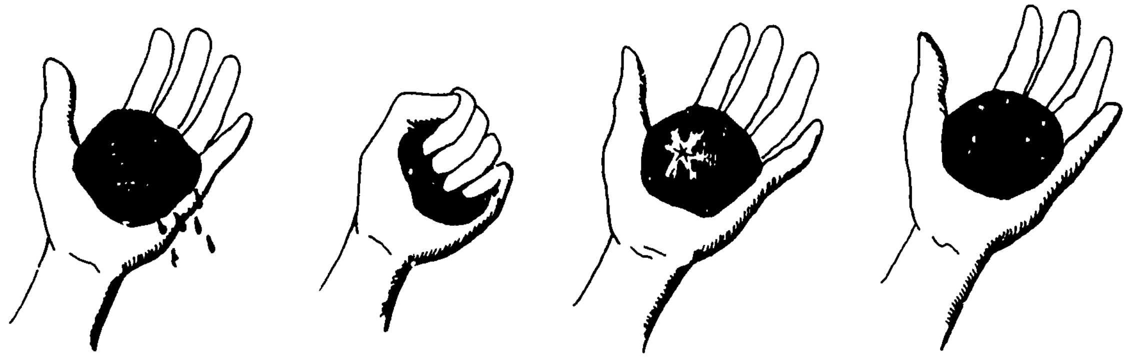


The first test is to determine if the soil has sufficient clay content. Make a ball of soil, adding enough water to make it stick together. Allow it to sun dry. Place the ball in a fire for 30 minutes. Let the ball cool and test it for strength. If it crumbles easily there is little clay in the soil.





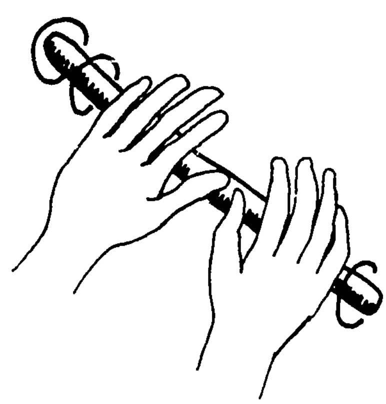
1. Remains whole - usable
2. Cracks - usable
3. Crumbles or Flakes - Unusable

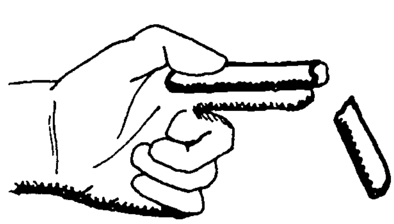


HIGH SAND CONTENT HIGH CLAY CONTENT

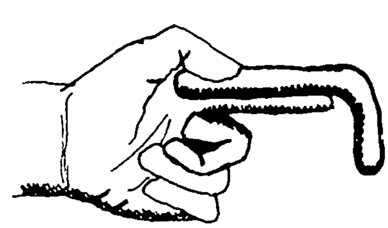
There are other tests to judge a soil's clay content. One of these is the shine test. Take a handful of soil in the palm of your hand and wet it. Open, then slowly close your hand. The soil should shine as your hand closes. If not, add more water. If when you reopen your hand the shine goes away, the soil has quickly absorbed the water and thus has a high clay content.

The pencil test will also aid in correct soil selection. Wet some soil until it is a stiff mud. Roll it into a pencil thin worm about 10 cm long. Carefully pick up the worm at one end with two fingers. If it breaks it shows a high sand or silt content. If it bends or sags, but doesn't break, it shows a high clay content.



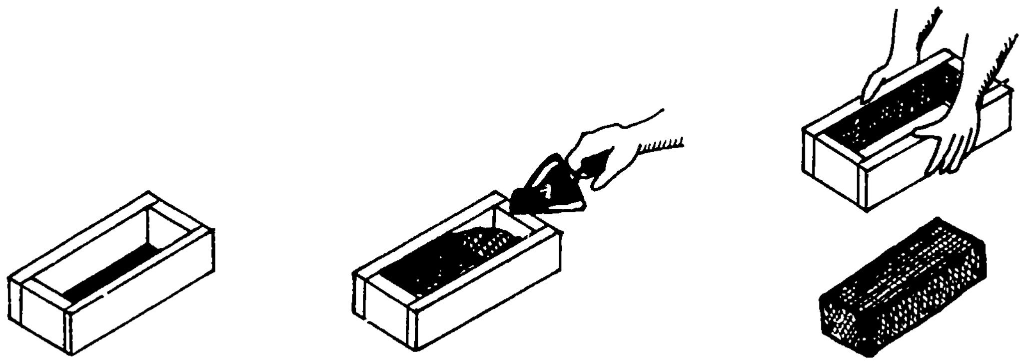


HIGH SAND CONTENT

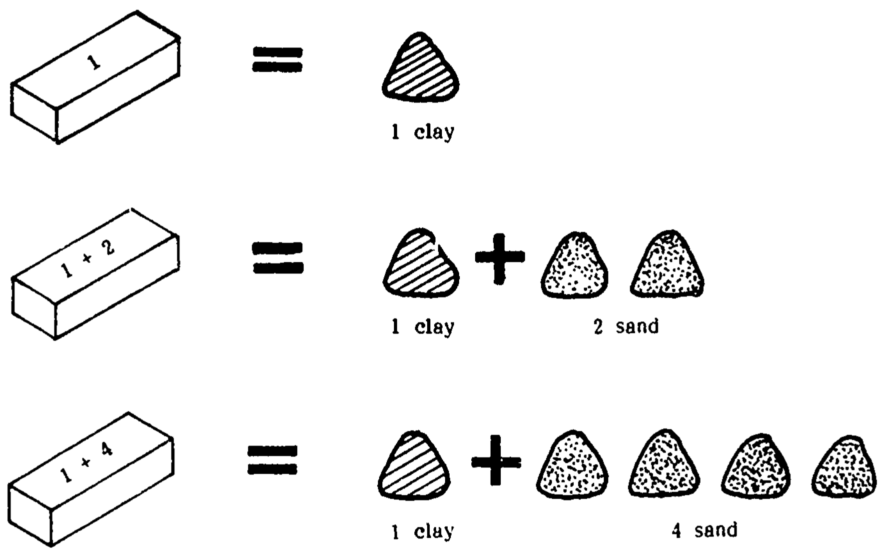


HIGH CLAY CONTENT

Attachment S-10-2, Page 3



The final and most conclusive test is to make test bricks. Make a form about 10 x 25 x 8 cm.



Make the first brick out of wet clay soil without adding sand. Make subsequent bricks out of various sand/clay soil mixes, for example, 1 part clay soil to 2 parts sand, 1 part clay soil to 4 parts sand. Let the bricks dry in the sun.

HIGH CLAY CONTENT HIGH SAND CONTENT CORRECT CLAY/SAND RATIO

If a brick cracks it has a high clay content and you would want a mix with more sand. If a brick crumbles or flakes it has a high sand content and you would want a mix with more clay. It is best to avoid very fine sands and use coarser ones. Learning to recognize a good clay/sand ratio comes with experience.

SESSION S-11 **EARTHEN STOVE CONSTRUCTION**

TOTAL TIME: 14-16 Hours

OBJECTIVES:

* To construct a clay stove based on the design of the group
* To understand and be able to articulate the steps involved in construction and their importance to the efficient working of the stove

RESOURCES: Lorena Book, pgs. 50-70
Attachments S-11-1 and S-11-2

MATERIALS: Clay, sand, water, blocks, screen, buckets, shovels, trowels, knives, spoons, wheel barrow, metal for chimney and dampers

PROCEDURE:

Step 1 — 15 Minutes
Review objectives and procedure, and work schedule.

Step 2 — 2 Hours
Layout stove design using the pots. Lay bricks and make the base.

Step 3 — 2-3 Hours
Prepare the materials: sift the sand and clay and add water.

Step 4 — 8 Hours
Make the stove body.

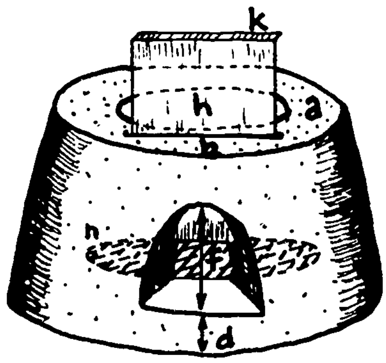
Step 5 — 2 Hours
Cut the tunnels, make the chimney and dampers and finish the stove.

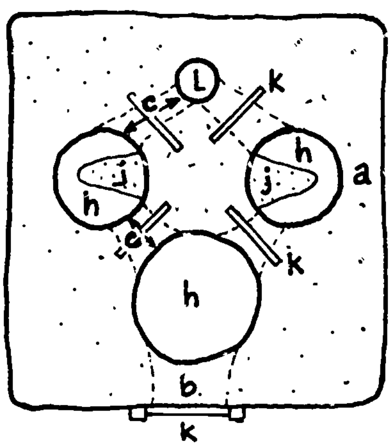
Trainer's Note

If the wet method of mixing clay and sand is to be used, the clay needs to be soaked in water at least 24 hours in advance.

Attachment S-11-1, Page 1

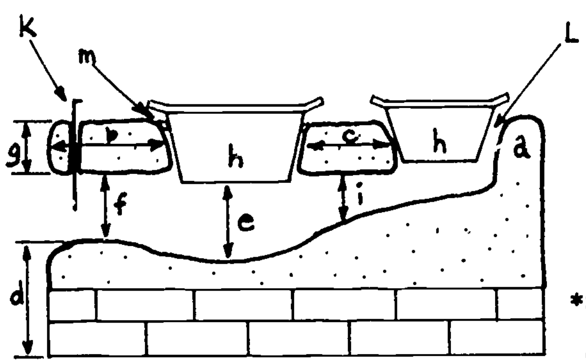
EARTHEN STOVES — CONSTRUCTION RULES OF THUMB





Ledger:*

a. distance from pot to side of stove
b. distance from first pot to the front of stove (over firebox entrance)
c. distance between pots
d. base
e. distance under first pot
f. size of doorway
g. distance from top of doorway to stove top
h. potholes
i. tunnels
j. baffles
k. dampers
l. chimney
m. collars
n. grate



*See following pages for complete descriptions

Attachment S-11-2, Page 1

EARTHEN STOVES — CONSTRUCTION RULES OF THUMB

The actual size of the stove is determined by pot size, the number of pots and the wishes of the owner. But there are certain minimum distances.

a. For reasons of strength there should be a distance of at least 10 cm between the outside edge of the pothole and the outside edge of the stove.

b. As the part over the firebox entrance is the weakest part, it is best to have at least 15 cm distance from the front of the stove to the first pothole.

c. A minimum distance of 10 cm is needed between potholes and between the last pothole and the chimney. It is easiest to place the pots in the spot desired and measure the outside stove dimensions from there.

d. The base can be made of one or more layers of brick and at least a 5 cm layer of mix. If no bricks are available start with the 5 cm layer of mix on the ground.

e. The distance under the first pot is usually between 12-15 cm. The size of wood and cooking habits can affect this. For larger wood increase the height. The diameter of the fire box is the same as the pot's diameter.

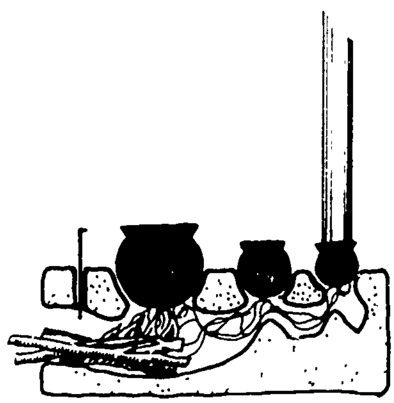
f. The doorway is about 15 cm x 15 cm. An arched doorway is stronger than a square cut.

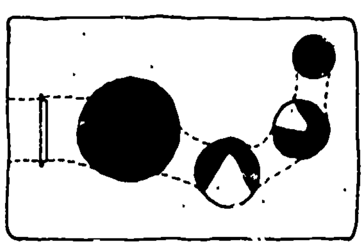
g. The distance from the top of the doorway to the top of the stove is usually the height of the pot, but needs to be at least 15 cm for strength.

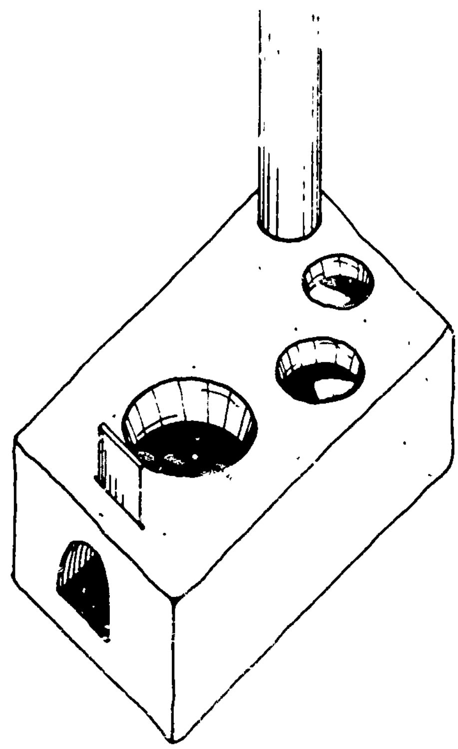
h. The pot that needs the most heat goes over the fire. The second pot will boil, though it will take longer than the first. The closer the second pot is to the first the quicker it will heat. Third or fourth pots are used for warming and generally do not boil. Second or third potholes need only a 2 cm space under them.

i. Tunnels should be 10-12 cms in diameter. To insure even heating and proper draft, exit the tunnel at the back. Place the tunnel so that ½ is behind the pot and ½ below it. To increase air circulation around the bottom of the pot dig a semi-circular indentation around the bottom of the pot, even with the tunnel.

j. In the second and third potholes, slow down the passage of air to aid in heat transfer to the pot. To help with this when possible place entrance and exit at a 90% angle and add a baffle. A baffle directs the air around the outside of the pothole. It is made of mix that touches the bottom of the pot on the side nearest the exit tunnel and slants downward across the pothole. The baffle is placed in front of the exit hole.

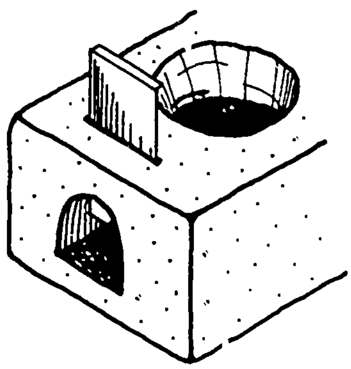


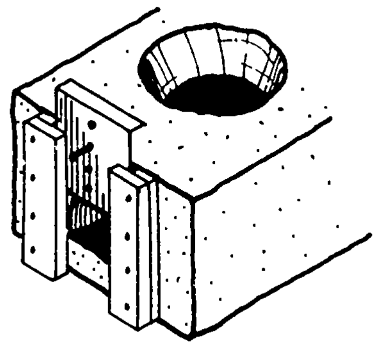




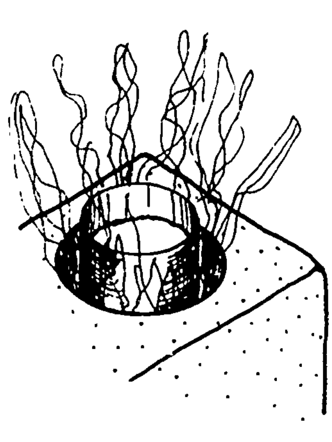
Attachment S-11-2, Page 3

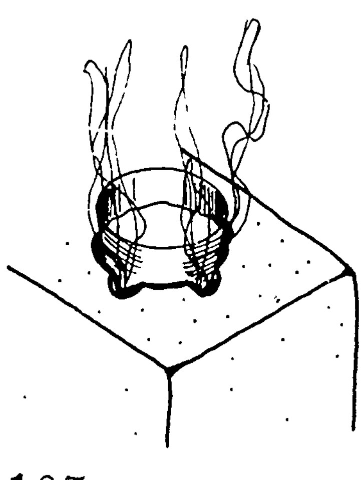
k. Dampers are used to regulate the fire and in double tunneled stoves to shut off one-half of the stove. An external front damper is recommended as an internal front damper causes stress on the firebox bridge. The front damper regulates air flow to the fire. A damper can be put in front of the chimney to aid in controlling air flow. Chimneyless stoves usually do not have dampers, though an external front damper is recommended.





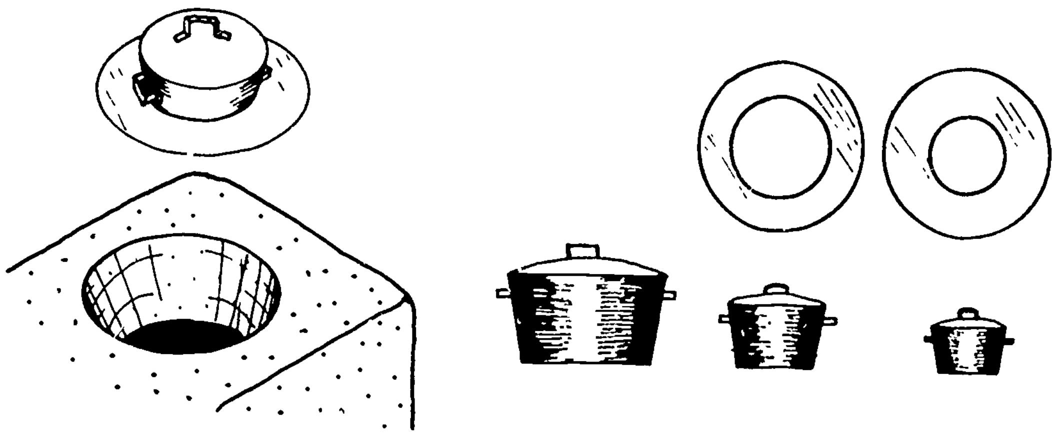
l. Chimneys increase draft in 2 or more potholed stoves and also remove smoke from the kitchen. The diameter of the chimney depends on the length of the tunnels and the height of the chimney. For the efficient working of the stove it is important to have the correct proportions. The easiest way to do this is to experiment with diameters and height. A general rule of thumb is to have a 10 cm diameter for a 2-3 meter chimney. In chimneyless model stoves either cut 2 cm space around the pot or in the back half of the pothole cut 3 columns, 2 cm wide and the depth of the pothole.



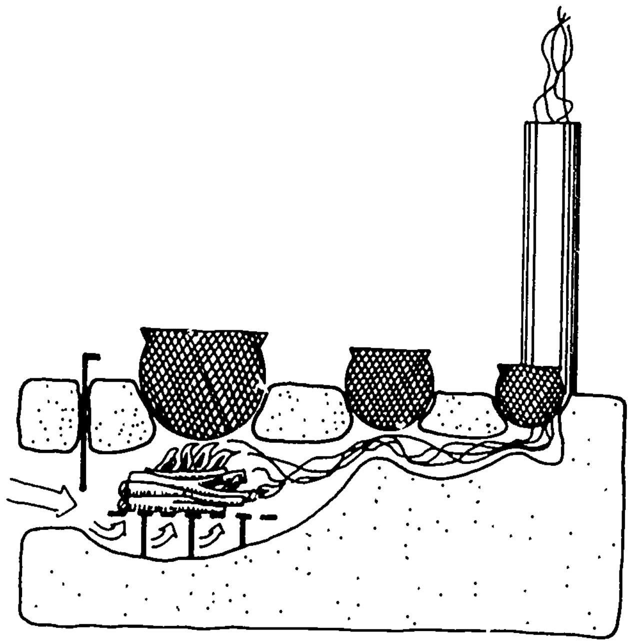


Attachment S-11-2, Page 4

m. To fit different sizes of pots in one hole make a "collar" out of a flat piece of metal. Make the pothole to fit the largest sized pot. Cut the collar to overlap the pothole on the outside edge and to fit the smaller pot snuggly. A separate collar is needed for each different sized pot.



n. An experimental option is a grate in the firebox. This brings air up under the wood and can aid in combustion. To be effective, the bottom of the firebox needs to be cleaned frequently of ash.



SESSION S-12 **INTRODUCTION TO CERAMICS**

TOTAL TIME: 2 Hours

OBJECTIVES:

* To introduce participants to basic ceramic construction methods
* To analyze different types of clay materials and identify their sources
* To practice using clay
* To discuss traditional firing techniques

RESOURCES: An experienced potter, Attachments S-13-1 thru S-13-5. (Attachments are in Session S-13)

MATERIALS: Knives (clay tools if possible), spoons, buckets, water, rolling pin, flat surface (plastic sheet), 1 pound of clay per trainee and a working surface (a potter's wheel is optional)

Trainer's Note

The format of this session is left to the discretion of the potter because it usually takes place in the potter's shop. The one activity which may require additional input from the staff is the discussion concerning clay sources and clay types available in Third World countries. The handouts are most helpful if trainees read them prior to this session to save time and to make the discussion more productive.

SESSION S-13 **CERAMIC STOVE DESIGN**

TOTAL TIME: 4 Hours (Part A, 2 hours, with an overnight break before Part B, 2 hours)

OBJECTIVES:

PART A

* To review cookstove design principles with emphasis on ceramic stove applications
* To discuss applications of ceramic stove design
* To design an improved ceramic stove

PART B

* To present individual stove designs to the group

RESOURCES: An experienced potter, Attachments S-13-1, S-13-2, S-13-3, S-13-4 and S-13-5

MATERIALS: Flip chart, markers, handouts, clay, sample ceramic stove (if possible)

PROCEDURES:

Step 1 1 Hour, 30 Minutes

Provide Attachments as handouts on clay construction methods, firing of clay, and ceramic stove design prior to session. Discuss each handout during session. Review modes of heat transfer and cooking methods.

Trainer's Note

Trainees should read the handouts before the session.

Using pictures, drawings or actual stoves, assist the group in comparing the critical design features of each stove type. Follow with a stove construction sequence slide show if possible. If possible extend the time of this step.

Trainer's Note

Stoves Comparison

Earthen	Ceramic	Metal
High mass—slow to heat	Low mass	Low Mass - quick to heat
Insulating	Portable	Portable
Inexpensive	Insulating (moderate)	
Self-help Projects	Market Appeal	Market Appeal
Large	Low Cost	Charcoal - Fuel (Primarily)
Long Life	Charcoal Fuel (primarily)	Heat Loss Unless Insulated
Large Variety of Fuel Size	Fuel Size Limited	Fuel Size Limited
High Maintenance	Brittle—Subject to cracking	Heat by Radiation (Primarily)
Heat by Convection (Primarily)	Requires Ceramic skills	Requires Metal Working Skills

Types of Cooking Applicable to Ceramic Stove

Boiling	Yes	depends on fuel type
Frying	Yes (not common)	conductive heat transfer
Grilling	No	conductive heat transfer
Baking	No	radiative or conductive
Broiling/Bar-B-Que	Yes	direct radiation

Step 2 5 Minutes
Break into small groups (or individuals) to design stoves. Assign or allow trainees to select the stove they will be designing and building using the stove scenarios and the construction documentation.

Step 3 25 Minutes
After everyone is clear on their assignment, have the trainees work on the design individually with several staff available to answer questions.

Trainer's Note

At this point a great deal of direction is needed from trainers to insure that design modifications identified by trainees or groups of trainees (if they are working in groups) are feasible and will, in fact, improve the stove performance and functionality, simplify construction or reduce costs. Conclude Session 13 on time, giving trainees the overnight assignment to complete their design and discuss it with other trainees.

PART B

Step 4 2 Hours (Following Day)
"Design Review"--Each trainee or group of trainees presents his or her improved stove design and the rationale behind the changes made. These should be formal presentations using visual aids to show diagrams, construction sequence and estimated cost.

Trainer's Note

Staff should take part in the "Design Review" providing a critical review of technical feasibility of the designs, examining their costs, and the skill and time required to build them.

Attachment S-13-1, Page 1

GENERAL CERAMIC STOVE RULES OF THUMB

1. Mix clay with a large amount of grog or sand if grog is not available. As much as fifty percent (50%) grog may be necessary to keep some clays from developing large cracks after continued use with charcoal fires.

2. Fire clay at a point well below vitrification to keep the clay porous and to minimize surface and internal stress. Vitrification temperature varies depending on clay type from 850°C for deep red clay, 1000°C for common red clay and 1260°C for stoneware clay.

3. Avoid sharp bends or edges when shaping the clay.

4. Maintain uniform thickness of clay in both curved and flat pieces. Minimum thickness should be 1.5 cm and maximum depends on the clay and stove design.

5. If the stove has a complex shape or many sharp curves in its design, try to make the stove in several pieces that fit together with room for expansion and contraction.

6. There are three basic methods for making ceramic stoves: slab, coil and throwing the stove on a wheel.* However, the experience at the Domestic Technologies Peace Corps stove training program has indicated that the coil method tends to develop fewer large cracks during use.

7. To cure, air dry all stoves until they are rigid hard and produce a slight ring when struck with the finger. For dry climates this might be eight days and for humid climates this might take several weeks. Once the stoves have cured, fire them just below vitrification temperatures (900°C).

* Use whatever method is traditional to the area of assignment and test the stove before trying other methods.

STRENGTHENING CLAY BY TRADITIONAL METHODS

(Edited and adapted by Domestic Technologies for Peace Corps training purposes from a paper by Jenny Trussel)

Clay

Clay is an abundant and cheap material which does not need major processing to make it useful. There are few places in the world where it cannot be found and it has been used as a building material for centuries. The fund of knowledge built up by local peoples about its properties and uses, plus its cheapness and ready availability make it a most suitable material for the construction of stoves.

The chief constituents of all clays are alumina and silica, the latter always being in excess of the former. All clays may be regarded as consisting of a mixture of one or more hydrous alumino-silicates with free silica and non-plastic minerals or rock granules. The chemical properties of the clay are dependent on the nature and proportion of these accessory ingredients.

Clay falls into two general categories:

1. Primary Clays: Those which have been formed on the site of their parent rock by the weathering of feldspathic or volcanic rock. The rocks are broken down by water seeping through the strata, leaving the clay in irregular pockets. The water action is fairly gentle and so particle size remains large and varied. Primary clays are usually non-plastic. They contain little or no contaminating materials and are recognizable by their purity and whiteness. Kaolin is an example of a primary clay.

2. Secondary Clays: These have been transported by water, glaciers or occasionally wind, to a site far from the parent rock. They are usually composed of a complex mix of different clays and minerals picked up on the way. The colour in the raw clay indicates the presence of either iron oxides, or carbonaceous matter. Iron and manganize which is present as haematite will produce the red, limonite gives yellow; ferrous iron gives grey/green and black. Iron in the clay lowers the vitrification point somewhat in firing, so many red clays are low firing or earthenware clays.

Clay used for the construction of cooking pots and earthenware vessels in the Third World is almost always the red secondary clay. It molds easily into large thin shapes and will harden into biscuit ware at low temperatures (600-800 degrees C) in primitive bonfire firings.

Sometimes the clay is not as plastic as is required and potters have various ways of dealing with this. Some dig the clay, let it dry, crush it, remove stones and unwanted debris, then leave the clay to soak again in pits. Others soak the clay for many months, then dry it, crush it and reconstitute it again for use. This soaking or "ageing" of the clay improves its plasticity because bacteria grow in the clay and produce acid residues. These aid the formation of gels which break down the particles and improve plasticity. Potters of China used clay prepared for them by their grandparents. They in their turn prepared clay for their grandchildren to use.

A primary factor in designing ceramic stoves is the suitability of the clay available. Close observation of local potters will give clues as to how to improve its qualities as these people have learned through traditions how to adapt the clay for the pots they make. Clay used for cooking pots is not necessarily going to be suitable for ceramic stoves but since clay cooking pots have to withstand localized thermal stress and a fair amount of pounding, it will come some way to meeting the demands and provides a good starting point.

Observation of a group of Voltaic potters working on the edge of the Sahara desert found them mixing the following with their clay: 15% grog (crushed fired pots), 15% millet husks, 5% charcoal and 5% ash (percentages of total volume). They also added a small amount of dried donkey dung to the clay used to shape the neck of the pot.

The strength of the final product will be a function of both firing temperatures and the addition. The addition of grog is a widespread practice. In a study of two Ethiopian pottery villages Roel Hakemulder (1980) writes:

> "Broken bricks are acquired from the Nicola Brick factory... The potters considered the powdered brick to be indispensable for it makes the pots strong. The bricks are powdered in several ways; using mortar and pestle, beating them to pieces with metal staves and milling small pieces of brick between rocks. The powder is seived and the fine powder sprinkled on the clay after which the clay is pounded and kneaded. Standard quantity of brick powder to be mixed with the clay; the potters judge by the feeling of the clay".

The addition of grog serves several functions; in a very fine plastic clay it opens out the body making it stronger for building larger shapes and less likely to shrink and warp excessively which could cause cracking in drying and in firing. The type of firing typically used by potters, i.e., bonfire firing, will only just serve to harden the clay into a biscuit stage with temperatures ranging from 600 - 850 degrees all in one firing. Grog additions, especially in the case of high fired particles such as bricks, will strengthen the weaker low fired body.

Charcoal and ash additions also act to strengthen the clay. The addition of grass stem ash or rice husk ash is a common ingredient in the clay used by the Thai Bucket stove makers in Thailand. There they add up to 40% ash to their mix making a non-plastic clay which has to be molded into shape. The ash addition lowers the maturing temperature of the clay. The tiny honeycomb structure makes an incredibly light pot which has some insulating qualities. Charcoal additions make a more porous body and the finer and more even the distribution, the stronger it will be as small pores tend to stop cracks propagating. It also serves as a localized fuel especially useful if the fuel for the firing itself is scarce. The Voltaian addition of millet husks would serve to some extent the points mentioned above with an emphasis on the increased burning during the firing.

Dung is well known in mud mix for increasing the binding strength of the mix by breaking down some clay particles into a bacterial ooze. The reasons for adding dried dung to clay are debatable. In the Voltaic potter's case, one can only hazard a guess that adding dung to the neck of a pot, would increase the burning and so raise the temperature locally, thus creating a stronger area of fired clay where it is most likely to get knocked.

Sand is also widely used as an addition. It is a plentiful and easily added form of silica. Its gritty texture adds strength to the wet clay when building shapes and in firing it helps to lower the sintering temperature of the clay because of its high silica content although this only increases the firing temperatures above 900 degrees C. The addition of sand increases the porosity of the fired clay, thus improving its resistance to thermal stress.

Most typical firings are in the range of 600 - 800 degrees where the maximum "positive dimensional change" occurs: that is to say the pores increase in number and size rather than contract and glassify at a higher temperature. This, along with the fired grog addition and honeycomb structures, seems to improve resistance to the effects of thermal cycling. However, open pores on the surface of a pot will weaken the structure if water is allowed to penetrate and turn to steam on heating. Primitive potters seem to have an answer to this as well: they finish their pots with a highly polished, almost impermeable surface. While in the "leather hard" stage, the pots are beaten and tempered into shape. This treatment consolidates the surface layers and aligns particles. The mica, prevalent in many primitive potter's clays responds well to that treatment, helping the thermal shock resistance and surface texture. Sometimes a fine clay slip is applied before the whole outside surface is burnished by rubbing with bone or pebbles to a high gloss. This then closes the surface pores of the pot giving it a hard impermeable skin and honeycombed granular structure within. Charcoal, however, would burn through the burnishing in the firing making a pitted surface.

Increased additions of all or some of the materials above, plus beating and burnishing should, with experiment, produce an acceptable clay mix for construction of ceramic stoves.

Glossary

Grog: Clay which has been fired and then ground into granules.

Plasticity: The property of a material enabling it to be shaped and to hold its shape. Plasticity in clay depends on particle size. Clay particles are plate-shaped and slide against each other on a film of water. The smaller the clay particle size, the more plastic the clay will be.

Vitrify: To fire to the point of glassification.

CLAY TESTING FOR POTTERY STOVES

(Edited and adapted by Domestic Technologies for Peace Corps training purposes from a paper by Robert Hausner)

There is a wide variety of clays but a lack of specific information about them, and it is necessary to use simple, quick tests to determine whether they would be useful for making stoves. In Nepal three simple tests were devised by Robert Hausner for the FAO Community Forestry Development Project.

PARTICLE SIZE

Clays used for simple pottery items are rarely pure clay and also include silt and coarse particles. A mix of particle size is essential in making "tough" stoves that can withstand thermal and mechanical shock.

Test Method

100 gms of dry clay are dissolved in 400 ml of water in a measuring glass and left to settle for 24 hours. It is then possible to distinguish between the clay fraction on top, the silt layer in the middle, and coarse particles on the bottom.

SPEED OF SEDIMENTATION

This is another way to measure particle size. Coarse particles drop out within 30 seconds, silt particles drop out more slowly, and clay particles can stay in suspension for up to 18 hours. A test can give a quick "portrait" of a sample which can be compared to other samples.

Test Method

100 gms of dry clay are dissolved in 400 mil of water by rocking the cylinder with top covered for 5 minutes. The cylinder is then placed down and the settling is measured for 6 minutes.

RELATIVE WATER REQUIREMENT

The amount of water a clay sample can absorb is relative to the type of clay particles present in the sample. The more water a sample absorbs the more it will shrink during drying.

Test Methods

100 gms of dry clay are put in a glass and water is slowly added and stirred in. The water requirement is reached when a line drawn into the mix with a pointed stick does not keep a groove line shape anymore.

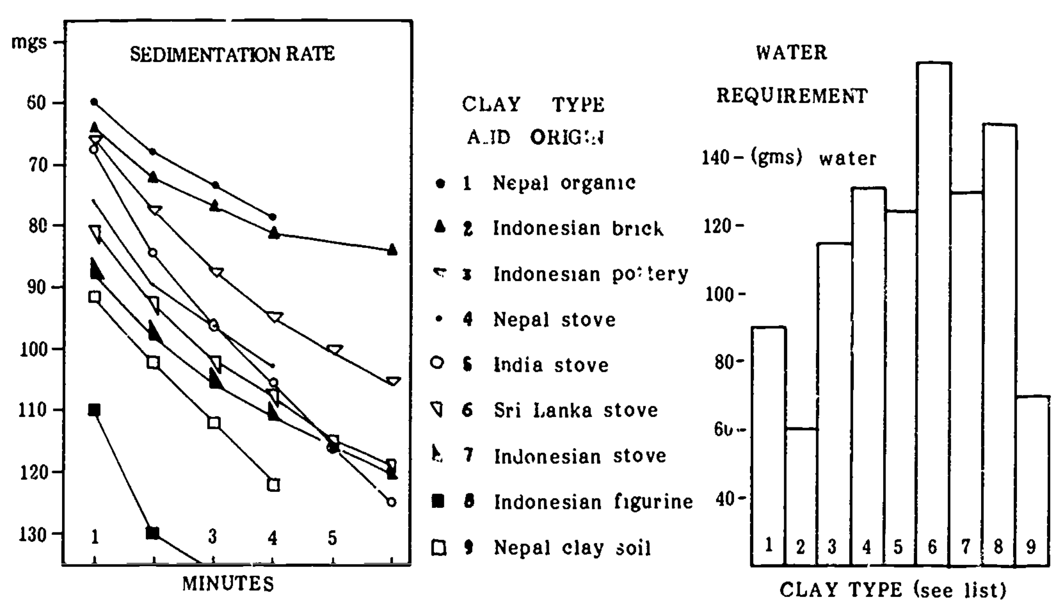
PLASTICITY

Although plasticity is an important characteristic for pottery clay its presence does not necessarily imply that the clay is of good quality for stoves as it may only be the effect of organic impurities and acidity. While the presence of plasticity makes clays with a high silt content workable on a potter's wheel, it results in a poor fired-strength after the organic "glue" is burnt out in the kiln. A plasticity test cannot be depended on to give consistently reliable results.

While the specific results of the tests do not match in all cases the best mixes have the following characteristics:

- high in coarse materials.
- as little fine sand and silt as possible.
- at least 30% clay by volume in a 24-hour test.

The graph of sedimentation rates shows a close similarity between the clays used to make improved pottery stoves in four countries. The bar chart of water requirement shows similarity for the water requirement of good quality stove clays with the exception of (and the reason is not clear) the Sri Lanka sample.



The main difficulty has been the lack of an appropriate test which would give a reasonable indication of merit. Because of the combination of material properties which are involved, it can be argued that ceramics which show good resistance to thermal shock (rapid cooling or heating) would also be resistant to thermal stress (slow temperature cycling) and mechanical impact too.

In seeking a test method to establish thermal shock resistance, specific requirements must be considered:

1. The method should be relevant to the stove application, i.e., shock from temperature levels such as experienced at the surface of stoves, samples of appropriate proportions and direct assessment of shock effects.

2. The method should be fairly simple, being easy to reproduce and not requiring highly trained investigators.

3. It should not require sophisticated or expensive equipment that could not be readily purchased or manufactured anywhere within reason.

4. Results should be quantitative and reproducible so that comparisons may be made between results obtained from different laboratories.

5. Low cost.

At the outset a direct shock method was considered essential. The temperature of 400°C was taken as the highest realistic temperature that might be expected on the surface of a ceramic stove used for cooking, and was therefore taken as the temperature to shock test samples. To achieve a severe shock, samples were plunged directly into a bucket of cold water (20°C-25°C).

Exploratory tests showed that simply shocking samples even thirty or more times did not by itself cause fracture, but did induce surface cracking. A residual strength test (measuring the loss of bending strength resulting from shock treatment) would register this type of damage, but would introduce too many problems in terms of the equipment needed and the interpretation of results. So a "residual impact" test involving a simple measurement was used which would be a reflection of the toughness of the material as well as the severity of the surface cracks.

The impact test adopted uses a light pendulum as the means of subjecting a simply supported test piece to repeated blows of gradually increasing severity. The fracture energy recorded is the energy of the impact which finally causes fracture. The method is open to criticism, especially as to the effect of repeated blows; however, results obtained to date are significant and repeatable.

The method used to test and assess the thermal shock resistance of a particular clay mix follows. Take a batch of 12 to 24 test bars and subject half of the test samples to the above impact procedure. Subject the remaining test samples to the same test after submitting them to 20 cycles of immersion from 400°C to cold water. By using this approach, the measurements before and after testing are of the same form which makes comparison straight forward.

TRADITIONAL CERAMIC CLAY DRYING AND CUTTING AND FIRING PROCEDURES

Both the grate and the liner should be slow-dried in a shaded place, protected from strong breezes. They should be disturbed as little as possible in the early stages of drying. When approaching a damp-but stiff leather-hard state, they can be turned over. This is when the ashbox door/air inlet is cut and the top trimmed evenly to size. The drying of the liners can be slowed by covering with damp fibers, cloth or plastic. Depending on air temperature and humidity, the liners will take 7-12 days to dry properly. To check for dryness, press the clay to determine the moisture remaining in it. Final drying can be done in the sun several hours before placing them in the kiln.

FIRING

The best firing temperature is 900°C. Well-fired stoves are porous for resistance to thermal shock but have good structural strength. Stoves fired too low will be quite porous and have a tendency to crumble on the surface. Stoves fired too high will start to vitrify on the surface, which will then expand and contract upon heating at a different rate than the inside, causing chips to flake off.

Porosity can be tested by rubbing a few drops of saliva or water on the (cool) surface. A material of high porosity will absorb it immediately. The more vitrified (glass-like) a surface is, the longer it will remain shiny-wet. This indication of porosity is a good way to test for consistency of firing temperature, both in different placements in the same kiln firing and from fire to fire, provided the same clay body is tested.

The simplest kiln is an open-air arrangement used by traditional potters all over the world. Here rocks or broken pottery are arranged to make a kiln floor. The rocks are covered with closely spaced fuelwood sticks on which the clay pieces are assembled in a carefully arranged heap to a height of 1.5 meters. The heap is then covered with wood or dry grass and fired for 1-2 hours. Woodchips, twigs, bamboo, rice husks, coffee husks, and sawdust also make good firing fuels with this method. They can penetrate into the spaces between the pots and provide more uniform temperatures in the kiln. Fuel is added as required at the top during firing. Kakamega, Kenya potters add green grass on top as a burn-resistant ceiling. As it dries and burns it is covered with more green grass. In other parts of the world it is common to place large pot shards as a ceiling.

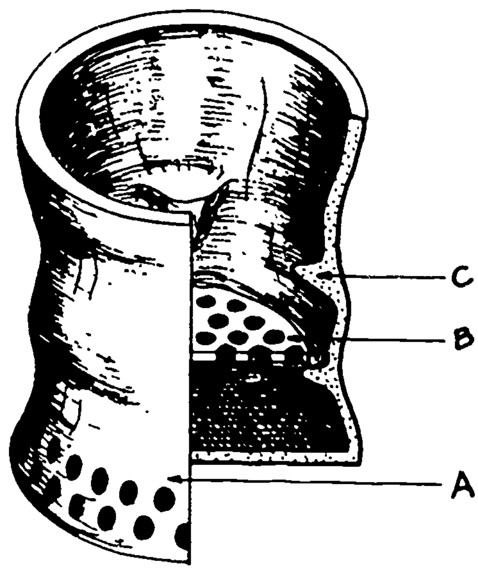
Stoves can also be fired in a brick pottery kiln using thinly chopped firewood or any of the previously mentioned fuels. Improved kilns range from simple wall enclosures with air inlets in concentration on the bottom to complex multi-chambered downdraft kilns of the Orient. If the kiln is properly designed and operated, these methods of firing are more fuel-efficient than the open-air kiln, and provide more consistent temperatures and results. Electric and gas-fired kilns may be easier to regulate but are more expensive. Firing with fuelwood is preferable where it is in good supply and efficient pottery kilns exist.

A kiln should be designed considering the size, shape and reasonable number of stoves to be fired and the nature of the fuel available. Wood-fired kilns are stoked manually, and pellet fuels (husks, sawdust, woodchips) are packed around the pots or fed into the firebox by means of hoppers. For more information on ceramics and kilns, the authors recommend Pioneer Pottery by Michael Cardew, Kilns by Daniel Rhodes, and UNIDO/United Nations Development Program Technical Report No. 30, Manual for Basic Kiln Design and Construction, by Hans G. Felbier.

Observe, talk and work with local potters, brick and tile makers, they may be capable of producing the ceramic liner. Once skills are well established, it is possible to produce 3000-5000 units per month in a cottage industry with 10-15 employees.

Attachment S-13-5, Page 1

IMPROVED COILED CERAMIC JIKO



PARTS

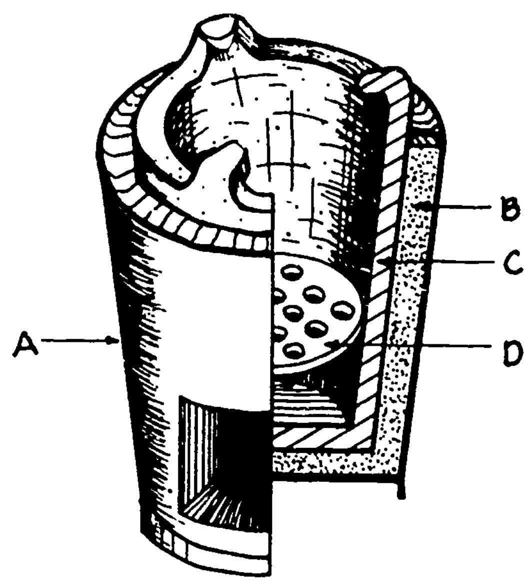
A. Coiled Ceramic Stove Body
B. Ceramic Grate
C. Built-in Pot Supports for Insert Pot Position

Stove Scenario

Origin:	DTI Peace Corps Training Program, U.S.A.
Construc. Materials	Ceramic clay, grog, and sand
Efficiency Range:	23-25% (preliminary measurements)
Primary Fuel:	Charcoal
Cost Index:	3
Skill Index:	4
Use:	Household and commercial cooking
Primary Heat Transfer:	Radiation

Attachment S-13-5, Page 2

TRADITIONAL BUCKET STOVE



PARTS

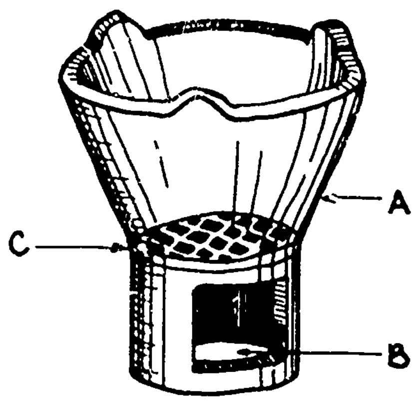
A. Outside Metal Bucket
B. Sand Insulation
C. Ceramic Liner
D. Ceramic Grate on Ceramic Steps

Stove Scenario

Origin:	Asia
Construc. Materials	Sheet Metal, Ceramic clay, grog, sand, ceramic firing capability
Efficiency Range:	20% (Estimated)
Primary Fuel:	Charcoal
Cost Index:	7
Skill Index:	8
Use:	Household and Commercial Grill and Pot Cooking
Primary Heat Transfer:	Radiation

Attachment S-13-5, Page 3

TRADITIONAL CERAMIC STOVE



PARTS

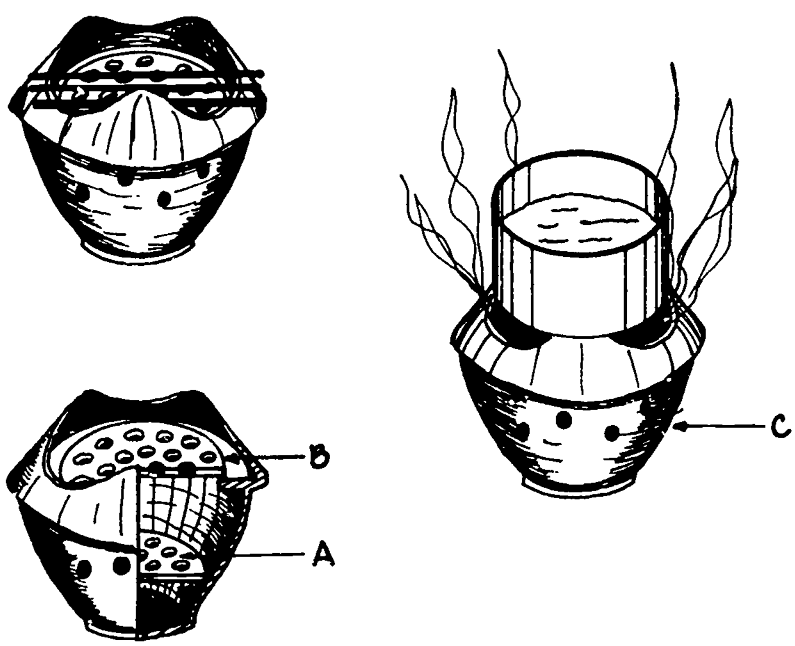
A. One piece Slab Ceramic Stove Bod"
B. Fuel Access Port
C. Separate Ceramic Grate

Stove Scenario

Origin:	Asia
Construc. Materials	Ceramic clay, grog, sand and a method to fire clay
Efficiency Range:	12% (preliminary measurements)
Primary Fuel:	Charcoal
Cost Index:	3
Skill Index:	4
Use:	Household spit and grill cooking
Primary Heat Transfer:	Radiation

Attachment S-13-5, Page 4

TRADITIONAL SOMALIA CERAMIC UTILITY COOKER



PARTS

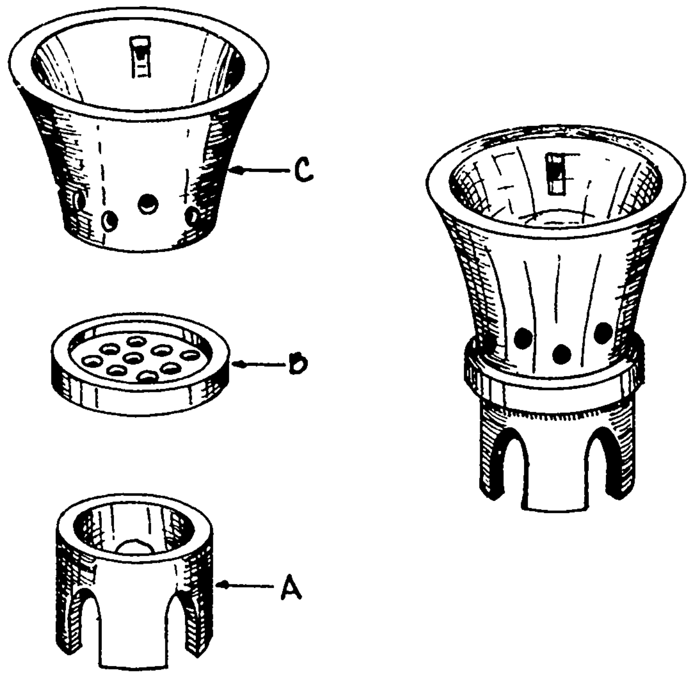
A. Lower Grate for Roasting or Inset Pot Position (not shown)
B. Upper Grate for Upper Pot Position or Grilling
C. Ceramic Cooker Body

Stove Scenario

Origin:	Somalia
Construc. Materials	Ceramic (clay and Grog)
Efficiency Range:	15-18% (estimated)
Primary Fuel:	Charcoal
Cost Index:	5
Skill Index:	6
Use:	Household and commercial
Primary Heat Transfer:	Radiation

Attachment S-13-5, Page 5

THREE PIECE CERAMIC STOVE



PARTS

A. Base with Air Intake (damper optional - not shown)
B. Inset Grate
C. Upper Stove Body - Holds Inset Pot or Grill

<u>Stove Scenario</u>

Origin:	DTI Peace Corps Training Program, U.S.A.
Construc. Materials:	Ceramic clay, grog, sand and a method to fire clay
Efficiency Range:	15-20% (Estimated)
Primary Fuel:	Charcoal
Cost Index:	3
Skill Index:	4
Use:	Fits many size pots or grill. (NOTE: advantage over traditional ceramic stove: if it breaks only one piece needs replacing)
Primary Heat Transfer:	Radiation

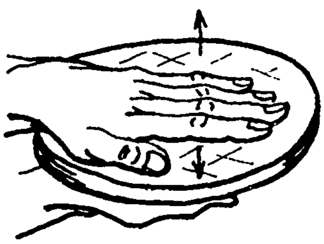
SESSION S-14	**CERAMIC ST^VE CONSTRUCTION**
TOTAL TIME:	8 Hours
OBJECTIVES:	*To construct a clay stove using the designs developed by participants.
RESOURCES:	An experienced potter, Attachment S-14-1.
MATERIALS:	4-5 pounds of clay and grog or sand for each stove to be built. Tools as identified in Session S-12.
PROCEDURE:	
Step 1	1 - 2 Hours (as needed) Prepare clay if necessary.
Step 2	6 - 7 Hours Construct a Ceramic Stove.

Attachment S-14-1, Page 1

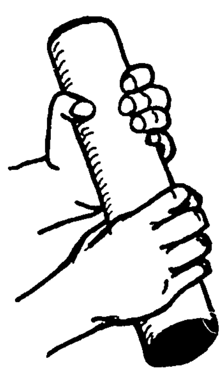
CERAMIC STOVE CONSTRUCTION

COIL METHOD USED TO BUILD THE IMPROVED COILED CERAMIC JIKO

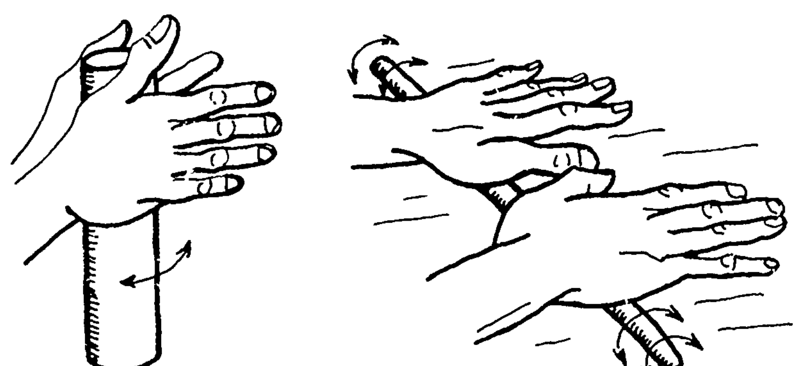
Knead the clay like bread dough to make the consistency homogeneous and free of air bubbles and foreign debris.



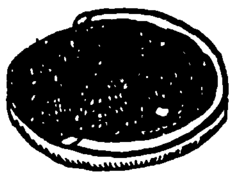
For bottom of stove make a flat round pancake of clay with hands on rolling pin and put it on movable platform. (e.g. pan or plate)



Squeeze roll and stretch clay to a thick coil.

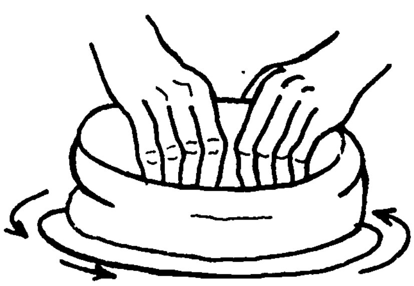


Roll clay outward to make a thinner coil using palms of hands. Make sure coil rolls back and forth 360° so coil is round and even.

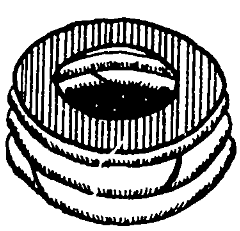


Put "slips" (clay and water mixed to consistency of thick cream to be used like glue) on each clay surface you wish to join.
NOTE: Never use just water - this causes cracks to form.

Cut coil at an angle so they will have maximum overlap at ends for greater strength at joints.



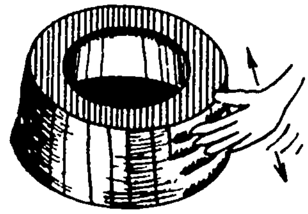
Join coils lengthwise pinching together and squeezing upward while turning plate in circles.



Make larger thick coil and join ends. Then flatten so the inside of the flattened coil will protrude creating a ledge inside the stove. This lip will hold the fuel grate.

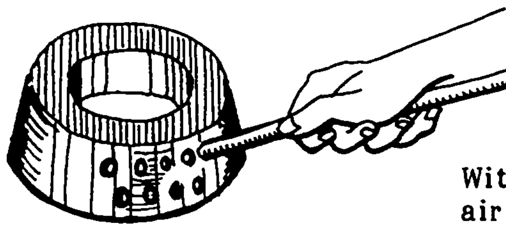
Thumbhole for grip

Make a scraper or rib out of stiff flexible plastic, rubber or metal.

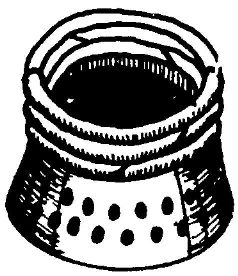


Using fingers and/or scraper, pull clay coils upward and together eliminating cracks inside and out.

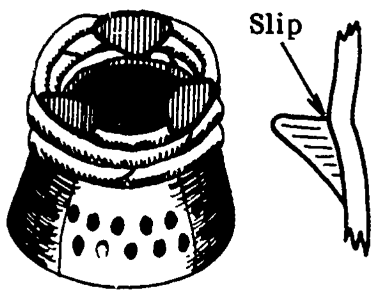
Attachment S-14-1, Page 3



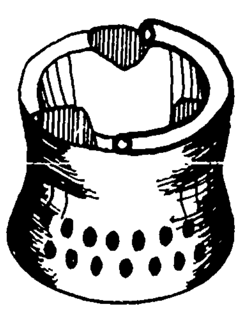
With hollowed pipe, poke air holes in base of stove.



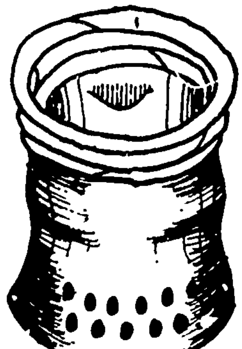
When bottom half slightly stiffens and can hold weight, continue to build surface upward with coils.*



Cut triangles of clay and join to coils with slips for pot supports.

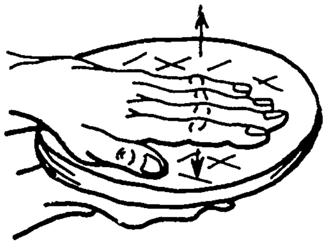


*NOTE: Do not let bottom of stove become too dry before adding more coils, otherwise difference in moisture in clay will cause weakness at joints. Cover with plaster to dry slowly and evenly when finished.

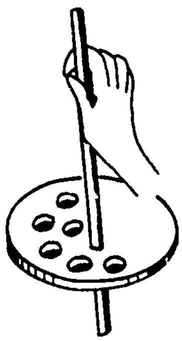


Continue to join coils when bottom is stiff enough to hold more weight. Scrape and pull together joints to make a smooth surface.*

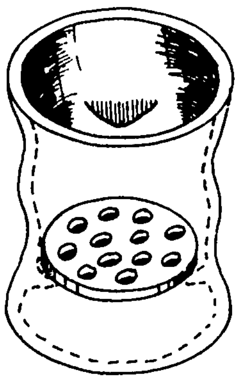
Attachment S-14-1, Page 4



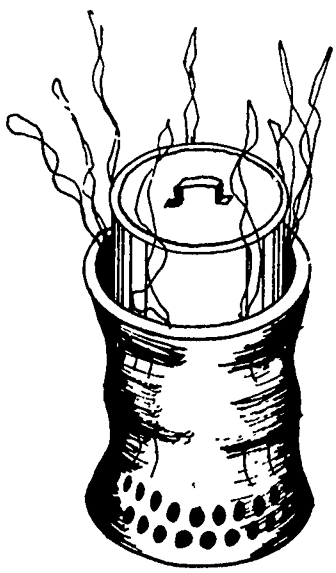
Begin making grate as a round solid pancake.
Measure so it will fit on lip shown in step #8.



With hollowed pipe,
poke holes in pancake.



After clay has been fired,
put grate and pot in place.



Completed stove in use

SESSION S-15 **CERAMIC STOVE CURING AND FIRING**

TOTAL TIME: 2 Hours

OBJECTIVES:
* To allow clay stoves to cure or dry.
* To observe firing of clay stoves to form ceramic stoves.

RESOURCES: An experienced potter and a method of firing the clay stoves.

Trainer's Note

The clay will require at least six days to dry (probably longer). This must be considered when scheduling the training program. The drying and firing in this session will be done outside the training format to save time. If participants are to do the "firing" using traditional methods the time for this session should be extended to two 4-hour sessions, separated by 48 hours.

SESSION S-16 **PROJECT DESIGN AND PROPOSAL PREPARATION**

TOTAL TIME 2 Hours

OBJECTIVE
* To introduce the components of a funding proposal.
* To practice writing a proposal.
* To tie proposal writing into over-all project design.

RESOURCES: Volunteer in Development Manual Session #9, Peace Corps Attachments S-16-1 and S-16-2

PROCEDURE:

Step 1 — 5 Minutes
Present the objectives and procedures.

Step 2 — 15 Minutes
Discuss briefly the uses of outside funds and explain that the most common way to receive funds is through a written proposal.

Step 3 — 20 Minutes
Brainstorm a list of components for a written proposal (see attachment S-16-1 for an example).

Step 4 — 30 Minutes
Write a practice proposal. Any hypothetical situation can be given the trainees, an example is funding a sheetmetal worker to make stoves. Trainer should have a prepared price list of materials.

Step 5 — 5 Minutes
Introduce the overall concept of Project Management which includes proposal writing.

Step 6 — 30 Minutes
Using the hypothetical proposal as a basis, have the trainees develop an overall plan for the project, including times, contingency plans and people to be involved.

Step 7 — 15 Minutes
As a large group discuss a few of the individual plans. Using the Critieria and Rating Sheet, rate the proposal.

Attachment S-16-1, Page 1

COMPONENTS OF A PROPOSAL

* Description of the problem
* Description of a proposed solution
* Expected specific impact and how the specific impact will be observable and measured
* A statement as to what is needed in terms of funds
* Statement of input from local community in terms of work, commodities or funds they will provide
* Budget, and materials list
* Statement of any additional technical assistance needed
* Name of local organization funds will be given to and the name of person responsible for disbursing funds
* Dates of project — beginning and ending and any important interim dates

Attachment S-16-2, Page 1

CRITERIA AND RATING SHEET FOR SMALL PROJECT ASSISTANCE PROPOSALS

Rating Scale
(Poor) 1 2 3 4 5 (Excellent)

CRITERIA	Rating for Proposal A	B	C	D
1. Does the proposal meet Peace Corps criteria?				
2. Is the project activity well planned and an approach clearly defined?				
3. Is the expected impact clearly stated?				
4. Is the expected impact reasonable and attainable?				
5. Are the costs reasonable and related to the work planned?				
6. Is there adequate support and participation from a local party (individual or group)?				
7. Are there adequate controls to ensure project execution?				
8. Is there a high probability of success?				
9. Is there adequate time to complete project?				
10. Is there a scheduled reporting and evaluation process included in the proposal?				

OVERALL RECOMMENDATION

5 Unqualified approval
4 Strongly supported
3 Accept
2 Accept with reservation
1 Reject

COMMENTS

1. Felt proposal was better than project
2. Felt proposal did not adequately represent value of project
3. Felt proposal and project of equal merit

SESSION S-17 **METAL STOVE DESIGN**

TOTAL TIME: 4 Hours (with an overnight break after 2 hours)

OBJECTIVES:

* To compare and contrast a number of traditional and improved metal and earthen stoves
* To discuss metal stove design principles
* To modify designs of traditional and improved stoves which can be made of metal to improve thermodynamic efficiency, operational convenience, safety and marketability
* To present the individual stove design to the group

RESOURCES: Attachment S-17-1, S-17-2 and S-17-3

MATERIALS: Flip chart or chalkboard, markers or chalk; portable metal and/or ceramic stoves; and 35 mm slide show of construction sequences

PROCEDURE:

Step 1 1 Hour
Using pictures, drawings or actual stoves, assist the group in comparing the critical design features of each ceramic stove type. Follow with a stove construction sequence slide show if possible.

Trainer's Note

Many approaches to this discussion can be used. The format suggested below has proven to be a successful vehicle for this activity when the facilitator has not had a broad experience using a variety of stoves or when slides are not available. Suggestion: break into one group for each stove type to do this diagnosis and then have each group report back.

Stoves Comparison

Earthen	Metal
High mass - slow to heat	Low Mass - quick to heat
Insulating	Portable
Inexpensive	
Self-help Projects	Market Appeal
Large	Charcoal - Fuel (Primarily)
Long Life	Heat Loss Unless Insulated
Large Variety of Fuel Size	Fuel Size Limited
High Maintenance	Heat by Radiation (Primarily)
Heat by Convection (Primarily)	

Question: Where do ceramic stoves fit into this comparison?

Step 2 — 15 Minutes
Review modes of heat transfer, if necessary. Have trainee facilitate here if possible.

Step 3 — 15 Minutes
Review cooking methods, if necessary. Have trainee facilitate here is possible.

Trainer's Note

Boiling	- Cooking depends on fuel type
Frying	- Cooking by conduction
Grilling	- Cooking by conductive transfer
Baking	- Cooking by oven wall or coals radiation
Broiling	- Cooking by direct radiation

Step 4 — 5 Minutes
Assign or allow trainees to select the stove they will be designing and building using the stove scenarios and the construction documentation.

Step 5 — 25 Minutes
After everyone is clear on their assignment, have the trainees work on the design individually with several staff available to answer questions.

Trainer's Note

At this point a great deal of direction is needed from trainers to insure that design modifications identified by trainees or groups of trainees (if they are working in groups) are feasible and will, in fact, improve the stove.

Trainer's Note

Conclude Session 17A on time giving the trainees the overnight assignment to complete their design and discuss with other trainees

Step 6 — 2 Hours, Following Day
"Design Review" — Each trainee or group of trainees presents their improved stove design and the rationale behind the changes made.

Trainer's Note

Staff should take part in the "Design Review" providing a critical review of technical feasibility of the designs, examining their cost, and the skill and time required to build them.

Attachment S-17-1, Page 1

GENERAL METAL STOVE DESIGN RULES OF THUMB

1. Stove should be portable but stable. The stove design should minimize the possibility of it being tipped over by children, animals, wind or the cook.
2. Easy access to light fuel and for replenishing fuel during cooking (if necessary) should be included in design.
3. The distance from the bottom of the pot to the grate should be greater (approximately 10-15 cm) for wood stoves and smaller (approximately 3-5 cm) for charcoal stoves.
4. Stoves should protect pots from wind where possible to minimize convective heat loss.
5. The total area of the primary and secondary air openings should be greater than the clear area of the grate and the openings should be distributed around the stove rather than in one place. The primary air intake should be 2 to 3 times larger than the secondary air intake.
6. Combustion air should be pre-heated before it enters the fire box if possible.
7. Damper openings should be adjustable from 0-25% of the total stove cross sectional fuel combustion area for charcoal fuel and from 50-75% of that same area for wood and dung fuel stoves.
8. The stove grate on which the fuel burns and the inner metal walls should be made of thick metal to avoid warping and burning up after extended use. Other stove parts can be made of light gauge metal if they are not exposed directly to the fire.
9. Charcoal fuel transfers heat radiatively (in straight lines) and therefore the amount of heat a pot receives is inversely proportional to the fraction one over the square of the distance from the top of the fuel to the bottom of the pot.
10. The distance from stove wall to pot wall can be very small for charcoal stoves when compared to wood burning stoves.
11. Charcoal stove designs should maximize the area of the pot exposed to the charcoal.

SPECIFIC DESIGN RULES OF THUMB

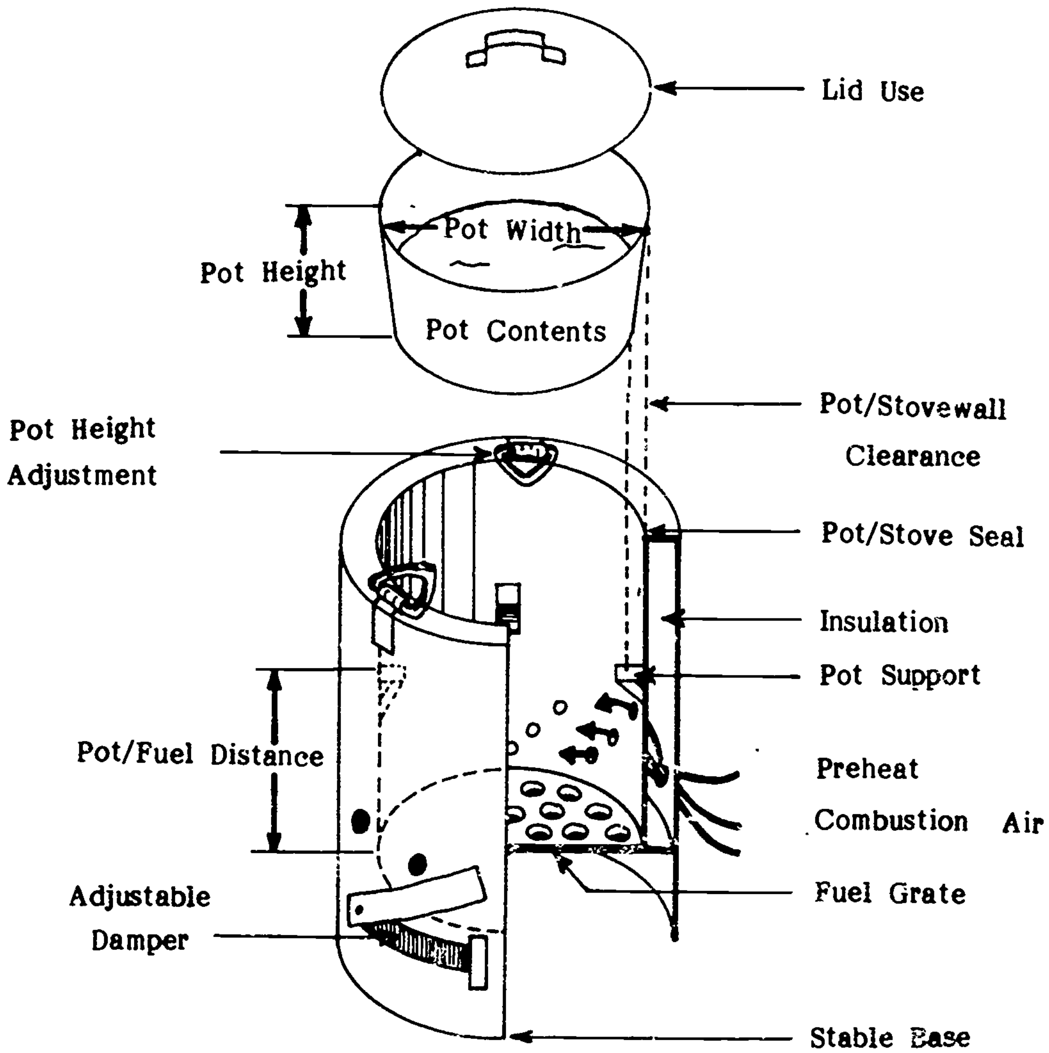
FOR METAL STOVES BY FUEL TYPE

Characteristic	FUEL: Wood	Charcoal	Animal Dung	Crop Residue Biomas
1. Primary Method of Heat Transport	Convection (300°C)	Radiation (500°C)	Convection (230°C)	Convection (350°C)
2. Pot distance from top of fuel (cm)	10-15	3-5	8-12	10-20
3. Percent of clear opening for grate	30-40	25 (ceramic if possible)	40	40-50
4. Insulation of Combustion Chamber (Fire Box)	1-2 cm airgap or earth	2 cm ceramic ring, charcoal or sand	mud applied on outside	not needed
5. Clearance between pot (cm) and wall of stove (cm)	½-1	small but as needed	½-1	½-1
6. Marketing considerations	Fuel can be collected	Less smoke, requires small amount of fuel	fuel availability	fuel availability
7. Approximate burning time for fuel load (hrs)	½	1½	½	4-48

Attachment S-17-2, Page 1

Attachment S-17-3, Page 1

METAL COOKSTOVE DESIGN CONSIDERATIONS

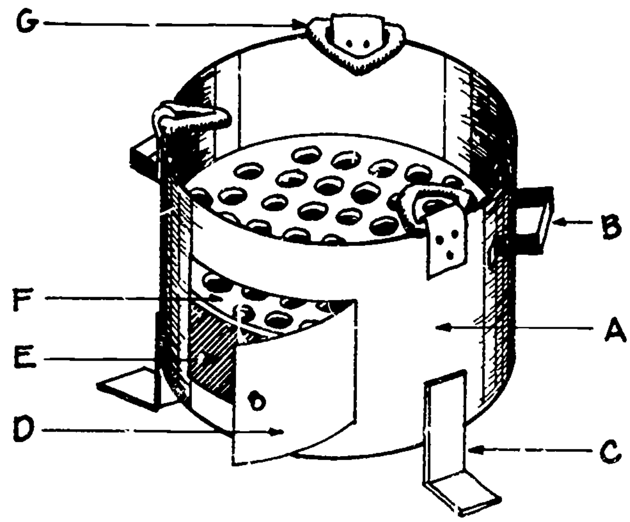


ADDITIONAL CONSIDERATIONS

- Cost
- Acceptability
- Construction Difficulty

Attachment S-17-3, Page 2

TRADITIONAL METAL JIKO



PARTS

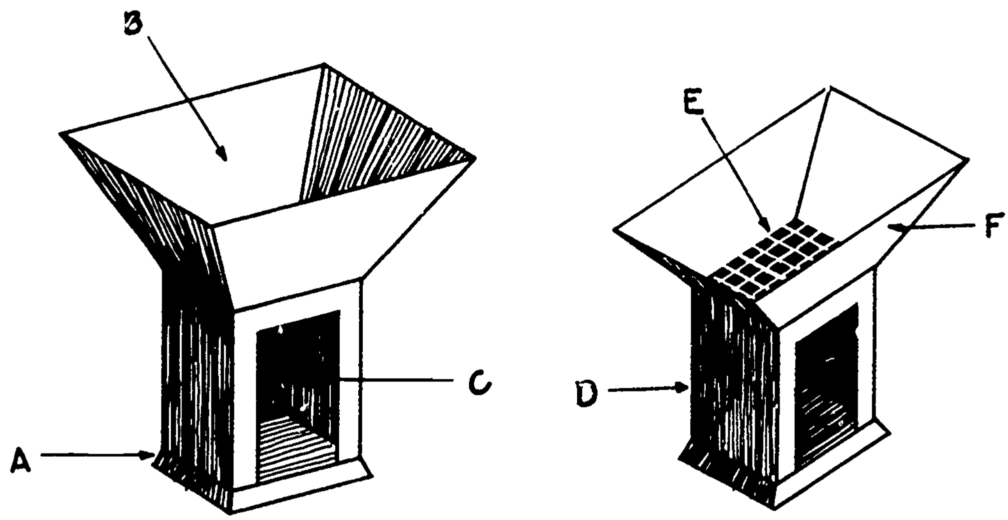
A. Stove Body—Metal Cylinder
B. Metal or Wood Insulated Handle
C. Feet for Elevation and Stability
D. Damper/Fuel Access Port Door
E. Fuel Feed/Ash Removal
F. Grate
G. Pot Adjustment—Simmer Position

<u>Stove Scenario</u>

Origin:	Kenya
Construc. Materials:	12 (grill) and 16-20 gauge metal (recycled barrels)
Efficiency Range:	18-22% (preliminary measurements)
Primary Fuel:	Charcoal
Cost Index:	7
Skill Index:	8
Use:	Household grilling or pot cooking
Primary Heat Transfer:	Radiation

Attachment S-17-3, Page 3

FEU MALAGACHE STOVE



PARTS

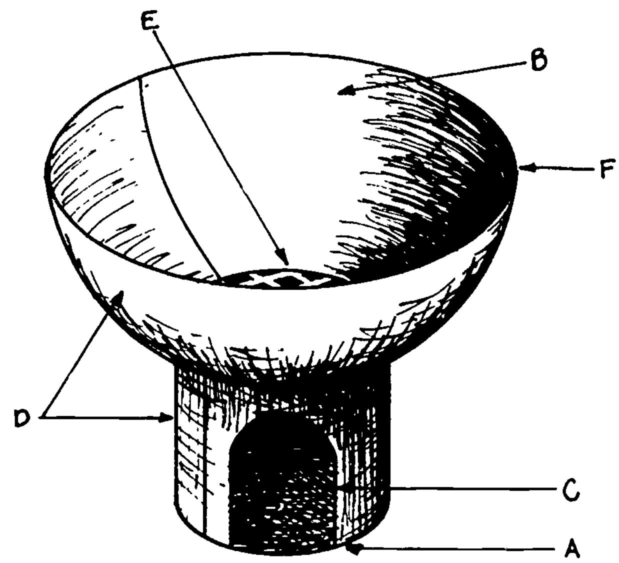
A. Base
B. Pot Position
C. Fire Starter and Air Intake Opening (No Adjustable Damper)
D. Stove Body
E. Grate
F. Pot Rest—Truncated Inverted Pyramid

<u>Stove Scenario</u>

Origin:	West Africa
Construc. Materials:	Metal (16 ga.)
Efficiency Range:	15-18% (preliminary measurements)
Primary Fuel:	Charcoal
Cost Index:	6
Skill Index:	6
Use:	Household cooking—accommodates various pot sizes
Primary Heat Transfer:	Radiation

Attachment S-17-3, Page 4

FEU MALAGACHE STOVE



PARTS

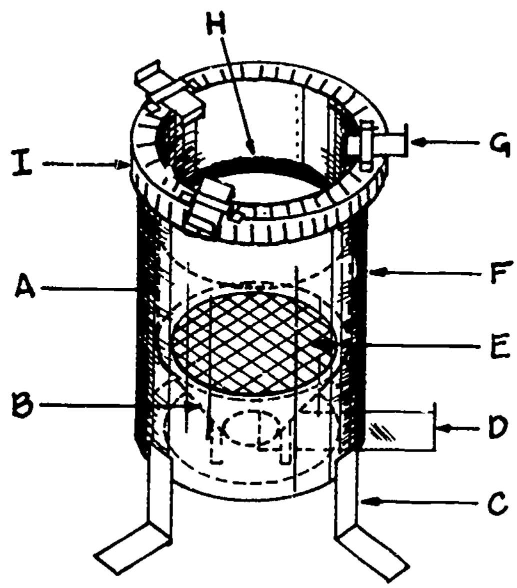
A. Base
B. Pot Position
C. Fire Starter and Air Intake Opening (No Adjustable Damper)
D. Stove Body
E. Grate
F. Pot Rest

Stove Scenario

Origin:	West Africa
Construc. Materials:	Metal (16 ga.)
Efficiency Range:	15-18% (preliminary measurements)
Primary Fuel:	Charcoal
Cost Index:	6
Skill Index:	6
Use:	Household cooking—accommodates various pot sizes
Primary Heat Transfer:	Radiation

Attachment S-17-3, Page 5

IMPROVED METAL JIKO



PARTS

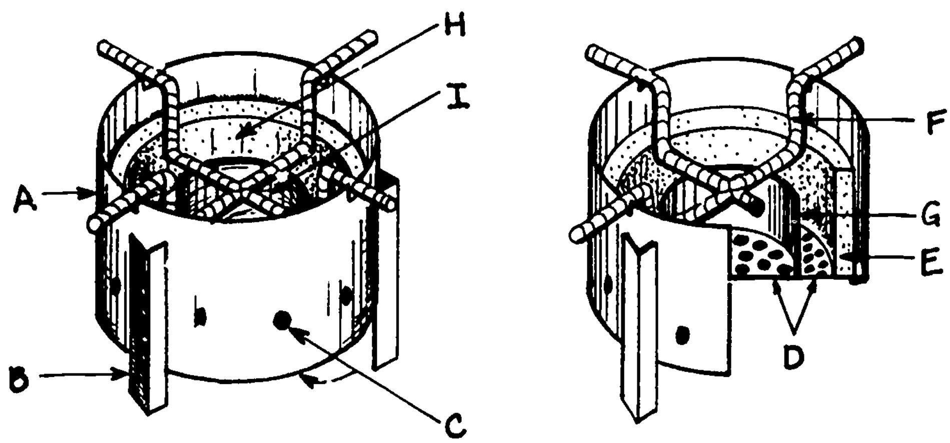
A. Inner Liner (Metal Cylinder)
B. Truncated Cone—Air Preheat
C. Legs
D. Damper
E. Grate
F. Outer Stove Body (Cylinder)
G. Pot Height Adjustments
H. Sand or Dirt Insulation
I. Stove Top Ring

Stove Scenario

Origin:	DTI Peace Corps Training program
Construc. Materials:	Metal (12 and 16 ga.), rivets or nails (new or scrap)
Efficiency Range:	30% (preliminary measurements)
Primary Fuel:	Charcoal
Cost Index:	6-8
Skill Index:	8
Use:	Cooking with pot
Primary Heat Transfer:	Radiation

Attachment S-17-3, Page 6

CONCENTRIC RING STOVE WITH CERAMIC RING



PARTS

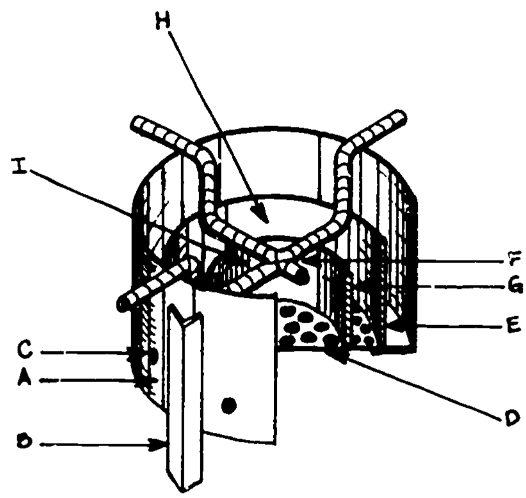
A. Stove Body (Metal Cylinder)
B. Legs
C. Combustion Air Openings
D. Thick Metal Grate
E. Optional Ceramic Ring or Metal Ring
F. Pot Rest—Metal Rebar
G. Inner Metal Ring Liner
H. Outer Fuel Ring
I. Inner Fuel Ring

Stove Scenario

Origin:	Sudan, DTI Peace Corps Training Program
Construc. Materials:	Metal rebar, sheetmetal, light steel, Ceramic clay and method to fire clay
Efficiency Range:	35-50% depending on grade of charcoal used (preliminary measurement)
Primary Fuel:	Low grade charcoal (outer ring), high grade charcoal (inner ring)
Cost Index:	8
Skill Index:	9 (metal), 5 (pottery)
Use:	Household cooking (uses very little fuel)
Primary Heat Transfer:	Radiation

Attachment S-17-3, Page 7

CONCENTRIC RING STOVE



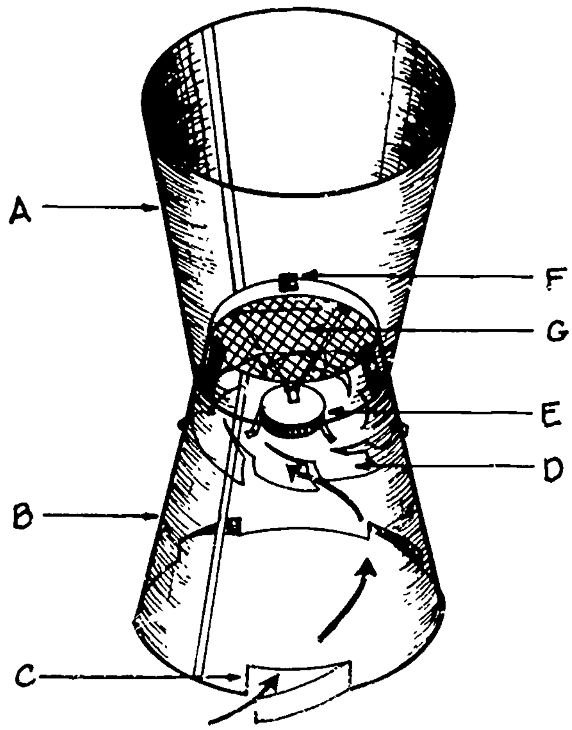
PARTS

A. Stove Body (Metal Cylinder)
B. Legs
C. Combustion Air Openings
D. Thick Metal Grate
E. Sheet Metal Liner to Hold Low Grade Charcoal
F. Pot Rest—Metal Rebar
G. Inner Metal Ring Liner
H. Outer Fuel Ring
I. Inner Fuel Ring

Stove Scenario

Origin:	Sudan, DTI Peace Corps Training Program
Construc. Materials	Metal rebar, sheetmetal, light steel
Efficiency Range:	35-40% depending on grade of charcoal used (preliminary measurement)
Primary Fuel:	Low grade charcoal (outer ring), high grade charcoal (inner ring)
Cost Index:	8
Skill Index:	9 (metal). 5 (pottery)
Use:	Household cooking (uses very little fuel)
Primary Heat Transfer:	Radiation

VENTURI STOVE



PARTS

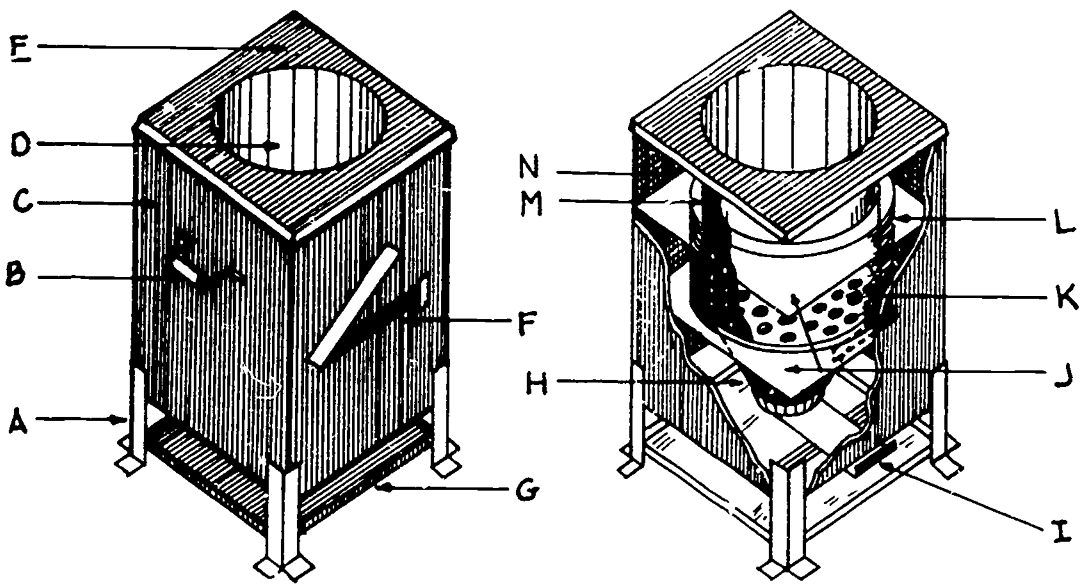
A. Upper Stove Cone--Pot Opening
B. Lower Stove Cone -Pre-Heater
C. Damper (Adjustable)
D. Air Turbulator Fins
E. Central Combustion Air Vent
F. Joining Clamps
G. Grate

Stove Scenario

Origin:	Domestic Technology International
Construc. Materials:	Sheet metal and metal mesh
Efficiency Range:	65% (theoretical) 45% (preliminary measurement)
Primary Fuel:	Any combustable material
Cost Index:	8
Skill Index:	9
Use:	Commercial or household cooking; blacksmithing; melting lead or tar
Primary Heat Transfer:	Depends on fuel used

Attachment S-17-3, Page 9

DOUBLE WALL STOVE



PARTS

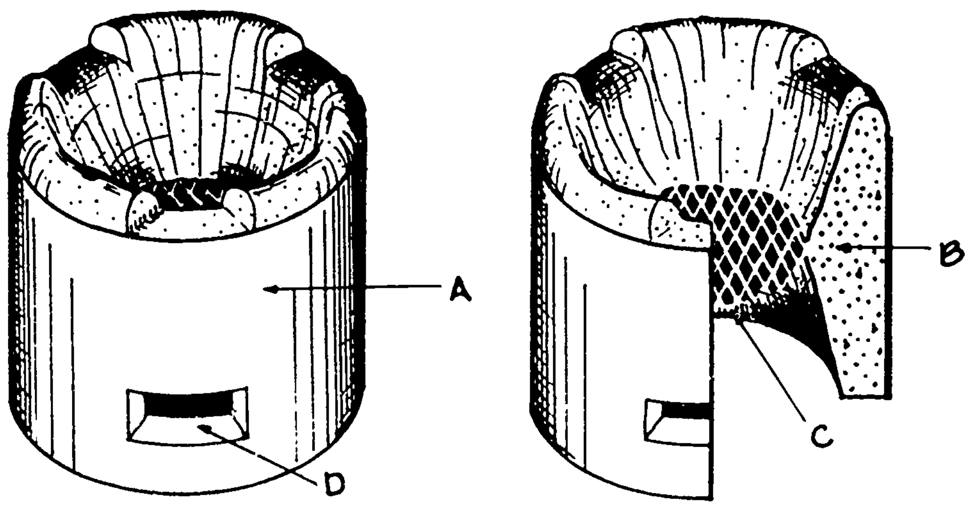
A. Stove legs
B. Handle
C. Stove Outer Body
D. Pot Insert-Opening
E. Stove Top Plate
F. Secondary Air Preheat Damper
G. Ash Tray--Primary Air Opening
H. Air Preheat Cone
I. Primary Air Damper
J. Air Baffles
K. Grate
L. Insulating Cylinder
M. Inner Cylinder with Air Holes (Optional)
N. Insulating Air Gap

Stove Scenario

Origin:	DTI/Peace Corps Training Programs (experimental)
Construc. Materials	Metal (12 ga.)
Efficiency Range:	50-58% (preliminary measurements)
Primary Fuel:	Charcoal/any fuel
Cost Index:	9
Skill Index:	9
Use:	Household cooking
Primary Heat Transfer:	Radiation - convection secondary Combustion

Attachment S-17-3, Page 10

SAMOAN PORTABLE STOVE



PARTS

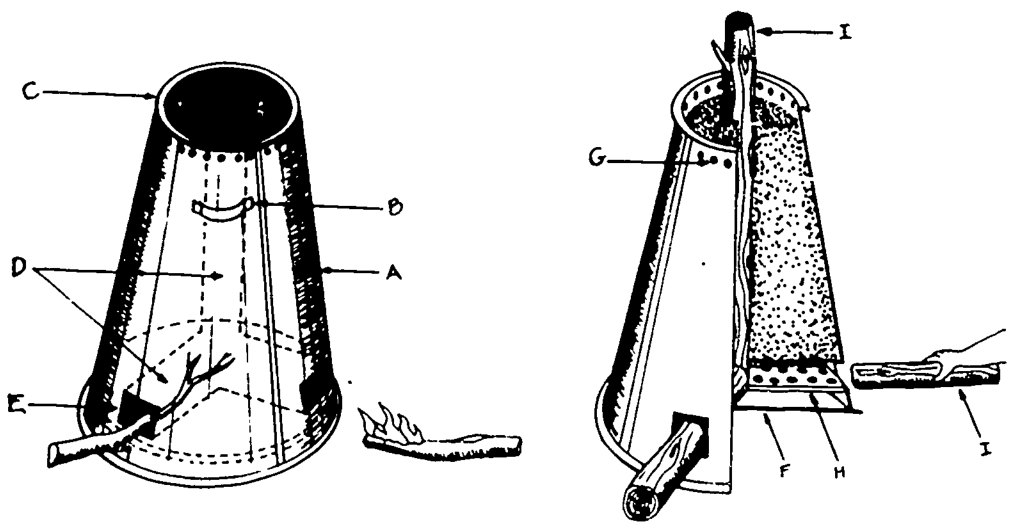
A. Metal Outside Skin
B. Concrete Stove Body
C. Metal Grate
D. Fuel Feed Access

Stove Scenario

Origin:	South Pacific
Construc. Materials	Cement, sand, sheet metal, metal grate
Efficiency Range:	12-15%
Primary Fuel:	Coconut shell charcoal
Cost Index:	6
Skill Index:	6
Use:	Grilling and pot cooking — household
Primary Heat Transfer:	Radiation

Attachment S-17-3, Page 11

CROP RESIDUE STOVE



PARTS

A.	Stove Body (Truncated Cone)	E.	Damper/Fire Start Location
B.	Handle	F.	Metal Bottom
C.	Pot Seat	G.	Exhaust Holes
D.	Air/Combustion Chamber formed in Fuel Material	H.	Grate
		I.	Air/Combustion Chamber Forms

Stove Scenario

Origin:	Asia/India
Construc. Materials:	Sheet metal
Efficiency Range:	35-45% for continuous cooking (preliminary measurements)
Primary Fuel:	Rice hulls, sawdust, chopped dry grass
Cost Index:	6 (small) 7 (large)
Skill Index:	6
Use:	Commercial or large family household
Primary Heat Transfer:	Convection

SESSION S-18 **METAL STOVE CONSTRUCTION**

TOTAL TIME: 14 Hours

OBJECTIVES:
* To observe layout of sheet metal patterns for cones, pyramids and boxes
* To review tool safety and proper use
* To answer stove design questions
* To construct a metal stove based on the designs presented and approved in Session 17

RESOURCES: Attachment S-18-1

MATERIALS: Basic hand metal working tools, tables, tree stumps or a place on the ground, an anvil, vice

PROCEDURE:

Step 1 10 Minutes
Review session objectives and construction schedule

Step 2 50 Minutes
Review tool safety, use and sharing of tools

Step 3 13 Hours
Construct stoves

Trainer's Note

Craftsmanship should be emphasized. Staff should continue to monitor stove constr''ction activities to insure this, also proper and safe use of tools. Staff to trainee ratio should be about one to five.

Attachment S-13-1, Page 1

TEMPLATES FOR METAL CHARCOAL FUEL STOVE CONSTRUCTION

Use of a template or pattern when cutting stove parts helps ensure dimensional accuracy and speeds production. The template can be drawn on paper at first. A more permanent copy can be cut out of sheet metal. To prevent its loss through use as a stove itself, weld metal bars to it lengthwise. For a spherical or cylindrical pot, template design is straightforward. Prepare such a template following the steps below:

1. The length of the template is given by

$$L = C + G + S + T$$

C is determined by the measurement of the pot around its widest circumference. G is determined by the desired pot-to-wall gap, G = 2 (gap). For a gap of 4 mm, G = 2.5 cm; for 6 mm, G = 3.8 cm; for 8 mm, G = 5.0 cm. A gap of four to six mm is recommended. Increase it only if excessive smoke comes out the door or the heating rate is too slow. S is determined by the amount of overlap in the seam. It is preferable to weld the stove together end to end to prevent the creation of a small vertical channel by which the heat can by-pass the pot. If the seam is crosswelded or folded, typical values for S will be 1 cm. T is determined by the thickness of the metal used. One typically uses 1 mm (T=0.3 cm) or 1.5 mm (T=0.47 cm) thick metal. Thus, for a 90 cm circumference pot, a 4 mm gap, an end to end welded seam, and 1 mm thick metal we find:

$$L = 90 + 2.5 + 0.3 = 92.8 \text{ cm}$$

2. For spherical pots, template height H is determined by the sum of the airhold height (A), the grate-to-pot height (P) and the amount necessary to extend a few centimeters above the pot's maximum circumference when in place on the stove (h).

$$H = A + P + h$$

Typical values for A are 3 cm and for P, 0.4 of the pot diameter. For cylindrical pots the height h is typically 5 cm to 10 cm. The best height h is determined more precisely by comparing the increased efficiency and reduced fuel use caused by the additional height versus the increased cost of the extra metal. Additional height can also be provided at the top and bottom of the template, typically 1 cm each, to allow the edge to be folded over to protect against sharp edges and increase the stove's rigidity and strength.

3. Stoves usually have four airholes, about 3 cm by 3 cm each (A=3 cm). Space them symmetrically, but far enough away from the door and the seams to avoid weakening the stove. Cut the airholes on two sides only so that when bent upward and inward they can act as supports for the grate. For larger pots or soft ground soil where the stove will sink in the ground, larger airholes may be necessary. Alternatively, for soft soil conditions a ring-shaped platform can be cut and attached to the stove bottom if necessary and cost effective.

4. Space pot supports evenly around the stove, but offset them from the damper/fuel opening and air vents if appropriate so that the stove is not weakened. The height Z for the pot supports above the top of the airholes (where the grate will rest) is given by the sum of the fuel thickness (4 cm) F, the distance from the bottom of the pot to the top of the fuel (W) (3-5 cm for boiling position and 8-10 cm for simmer position), the distance that the air hole flaps fold upward A (3 cm). (Note: There are two pot positions, simmer and boil.) Therefore:

$$Z = F + W + A$$

5. The door size is somewhat arbitrary and is determined by the locally available wood size. Typical sizes for a 90 cm circumference pot are 12 cm wide by 9 cm high. Place the bottom of the door at the grate position-the top of the airholes. Make the top of the door several centimeters below the bottom of the pot so that the hot gasses are guided up around the pot rather than out the door. If necessary, decrease the door height to ensure that it is below the bottom of the pot.

6. The grate is a circle of sheet metal cut to fit snugly into the finished cylinder. Punch the center diameter with a 30 percent hole density of 1 cm holes.

To produce stoves in quantity:

1. Trace the template on a sheet of metal as many times as desired or as space permits.
2. Cut each form out in outline. Cut the door, pot support holes and strips for the airholes.
3. Roll the metal into a cylinder. The cylinder should be as straight and smooth as possible.
4. Cut out other components such as pot supports and stabilizers and put them into place.
5. Cut the grate and punch the holes in it.
6. Weld the stove together. Weld pot supports into place. Alternatively, fold all seams together.
7. Place the grate in the stove, fold the tabs from the airholes inward and upward.
8. Paint it with heat resistant paint where available.

SESSION S-19 **COOKING ON COOKSTOVES**

TOTAL TIME: 4 Hours

OBJECTIVES:
* To practice using stoves constructed during training
* To use foods and recipes from countries of destination and to include food from gardening and drying sessions
* To make observations on how the stove works and possible fine-tuning to be done

Trainer's Note

In in-country training the trainees can buy their food in the market. In stateside training a food list needs to be provided several days in advance.

REFERENCES: Lorena Book, pgs. 70-72
Attachment S-19-1

MATERIALS: Stoves, fuel, matches, water, cooking pots and utensils, food and seasoning, plates, spoons, forks

PROCEDURE:

Step 1 — 5 Minutes
Review objectives and procedure. Explain that this session is to learn stove use and also practice lighting and maintaining a fire in preparation for the testing session.

Step 2 — 30 Minutes to 1 Hour
Prepare ingredients and transport to the cooking site.

Step 3 — 2½ Hours
Cook a meal and share the results with other trainees.

Step 4 — 25 Minutes
Record the observations on stove use. These observations will be used in the diagnosis and repair session.

Step 5 — 30 Minutes
Clean up site.

Attachment S-19-1, Page 1

TRADITIONAL COOKING DISCUSSION QUESTIONS

Design

What are the major design features of your fire or charcoal cooker (i.e., draft system, smoke control, baffles, flues, chimneys, construction material, etc.)?

Starting the Fire

What problems did you encounter in starting the fire?

How long did it take for your fire to heat up?

Was there much smoke?

Preparing the Meal

How often did you need to add fuel?

Did the fire stay lit?

Was there much heat loss?

Did the pots fit well over the fire?

Once heated, did the dishes hold their heat?

Was there much smoke?

Note any problems in use of stove.

After the Meal

Was your fuel source easy to handle?

Was there much work involved in preparing the fuel for use?

How long did your fire hold its heat after the meal was prepared?

How much fuel did you use?

SESSION S-20 **COOKSTOVE BUSINESS DEVELOPMENT**

TOTAL TIME: 2 Hours

OBJECTIVES:

* To identify the conditions to successfully develop and sustain a village or urban business which builds, sells and repairs cookstoves
* To identify and explore the essential features of a cookstove business
* To discuss the relative importance of business loans, bookkeeping/accounting, technology transfer, expansion of a business, market analysis and other important factors affecting cookstove business development

RESOURCES: Local business persons, e.g., metal workers or persons with third world small business experience, bookkeeping/accounting handouts, sample business scenerios which participants could analyze

REFERENCES: Accounting for Microbusiness — a Teaching Manual, Peace Corps R23B
Consultancy for Small Business, Malcolm Harper, ITTDG, London U.K.
Small Business Assistance Manual, Partnership for Productivity, Washington, D.C.

MATERIALS: Flip chart, markers

Trainer's Note

This session should be modified to fit the in-country situation using local business people whenever possible. This session will probably not be needed in most SST situations because small business is usually offered in a different track or as part of core curriculum.

PROCEDURE:

Step 1 — 1 Hour
Discuss the essential features of successful business which flourish in the countries in question. Try to draw parallels between these businesses and a potential cookstove business. If cookstoves are already built and sold in-country, analyze that business.

Step 2 — 1 Hour
The trainer or a local business person should go over the basics of accounting, obtaining loans and SPA, if appropriate.

SESSION S-21 **DIAGNOSIS AND REPAIR OF COOKSTOVES**

TOTAL TIME: 2 Hours

OBJECTIVES:
* To discuss the importance of and ways to do follow-up
* To diagnose problems that occur with malfunctioning cookstoves
* To begin repair of any malfunctioning stoves

RESOURCES: Attachments S-21-1, S-21-2 and S-21-3
Lorena Book, pgs. 72-78

MATERIALS: Stoves, pots, clay/sand mix, extra tin, tin snips, spoon, water

PROCEDURE:

Step 1 5 Minutes
Review the objectives and procedures

Step 2 20 Minutes
Distribute attachments S-21-1. Have the participants develop an outline for a follow-up visit based on the two scenarios, no more than 3 to a group.

Step 3 20 Minutes
Review the outline of each group and discuss them as a large group.

Step 4 30 Minutes
Discuss observation sheet from the cooking session. Note problems and have the trainees discuss why these problems occurred, and how to correct each problem. Distribute Attachment S-21-2 and allow time for reading.

Step 5 45 Minutes
Begin repairing the stoves. Explain the stoves will be tested in the following session, so repairs need to be completed before the next session begins.

SCENARIO #1

The Volunteer before you was assigned to introduce improved metal stoves. At a stove center in a regional capitol she worked with a local sheet metal worker to improve the efficiency of the existing metal stove. Both the Peace Corps Volunteer and the metal worker developed several design modifications which were then tested. A model was found that both the Volunteer and local metal worker found efficient and relatively easy to produce. The metal worker began making and marketing these stoves. You are replacing this Peace Corps Volunteer. Due to a timing problem, when you arrive the Peace Corps Volunteer has been gone for six months. Based on what you have learned in the Survey and Assessment Session and your understanding of stoves, develop an outline of your follow-up on the metal worker's stoves. Include what information you want to learn and how you would gather it.

SCENARIO #2

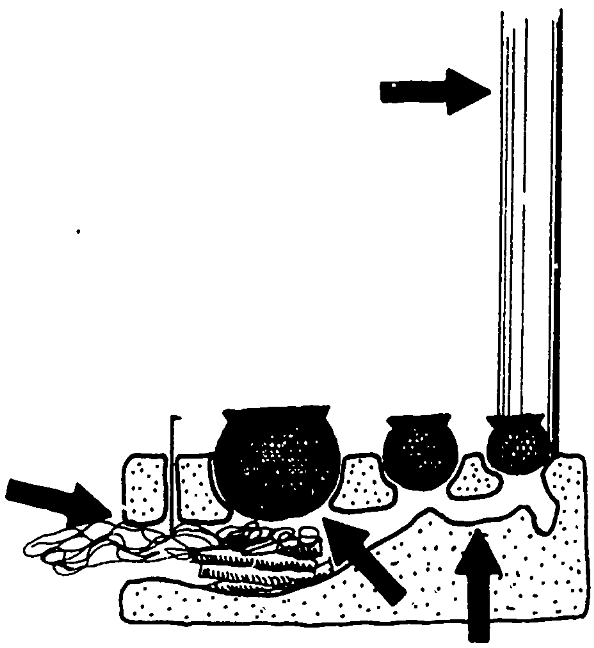
Develop an outline for a follow-up visit. Use this scenario: You (PCV) did a stove training with your counterpart three months ago in a village 30 miles from where you live. The training was arranged by the government rural development worker in your town. He is responsible for the region you live in. At the training five local men were trained to make a two-pothole stove with a chimney. During the five-day training, six stoves were made. Your counterpart came back two weeks after the training to teach women how to use the stoves. He found that three new stoves had been made. Based upon what you have learned in the Survey and Assessment Session and your understanding of how stoves function, develop an outline of a follow-up visit. Include length of visit, who you would talk with, information you want to learn.

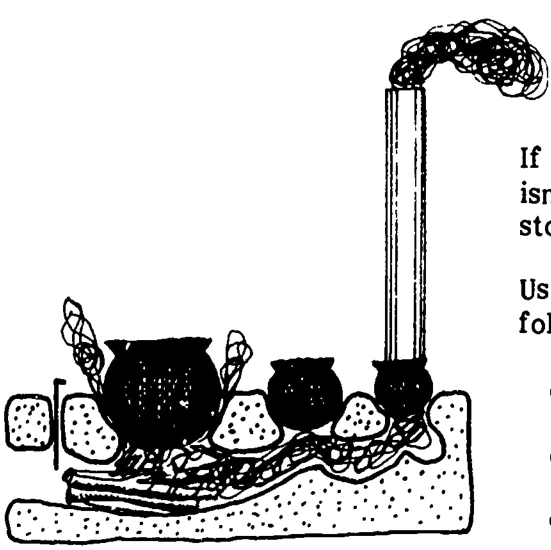
Attachment S-21-2, Page 1

When using an earthen stove there are several problems that can occur:

If you have difficulty maintaining a fire or smoke comes out the front rather than the chimney, check the following areas:

- o Doorway size
- o Tunnel sizes
- o Chimney height
- o Pot diameter
- o Distance between pot and fuel.



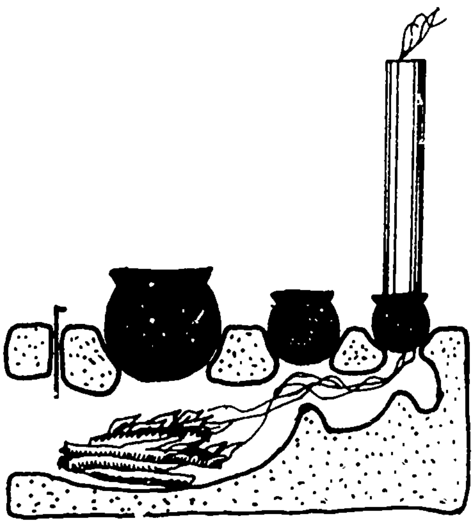


If the fire keeps dying it means there isn't enough air flow through the stove.

Usually you will find one of the following:

- o The tunnels are too small
- o Pot too close to fire
- o Wrong chimney dimensions

Generally, if the chimney is very tall you want a small diameter.



Attachment S-21-2 Page 2

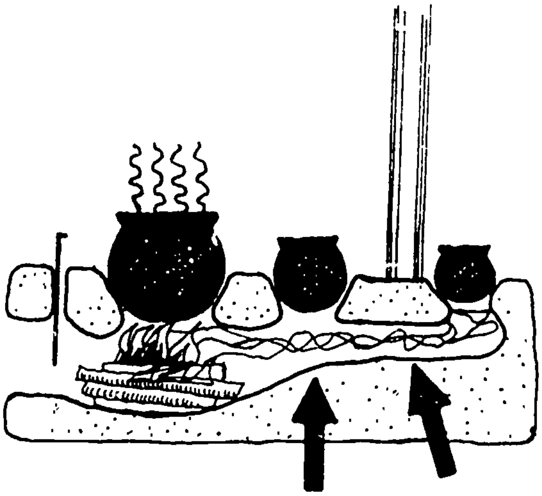
If the second pot doesn't boil there are several areas to check.

o If there is too much draft it will take the air through the stove too rapidly and there will not be time for the pot to absorb the heat.

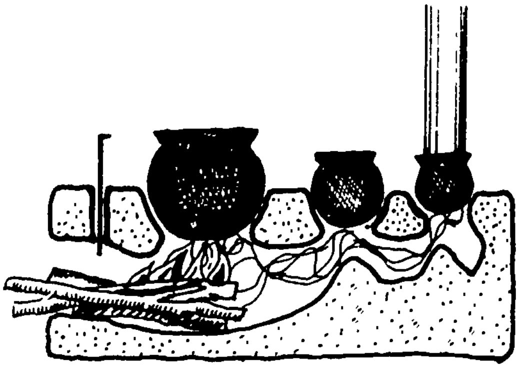
A damper will control air flow.

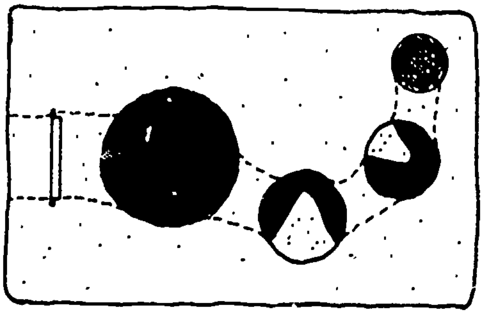
o Also, the second pot could be too far from the first. In which case you should fill in the second pothole and dig a new one closer to the first.

o In addition, there could be too much space between the bottom of the pot and the stove floor. Add mix to within 2 cm of the pot and add a baffle.



Correct Air Flow and Design





Attachment S-21-3, Page 1

DIAGNOSIS AND REPAIR OF COOKSTOVES

Earthen Stoves:

1. The weakest place on the stove is the part over the firebox entrance. If this section breaks, it can be repaired in one of two ways. One, you can scrape and even out the broken edges, wet down the sides, make some new mix and rebuild the doorway. When the new mix has dried enough to be firm, cut out the doorway. Two, you can cut out a shelf on both sides of the door, make a brick of mix to fit into the space and rest the brick on the shelf.

2. Cracking is a common occurrence. When cracks occur cut the crack slightly larger, wet down the crack and fill with new mix.

3. In using the stove, there are several problems that can occur:

   a. If you have difficulty maintaining a fire or smoke comes out the front rather that the chimney, check the following areas: the size of the doorway, tunnel sizes, chimney height and diameter and the distance of the pot from the wood. If a fire keeps dying out it means there isn't enough air flow through the stove. Usually the tunnels are too small in diameter, the pot is too close to the fire or the chimney dimensions are wrong. Generally, if the chimney is very tall, the diameter should be smaller.

   b. If the second pot doesn't boil there are several things to check. If there is too much draft it will take the hot air through the stove too fast and not give the pot time to absorb the heat. A damper will control the passage of air, or the second pothole could be too far from the first pot. In this case it is necessary to fill in the second pothole with mix and dig out a new hole closer to the first pot. To slow down and direct the passage of hot air, add a baffle.

Ceramic/Metal Stoves:

1. If the pot heats too slowly, the pot is either too far from the fire or there aren't enough vent holes in the grate and under the grate to allow full combustion. Adjust the grate distance and in metal stoves make more vent holes.

2. If the fire dies it could once again be a matter of vent holes. Also the pot could fit too tightly not allowing the hot air to escape around the sides.

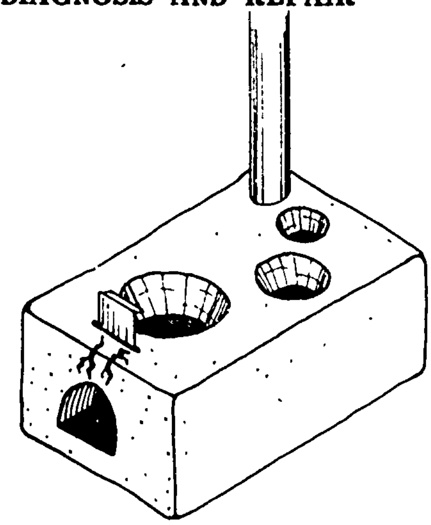
3. If the fire is too hot and burns the food, instruct the cook to use less fuel. To be able to control boiling and simmering a damper is needed, or raise or lower the distance of the pot from the fire.

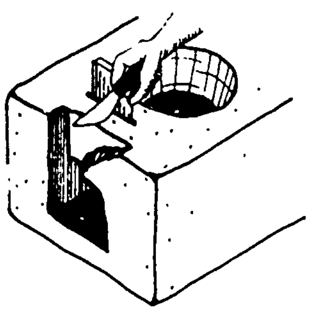
NOTE: When making adjustments, make one change in the stove and test to see how it affects the functioning of the stove before making another change.

Attachment S-21-3, Page 3

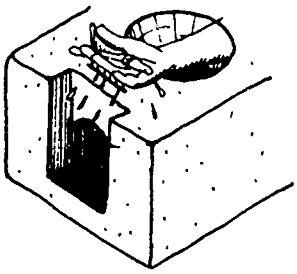
EARTHEN STOVES — DIAGNOSIS AND REPAIR

The weakest place on the earthen stove is the part over the firebox entrance. If this section breaks it can be repaired in one of two ways.

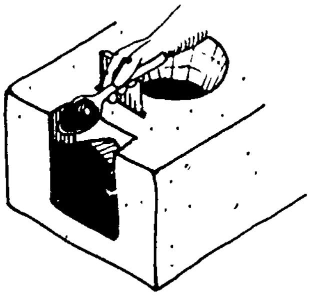




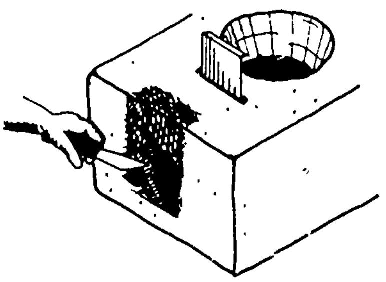
First, scrape away and even out the broken edges.



Wet down these surfaces.

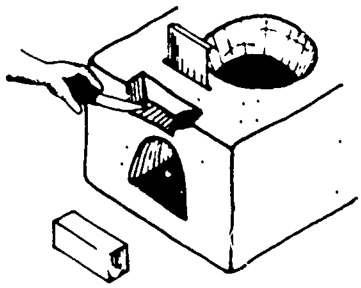


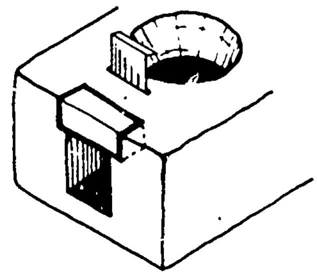
Prepare some new clay/sand mix and rebuild the doorway.



When the new mix has dried, re-cut the doorway.

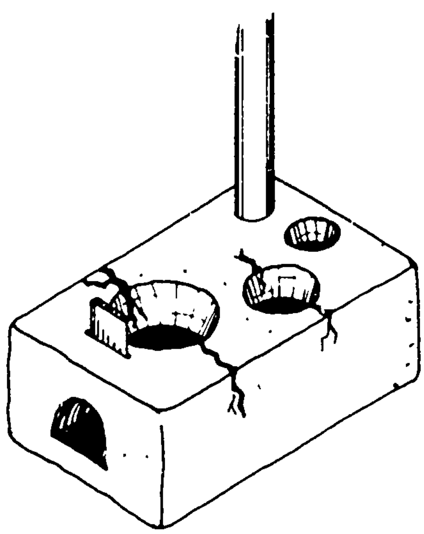
Attachment S-21-3, Page 4

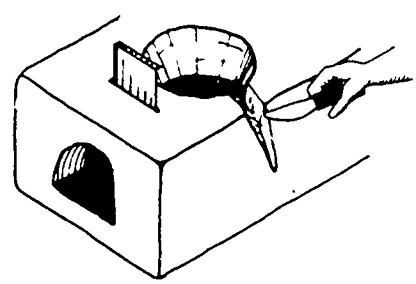


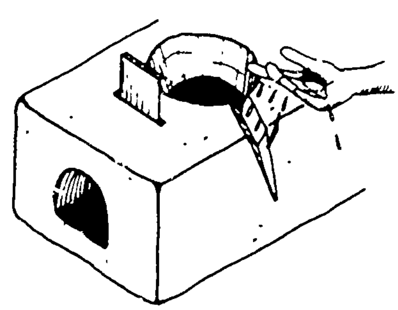


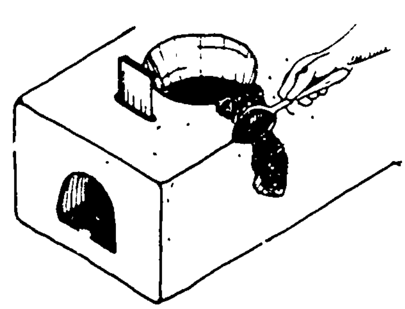
Secondly, cut a shelf on both sides of the door, make a brick out of the mix to fit into the space and rest the brick on the shelf.

Cracking throughout the stove body is a common occurrence. When cracks occur, cut the crack slightly larger, wet down the crack and fill with new mix.









SESSION S-22 **COOKSTOVE TESTING AND MONITORING**

TOTAL TIME: Two 4-Hour Sessions (8 Hours Total)

OBJECTIVES:

* To discuss different methodologies used for measuring the fuel consumption of cookstoves
* To discuss the need for and relative merits of a stove testing standard
* To evaluate the fuel consumption characteristics of several improved cookstoves built by participants by performing at least two "Water Boiling Tests," using stoves
* To look at the variables that influence stove testing and efficiency ratings
* To compare stove testing results

RESOURCES: Attachments S-22-1 through S-22-8
Helping People in Poor Countries Develop Improved Cookstove Programs, GATE, pgs. 86-95
Lorena Book, pgs. 85-106.
A Woodstove Compendium, Eindhoven University of Technology, pgs. 337-350

Trainer's Note

Other testing formats may be used if appropriate.

MATERIALS: 10 kg scale, pots with lids that have holes in which to place thermometers, thermometers for each group testing a stove, rubber stoppers with holes for thermometers, fuel (dry), matches, water, metric liquid measuring unit, clock, sling psychrometer or wet and dry bulb apparatus, flip chart, markers, forms for recording the data, stoves to be tested

Trainer's Note

Handouts should be distributed a least one day before session as a reading assignment.

PROCEDURE: PART I (4 Hours)

Trainer's Note

It is better to conduct Part I and Part II on two separate days, four hours the first day and four hours the second. The first session will be divided into two hours of discussion and lecture and two hours to prepare for and conduct a "dry-run" test. The second session should consist entirely of testing.

Step 1 5 Minutes
Review session objectives and procedures.

Step 2 — 10 Minutes
Brainstorm reasons for testing and uses of performance test data.

Step 3 — 1 Hour
Trainer should give a lecture on testing procedure being open to questions throughout. It is helpful if the trainees read the GATE and Lorena books and the handouts provided in this session beforehand.

Trainer's Note

Refer to the Woodstove Compendium, pgs. 337-350 for information.

Step 4 — 40 Minutes
Review the test forms and procedures and explain how to use them. Give trainees sample calculations examples.

Step 5 — 2 Hours
Explain what needs to be done to set up the testing session. Choose two to three monitors to help with weighing wood, measuring temperatures periodically and overall supervision of the tests if appropriate. Identify two trainees to dry fuel samples overnight to obtain moisture content which will be used in calculations.

Trainer's Note

The trainer should take some time to familiarize the monitors with testing procedures prior to this session. Encourage participants to make a dry run test if there is sufficient time. Frustration by participants is likely during the first test.

PROCEDURES: PART II

Step 1 — 30 Minutes
Review testing procedures and check to see that each testing group has weighed their wood, has pots with lids, etc.

Step 2 — 2 Hours, 30 Minutes
Do the actual testing. Have participants do as many tests as they can in the time allowed.

Step 3 — 30 Minutes (Optional)
Review the testing results, discuss problems, observations and clean up the area.

Step 4 — 30 Minutes
Assign several volunteers the task of compiling the information from the tests. Trainees should be required to include this information in their final stove presentations and in any documentation.

COOKSTOVE TESTING METHODOLOGIES

There are many methods to assess the performance or efficiency of cookstoves. Direct accurate thermodynamic efficiency measurements of stoves are difficult to perform and require controlled conditions usually associated with a laboratory. Consequ ntly the test methods used most often are comparative methods which eliminate the need for measurement of precise thermodynamic parameters and instead measure weights of evaporated water lost and fuelwood consumed over a period of time. These parameters can be measured accurately with locally available equipment by lay persons and can yield useful stove performance data.

Comparative testing methods are different for both stove and fuel types. Charcoal fuels require different testing procedures as do single and multiple pot stoves. The particular comparative test method recommended for this training is the "Water Boiling Test".

WATER BOILING TEST

Water Boiling Tests (WBT) are short, simple simulations of standard cooking procedures. They measure the fuel consumed and time required for simulated cooking. They are used for a quick comparison of the performance of different stoves and the performance of the same stove under different operating conditions to quantify an expected stove peformance. WBTs are done by stove designers, research people, and field workers.

Water Boiling Tests use water to simulate food; the standard quantity is two-thirds the full pan capacity.

The test includes "high power": and "low power" phases. The high power phase involves heating the standard quantity of water from ambient temperature to boiling as rapidly as possible, and keeping it boiling at the same high power for 15 minutes. The low power phase follows. The power is reduced to the least level needed to keep the water within 2 C of boiling over a one-hour period.

WBT should be repeated at least four times, and the results summarized statistically. Test results are expressed in terms of wood consumption and time required. Correction factors are used to reflect the known influence of some non-standard parameters.

<u>Equipment</u>

* Stove
* Pot with lid
* A balance accurate to 10 grams with a recommended capacity of 5 kg (Technical note 5)
* Locally available wood or charcoal for other fuels, air dried preferably 2 to 3 cm diameter

* Water, within 2°C of ambient temperature
* Timing device
* Mercury or digital thermometer for measuring temperatures up to 105°C
* Device to measure/estimate the moisture content of wood, dung and peat fuels. It is not necessary to measure moisture content of charcoal under normal circumstances
* Equipment for removing and weighing hot coals
* Forms for recording data and calculations

Procedure For Testing Single Pot Charcoal Fueled Cookstoves

1. Note and record the test conditions. Prepare a drawing of the pot and stove to be tested. Include all relevant stove dimensions and show how the pot fits into the stove (Technical Note 8). Note climatic conditions (Technical Note 1).
2. Take a quantity of charcoal not more than twice the estimated needed amount, weigh it, and record the weight on the data reporting sheet.
3. Weigh the pot with its lid, and record the weight. Fill the pot with water to 2/3 capacity, replace the lid, and record the new weight.
4. Put a thermometer in the pot so that it is fixed in the center, about 1cm from the bottom (Procedural Note 1). Record water temperature and confirm that it varies no more than 2°C from ambient.
5. After a final check of preparations, light the fire as in Technical Note 10. Record the exact starting time and the amount of kerosene added. Throughout the following "high power" phase of the test, control the fire with the means commonly used locally to bring the pot to a boil as rapidly as possible.
6. Regularly record the following on the Data and Calculation Reporting Form and the Water Boiling Test Record Sheet:
   - the water temperature in the pot;
   - the weight of any charcoal added to the fire;
   - any action taken to control the fire (dampers, blowing, etc.); and
   - the fire reaction (smoke, etc.).
7. Record the time at which the water in the pot comes to a brisk boil. Move the lid if necessary to prevent the pot from boiling over. Continue to maintain the fire at the same high power level.
8. Exactly 15 minutes after boiling begins, rapidly do the following:
   - note the time;
   - remove all charcoal from the stove, and weigh it (Procedural Note 2);
   - record the water temperatures from the pot;
   - weigh pot, including water and lid; and
   - return charcoal, and pot to the stove to begin the "low power" phase of the test.

   With practice a single tester can complete this step within 2 to 4 minutes and move on to Step 9 without introducing significant error to the data.
9. For the next 60 minutes maintain the fire at a level just sufficient to keep the water in the pot within 2°C of boiling. Use the least amount of charcoal possible, and avoid vigorous boiling. Continue to monitor all conditions in Step 6. If the temperature of the water in the pot drops more than 5° below boiling, the test must be considered invalid.
10. Weigh, and record data for the remaining charcoal.
11. Weigh and record the water remaining in the pot.
12. Calculate the amount of charcoal consumed, the amount of water remaining, the specific time, and the Standard Specific Consumption (SSC), using the Data and Calculation form for single pot charcoal stoves.
13. Interpret test results (see Procedural Note 4), and fill out a Test Series Reporting Form.

9. For the next 30 minutes maintain the fire at a level just sufficient to keep the water in the first pot within 2°C of boiling. Use the least amount of charcoal possible and avoid vigorous boiling. Continue to monitor all conditions in Step 6. If the temperature of the water in the first pot drops more than 5° below boiling, the test must be considered invalid.

10. Weigh and record separately the residual charcoal. Record data on Data and Calculation Form for Multi-Pot Wood Stove.

11. Weigh and record the water remaining in each pot.

12. Calculate the amount of charcoal consumed, the amount of water remaining, the specific time, the Standard Specific Consumption (SSC), the Consumption Ratio and maximum power levels.

13. Interpret test results and fill out a Test Series Reporting Form.

Attachment S-22-2, Page 1

WATER BOILING TEST

DATA AND CALCULATION AND REPORTING FORM

FOR SINGLE POT CHARCOAL STOVES (ONLY)

Test No. ________ Location ________________________________
Date ________ Air temp. ______ ^{o}C Wind ______ Rel. humidity __________
Stove ________ Stove condition ______________________________
Tester ________ Remarks ______________________________
Altitude ______________________________

BASIC TEST DATA	Initial Measurement	End of High Power Phase	End of Low Power Phase
Weight of charcoal	a)______g	e)______g	j)______g
Weight of charcoal added (prior to end of phase)		f)______g	k)______g
Weight of pot with lid and water	b)______g	g)______g	m)______g
Water temperature	c)______ ^{o}C	h)______ ^{o}C	n)______ ^{o}C
Time	d)______min	i)______min	p)______min.

(Use the "cookstove time versus temperature curve" and the "test record" to record the changes in water temperature.)

CALCULATIONS	HIGH POWER PHASE	LOW POWER PHASE
Charcoal consumed	A) (a+f)-e = ______g	G) (e+k)-j = ______g
Equivalent dry wood consumed	B) 1.5 (A) = ______g	H) 1.5 (G. = ______g
Water vaporized	C) b - g = ______g	J) g - m = ______g
Std. specific consumption/charcoal	D) A/C = ______	K) G/J = ______
Std. specific consumption/wood	E) B/C = ______	L) H/J = ______
Duration of test	F) i-d = ______	M) p-i = ______min

Attachment S-22-2, Page 2

WATER BOILING TEST
TEST SERIES REPORTING FORM*
FOR SINGLE POT CHARCOAL STOVES (ONLY)

Organization conducting tests ____________________
Address ____________________
Name of stove tested ____________ Name of tester ____________
Test numbers being reported: ____________ Testing period ____________
(Mos.) (Yea.)

CLIMATIC CONDITIONS		MAXIMUM	MINIMUM	MEAN
	Air temperature	______	______	______
	Relative humidity	______	______	______
	Wind conditions	______	______	______
CHARCOAL	SPECIES (Botanic Name)	Approx. % Total (By weight)	Mean Length	Mean Diameter
	______	______	______	______
	______	______	______	______
	______	______	______	______
	Charcoal Cost of kg: ______ est. coll. time	OR ______ local curr.	= $ ______ U.S. dollars	
MEASURING DEVICES	INSTRUMENT	RANGE	ACCURACY	TYPE, MANUFACTURER
	Balance #1	____ kg	______	______
	Balance #2	____ g.	______	______
	Thermometer	____ °C	______	______
	R.H. indicator	____ %	______	______
	Anemometer	____ m/s	______	______
	Other	____	______	______

	Mean	Standard Deviation	Coeff. of Variation	Standard Error	95% Confidence Interval
Standard specific consumption	____	____	____	____	____
Duration of tests	____	____	____	____	____

Total No. of tests reported ____

Procedure for Testing Multipot Woodfueled Earthen Cookstoves

1. Note and record the test conditions. Prepare a drawing of the pots and stove to be tested. Include all relevant stove dimensions and show how the pots fit into the stove. Note climatic conditions.

2. Take a quantity of wood not more than twice the estimated needed amount, weigh it, and record the weight on the data reporting sheet.

3. Weigh the pots with their lids, and record the weight. Fill each pot with water to 2/3 capacity, replace the lids, and record the new weig t.

4. Put a thermometer in each pot so that it is fixed in the center, about 1 cm from the bottom. Record water temperatures and confirm that they vary no more than 2°C from ambient.

5. After a final check of preparations, light the fire using a small measured amount of kerosene if necessary. Record the exact starting time. Throughout the following "high power" phase of the test, control the fire with the means commonly used locally to bring the first pot to a boil as rapidly as possible.

6. Regularly record the following on the Data and Calculation Reporting Form and on the Water Boiling Test Record Sheet:
   - the water temperature in each pot;
   - the weight of any wood added to the fire;
   - any action taken to control the fire (dampers, blowing, etc.); and
   - the fire reaction (combustion) characteristics, color of smoke and fire, etc.

7. Record the time at which the water in the first pot comes to a brisk boil. Move the lid if necessary to prevent the pot from boiling over. Continue to maintain the fire at the same high power level.

8. Exactly 15 minutes after boiling begins, rapidly do the following:

   - note the time;
   - remove all wood from the stove, knock off any charcoal, and weigh it together with the unused wood from the previously weighed supply;
   - weigh all charcoal separately;
   - record the water temperature from each pot;
   - weigh each pot, including water and lid;
   - return charcoal, burning wood, and pots to the stove to begin the "low power" phase of the test.

   With practice a single tester can complete this step within 2 to 4 minutes and move on to Step 9 without introducing significant error to the data.

9. For the next 60 minutes maintain the fire at a level just sufficient to keep the water in the first pot within 2°C of boiling. Use the least amount of wood possible, and avoid vigorous boiling. Continue to monitor all conditions in Step 6. If the temperature of the water in the first pot drops more than 5° below boiling, the test must be considered invalid.

10. Weigh and record separately the residual charcoal and all remaining wood. Record data on Data & Calculation form for Multi-Pot Wood Stove.

11. Weigh and record the water remaining in each pot.

12. Calculate the amount of wood consumed, the amount of water remaining, the specific time, the Standard Specific Consumption (SSC), the Consumption Ratio for two or three pot stoves and the minimum and maximum power levels.

13. Interpret test results and fill out a Test Series Reporting Form.

Attachment S-22-3, Page 1

WATER BOILING TEST
DATA AND CALCULATION FORM**
FOR
MULTIPOT WOODFUEL EARTHEN STOVES (only)

Test Number_______ Location ______________________________
Date______________ Air temp._____°C Wind_____Rel. humidity_____
Stove_____________ Stove condition ______________________________
Tester____________ Remarks ______________________________

BASIC TEST DATA	INITIAL MEASUREMENT	END OF HIGH POWER PHASE	END OF HIGH POWER PHASE
Wood moisture content	a) ________		
Weight of wood	b) ________ kg	j) ________ kg	u) ________ kg
Total wood added		jj) ________ kg	jj) ________ kg
Weight of charcoal		k) ________ kg	v) ________ kg
Wt. of Pot#1 w/lid & water	c) ________ kg	m) ________ kg	w) ________ kg
Wt. of Pot#2 w/lid & water	d) ________ kg	n) ________ kg	y) ________ kg
Wt. of Pot#3 w/lid & water	e) ________ kg	p) ________ kg	z) ________ kg
Water temperature, Pot#1	f) ________ °C	q) ________ °C	aa) ________ °C
Water temperature, Pot#2	g) ________ °C	r) ________ °C	bb) ________ °C
Water temperature, Pot#3	h) ________ °C	s) ________ °C	cc) ________ °C
Time	i) ________	t) ________	dd) ________

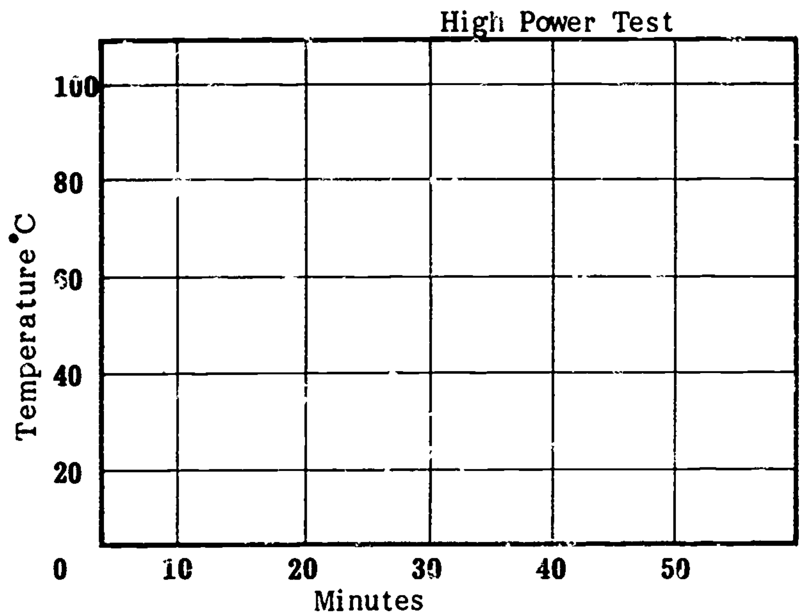
(Use the graph outline on reverse side to record changes in water temperature)

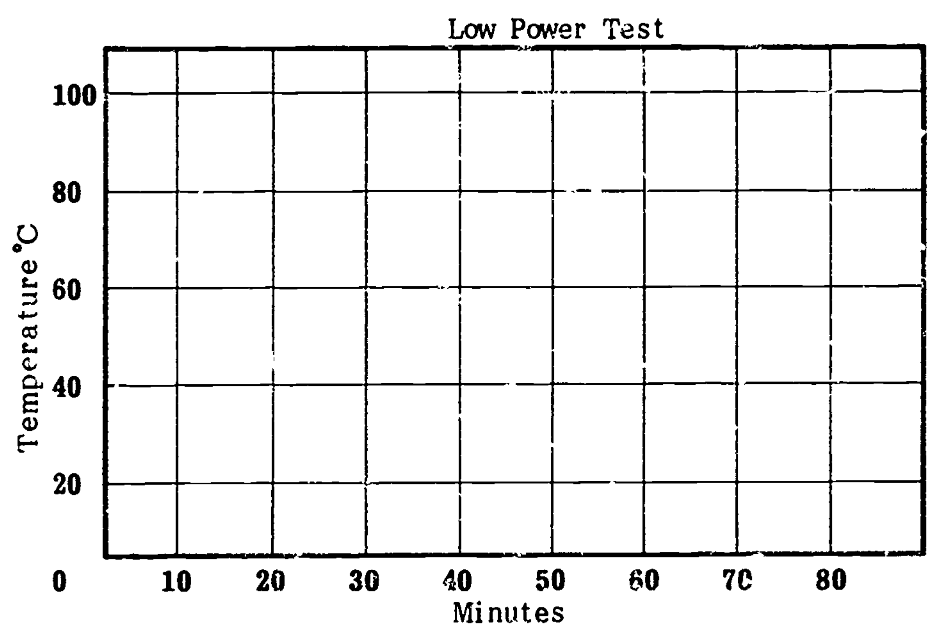
CALCULATIONS	HIGH POWER PHASE	LOW POWER PHASE
Wood consumed	A) b-j= ________ kg	J) (j+jj)-u= ________ kg
Charcoal remaining	B) k= ________ kg	*K) v-k= ________ kg
Equivalent dry wood consumed	C) A(1-a)-1.5 B= ____ kg	L) J(1-a)-1.5 K= ____ kg
Water vaporized, Pot #1	D) c-m= ________ kg	M) m-w= ________ kg
Water vaporized, Pot #2	E) d-n= ________ kg	N) n-y= ________ kg
Water vaporized, Pot #3	F) e-p= ________ kg	P) p-z= ________ kg
Consumption ratio	G) D/(D+E+F)= ________	Q) M/(M+N+P)= ________
Std. specific consumption	H) C/D = ________	R) L/M = ________
Duration of test	I) t-i = ________	S) dd-ι= ________

**This is an example of a form to be completed every time a test is run.
* Note: "K" can be a negative number

Attachment S-22-3, Page 2

COOKSTOVE WATER BOILING TEST
COOKSTOVE TIME VERSUS TEMPERATURE CURVE





Attachment S-22-3, Page 3

WATER BOILING TEST
TEST SERIES REPORTING FORM

Organization conducting tests ______________________________

Address ______________________________
Name of stove tested ______________ Name of tester ______________
Test numbers being reported: ________ Testing period ______________
(Month) (Year)

CLIMATIC CONDITIONS		MAXIMUM	MINIMUM	MEAN
	Air temperature	______	______	______
	Relative humidity	______	______	______
	Wind conditions	______	______	______

FUELWOOD

SPECIES (Botanic Name)	Approx. % Total (By weight)	Mean Length	Mean Diameter
______	______	______	______
______	______	______	______
______	______	______	______

Calculated overall fuelwood moisture content: ______________

Method of determining moisture content: ______________

Fuelwood cost per kg: ____________ OR ____________ = $ ____________
collection time estimate / local currency / U.S. dollars

MEASURING DEVICES	INSTRUMENT	RANGE	ACCURACY	TYPE, MANUFACTURER
	Balance #1	______ kg	______	______
	Balance #2	______ g.	______	______
	Thermometer	______ °C	______	______
	R.H. indicator	______ %	______	______
	Anemometer	______ m/s	______	______
	Other	______	______	______

	Mean	Standard Deviation	Coeff. of Variation	Standard Error	95% Confidence Interval
Standard specific consumption	____	______	______	______	______
Duration of tests	____	______	______	______	______

Total No. of tests reported ______________

Attachment S-22-3, Page 4

COOKSTOVE PHYSICAL FEATURES REPORTING FORM

Name and origin of stove

Name of stove builder(s)

Construction date:______________ Materials used ________________________

Stove location and condition

TOP VIEW

PERSPECTIVE

CUTAWAY VIEW WITH POTS

FRONT VIEW

Attachment S-22-3, Page 5

	Pot #1	Pot #2	Pot #3
Weight (empty)	________kg	________kg	________kg
Maximum capacity	________l	________l	________l
Diameter at rim	________cm	________cm	________cm
Composition	________	________	________

Details of stove construction, materials, sketches and dimensions. special features, etc.

Attachment S-22-4, Page 1

WATER BOILING TEST RECORD SHEET

Name______________________ Stove Type____________ Date_______

TIME	ELAPSED TIME	ACTIVITY	WATER TEMPERATURE

Attachment S-22-4, Page 2

SAMPLE WATER BOILING TEST RECORD SHEET

Date 8/15/85

TIME	ELAPSED TIME minutes	ACTIVITY	WATER TEMPERATURE Pot 1	Pot 2	Pot 3
9:50	0	Lit wood - all dampers open used kerosene	15	17	19
9:55	5	Added 3 pcs. wood Wet bulb = 12°C Dry bulb = 20°C	37	45	25
10 00	5	Added 2 pcs wood	61	62	35
10 05	5		89	80	42
10 06	1	Pot 1 boiling Closed damper on upper feed	92	-	-
10:11	5	Wet bulb = 12°C Dry bulb = 21°C	92	86	49
10:16	5	Added 3 pcs. wood	9..	89	46
10:21	5	At 10:18 Pot 2 started boiling	92	92	49
/ /	/ / /	END of HIGH POWER TEST /	/ /	/	/ /
10:27	6	Top & bottom dampers closed Wet bulb=12°C Dry bulb=23°C	89	89	44
10:32	5	Added 3 pcs. of wood	92	92	51
10·37	5	Dampers still closed incl. Chimney	92	92	50
10·42	5	Wet bulb = 12 5°C Dry bulb = 24°C	92	92	50.5
10·47	5	Opened bottom damper & chimney	92	90	50
10 52	5		92	89	50
10·57	5		92	88	50
11:02	5		92	85	50
11:07	5	1st Pot stopped boiling	91.5	83	50
11:12	5		91	82	49
11·17	5	Added 1 pc. of wood & some kerosene	89.5	79	49
11:22	5		91	78	48
11:27			92	77	48

Attachment S-22-5, Page 1

TESTING NOTES

1. Climatic conditions

Among the climatic data to be reported during stove testing,the most important are: air temperature, wind conditions, relative humidity, altitude and moisture content of wood, dung or peat fuel. Moisture content of dry charcoal is not relevant.

* Air temperature affects the rate of heat loss from stove and pot. It also establishes initial water temperature in the Water Boiling Test. Ideally, air temperature measurements should be taken before and after each test so that a mean value can be estimated.

* Wind conditions affect the stove's draft and can have considerable influence on stove performance. Ideally, stove testing should be done only when conditions are calm. Where this is not possible, a windbreak should be erected around the stove to reduce air movement and convective heat losses.

  A hand-held anemometer is useful for measuring wind speed. However, precise measurements are probably unnecessary, and a simple description of wind conditions may be satisfactory.

* Relative humidity provides one indication of the moisture content of air-dried fuel. It is a simple and useful condition to measure during stove testing. For this purpose, a small sling psychrometer, a hair hygrometer, or a similar instrument is satisfactory. Recalibrate a hygrometer frequently by wrapping it in a wet cloth, leaving it for five minutes, and adjusting it to 100% RH. Wet and dry bulb measurements can be used in conjuction with a psychrometric chart.

2. Atmospheric pressure and temperature

The normal boiling temperature of water depends on the local atmospheric pressure and thus mainly on the altitude above sea level (H). At an altitude (H) the normal boiling point can be computed from

$$t_b = (100 - H/300)^\circ C$$

When H is expressed in meters (one foot equals 0.305 meters). The normal boiling point is 100°C at sea level, for example, and 95°C at 1500 m altitude.

With a given ambient air temperature (T_o), the net (minimum) heat needed to bring water to a boil and to maintain simmering is proportional with the temperature difference $T=T_b - T_o$, and so is probably the fuel consumed for cooking.

This can be taken into account by using a temperature factor when computing the food or water being cooked (W") from weighed quantities (w')

$$W'' = w' (T_b - T_o) /100$$

where 100°C is considered as a reference temperature difference.

Note that cooking times increase with reduced boiling temperatures at high altitude. The cooking time is doubled for a temperature decrease of 10°C, depending on the kind of food. This may influence Kitchen Performance Test results, but not Water Boiling Tests.

3. Humidity and moisture

The relative humidity of air (RH) controls the equilibrium moisture content (X) of "air-dried" fuels which in fact still contains moisture. The type or quality of fuel and the ambiant temperature also influence moisture content. A useful first approximation of wood fuel moisture content is given by:

$$X = \frac{\text{water mass}}{\text{mass of dry wood}} = \text{or approximately } 0.2\,RH$$

For example, in saturated air (RH = 1), 1.0 kg of dry wood will contain about 0.2 kg of water (possibly more). At a lower RH = 0.6, the moisture content (X) drops to about 0.12. Of course, RH and X can be expressed as percentages as well.

Obviously, the specific heating value (H_x), of moist fuels is lower than the heating value of dry fuel (H_o). It can be shown that for moderate moisture contents (X=0.2 or less) that:

$$H_x = H_o (1 - X) = H_o (1 - 1.1 X)$$

As a consequence, a larger quantity of moist fuel M_x is needed for a given job than of dry fuel M_o. This can be accounted for by computing an equivalent dry fuel consumption from a measured moist fuel quantity.

$$\text{(equiv. dry fuel quantity)} = M_o = (1 - X) \cdot M_x$$

4. Moisture measurements

The moisture content (X) of air-dried wood can be estimated from the humidity (RH).

The most direct and precise procedure is to make a double weighing of a moist or air-dried sample: first as it is, and then after drying it in an oven (at 110°C for 24 hours or more, depending on the sample size). M_X is the moist weight and M_O is the dry weight:

$$X = (M_X - M_O)/M_O \text{ or } X = (M_X - M_O)/M_X$$

The moisture content may be expressed with reference to the dry wood quantity as done above or, alternatively, with reference to the moist wood quantity as well:

$$X = \frac{\text{water mass}}{\text{mass of moist charcoal}}$$

In field work the first weighing is done at the test site (Mx). The second weighing can be done afterwards in a lab.

Alternatively, the charcoal moisture (X) can be measured with a battery operated tester which uses the electric resistance of the sample as an indication of its moisture content. The results will depend slighlty on the quality of the charcoal and on the quality of the instrument used.

5. Weight (mass)

Weighing can be done with any good balance. For field testing, direct reading instruments are preferable, as no adjustments of weights are needed. Spring balances do a good job if they have a long reading scale and thus good resolution, and if they are used within 20 to 100% of the full capacity. Spring balances should occasionally be checked with calibrated weights (1 liter of water has 1 kg of weight, etc.). A set of balances with different full-scale capacities should be used, for example, 1, 5, and 15 kg. Compare them with each other: they should give the same reading for the same load.

The weighing basket used with a balance should be as light as possible, since precision is lost when the difference between two weighings is relatively small.

6. Volume

Volumes can be measured with graduated bottles. One can also use commercial bottles with known volumes (1/4, 1/3, 3/4, 1/1 liter). A balance can do the job too, as 1 liter of water weighs 1 kg.

Attachment S-22-6, Page 1

FUEL USE MEASUREMENTS AND FUEL SAVINGS CALCULATIONS

There are two ways to calculate fuel savings, one for total use (cooking, lighting, heating, etc.) and the other for cooking only. It is possible that the introduction of a stove may decrease fuel consumption for cooking but cause a slight increase in the amount used for another purpose, for example, heating. Fuel needs for other uses may vary seasonally, especially for heating or a fire to sit around. Total fuel savings will be calculated taking into account measures of all uses of fuel whereas the fuel saved in cooking alone can be calculated from figures for cooking only.

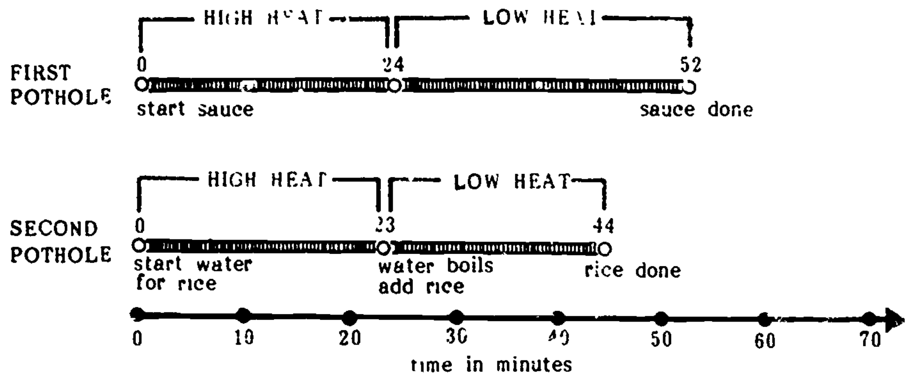
For doing isolated variable tests only, construct a typical local cooking profile. This profile includes:

* a description of a typical day's use of the cookstove.
* the amount of food being cooked at each meal.
* the kinds of pots used for each typical meal and whether lids are used.
* a description of any other fuel use (heating, lighting, water heatings, etc.).
* the average amount of fuel which is used for each task.
* a standard cooking timeline showing the progression of how food is cooked, for how long and over what heat, for morning, noon and evening meals.

NOTE: It cannot be assumed that an improved cookstove will save the same amount of fuel in places or under conditions other than where it is tested.

Attachment S-22-6, Page 2

Sample timeline:



Do a number of sample timelines for typical meals with several different cooks until you feel you have a good average. They should define events which occur during cooking: lighting the fire, rice coming to a boil and simmering, sauce boiling, etc.

NOTE: It is important to stay in contact with people who have been especially helpful. Let them know the results of this evaluation and pass on to them any fuel-saving tips you may have learned in the process. Comment on things they have taught you.

ISOLATED VARIABLE TESTS

Fuel savings due to changes in stove design or operating conditions can be determined by using isolated variable tests. These tests provide a quantitative measure of the amount of fuel used to cook a typical meal. The information gained from them can tell how much a single design modification changes the amount of fuel used. Because many household conditions will not be replicable these tests should be used only for stove design improvements, not for the projection of how much fuel can be saved in the field.

Isolated variable testing speeds the evolutionary process of stove design by testing and evaluating new stove ideas. These design ideas, most of which should come from the local people, will help develop a stove uniquely adapted to local cooking and fuel conditions.

WHAT ISOLATED VARIABLE TESTS CAN TELL YOU:

* the amount of fuel a stove uses to cook a typical meal.
* the effect of changing a stove design or operating it differently.
* which adaptations should be discouraged because they use more fuel.

The purpose of testing stoves under controlled conditions is to develop a design which conserves fuel or has some other desirable quality which will improve the likelihood of the cookstove being used in the area. To make the test as relevant as possible to local conditions it is important to:

* use cooks who are experienced in cooking local foods.
* maintain environmental conditions which are similar to those in households; for instance, don't test outdoors if cooking is done inside, or don't test with pot lids on if people seldom use them.

Only one variable can be tested at a time. All other differences should be minimized. Special attention should be given to standardizing these things:

* The Cook: her cooking behavior, the sequence of cooking operations, and how she stokes the fire.
* The Fuel: its species, size, and moisture content.
* The Cooking Pots: their shape, materials and size.
* The Stove Construction: its materials and design.
* Weather: especially the effect of wind.

The Organization

Testing improved stoves should take place in regional test centers. These test centers should be located in the areas where the stoves are used, and where they are readily accessible to the general public. They should be close enough to the communities to insure that altitude, weather, and other environmental factors will be similar to local conditions. The food and fuel used should come from the same sources that a typical household in the community would use. Be sure the supply of fuel can be maintained for the duration of the test.

Local people should be employed and consulted as much as possible in the construction and testing of stoves. As the community becomes involved in the program the people will identify with the stoves and offer design ideas.

Cooking tests should be conducted by two or three women from the community who are experienced in the cooking of local foods. Having several cooks participate in the tests will minimize differences in test results.

Attachment S-22-7, Page 1

COOKSTOVE TESTING GLOSSARY

Coefficient of Variation (COV): Normalized measure of variability, independent from the units of the quantity being measured.

Consumption Ratio: An expression sometimes used in the WBT to describe the amount of water evaporated from the first pot relative to the water evaporated from all the pots on the stove; calculated by $CR = W_1/W_1 + W_2 + W_3 + ... + W_n$, where W is the amount of water evaporated.

Controlled Cooking Test (CCT): An intermediate laboratory test to compare fuel and time used to prepare a meal on different stoves, and to determine the range of meals a stove can accommodate in a given area.

Degrees of Freedom: The number of test measurements minus the number of parameters that have been estimated on the measurements.

High Power: Maximum stove power. WBT high power phase brings the water to boiling as rapidly as possible, and then maintains boiling at the same heat level for 15 minutes.

Kerosene: Petroleum-based fuel, known as "paraffin" in British English.

Kitchen Performance Test (KPT): A field test to measure fuel consumption in a normal household situation.

Low Power: Minimum stove power. WBT low power phase requires the fire to be maintained at the lowest level necessary to simmer water for one hour.

Partial Efficiencies: Fractions of the overall efficiency of a system. For a cookstove these might include combustion efficiency, heat transfer efficiency, pot efficiency, and control efficiency.

Percentage of Heat Utilized (PHU): A commonly used expression to describe stove performance, calculated by measuring energy gain in all pots (increase in temperature + evaporation losses), divided by calculated heat input from wood or charcoal.

Specific Consumption (SC): Fuel consumed divided by a measure of the work performed.

Specific Daily Consumption (SDC): An expression used in the KPT to describe the amount of fuelwood (in kg) used for cooking per person served per day.

Specific Fuel Consumption (SFC): An expression of the total amount of food cooked in the CCT, divided by the total amount of wood used to cook it.

Attachment S-22-7, Page 2

Standard Adult Equivalent: A standard way to define and compare the number of people in a family group.

Standard Deviation: A statistic used as a means of dispersion in a distribution, indicating the amount of variability within a series of measurements.

Standard Specific Consumption (SSC): An expression used in the WBT to describe the equivalent dry wood consumed relative to the amount of water vaporized from the first pot on the stove. A low SSC indicates a high stove energy conversion efficiency and allows comparison of stoves without extensive thermodynamic assumptions and calculations.

Water Boiling Test (WBT): A simple laboratory test to measure the fuel and time necessary to cook a simulated meal.

COOKSTOVE TESTING ABBREVIATIONS

C	Centigrade
CCT	Controlled Cooking Test
cm	centimeter
COV	coefficient of variation
ISo	International Standards Organization
kg	kilogram
KPT	Kitchen Performance Test
kw	kilowatt
m/s	meters per second
PHU	Percentage of Heat Utilized
RH	relative humidity
SC	Specific Consumption
SDC	Specific Day Consumption
SFC	Specific Fuel Consumption
SSC	Specific Standard Consumption
t_b	time to boil
WBT	Water Boiling Test

KITCHEN PERFORMANCE TEST

The Kitchen Performance Test (KPT) measures the relative rate of fuelwood consumed by two stoves as they are used in the normal household environment. It is a prolonged test conducted with the willing cooperation of individual families. Compared to the previously described tests, the results of the KPT can provide the most reliable indication of stove performance under actual household conditions. However, because of the large effort involved, it is normally conducted only after the more controlled tests have been completed.

The primary objectives of the KPT are:

- To study the impact of a new stove on overall household energy use (Procedural Note 1); and
- To demonstrate to potential users the fuel-saving quality of a new stove in the household, and to suggest correct operating practices.

Variations of the Kitchen Performance Test may also be used in conjunction with a stove dissemination program (Procedural Note 2) or as part of a survey of household energy use (Procedural Note 3).

Kitchen Performance Tests should be carried out by an investigator who is trained to follow instructions, is motivated to do so, and has certain basic numerical skills. Extension workers, school teachers, or high school students are well suited for the tasks. It is important that the person be well motivated in order to obtain reliable and useful data.

Equipment

- Balance for weighing fuelwood
- Forms for recording data and calculations
- Pots, etc., to be supplied by household

Procedure

1. Select households to participate in the test (Procedural Note 4). Explain to family members the purpose of the test, and arrange to measure their fuelwood each day. Encourage the family to use only a single stove throughout the test.

2. Gather any needed information about each participating household. For example: determine the sex and age of each person served meals, and use this information to calculate the number of standard adult persons served (Procedural Note 5); ask about the approximate cost of the fuelwood used, in terms of either money spent or time needed to collect it; and collect any other information that may help interpret the final data (Procedural Note 6).

3. Define an inventory area for fuel consumption measurement. Any fuel entering or leaving this area must be accounted for (Procedural Note 7). Weigh all wood and other fuels in the inventory area. Estimate or measure the moisture content of the wood (Technical Note 4).

4. Define the testing period of seven consecutive days. If it is not possible to measure for seven days, measure for at least five days. Stop and start at the same hour each day (Procedural Note 8).

5. Visit the household at least daily, if possible, without being intrusive. Weigh wood remaining in the inventory area, and add to it if necessary. Inquire about the number of people being served each day, and confirm that the stove is operating properly.

6. Compile the results at the end of eight days. Calculate specific daily consumption for each household, and then the mean and standard deviation. Compare the results with those from households using other stoves.

7. Inform participating families of the results, and thank them for their cooperation.

Procedural Notes

1. The introduction of a new stove may alter the amount and type of cooking done in the household. For example, the result may be a substantial improvement in the well-being of the family, but make little change in overall fuel use. Or it may be that fire enclosed within the stove provides so little light that it becomes necessary to use a kerosene lamp.

2. A survey of cooking practices to determine current local cooking procedures, foods cooked and eaten, types of stoves used, etc., is a useful starting point for the development and dissemination of improved cook stoves. The survey may be accompanied in a number of households by a measurement of all the fuel used for cooking, such as is involved in the Kitchen Performance Test.

   Later, new stoves can be built in these same households, and another KPT may be carried out after the households have had an opportunity to get acquainted with the new stoves. At that time the KPT may be accompanied by a user survey to determine how well the stoves are being received, with later surveys to evaluate other parameters such as stove durability. Later KPTs may be performed to evaluate whether the fuel savings have remained the same and if other factors have had a positive or negative influence on the stove's long term acceptability.

3. It may be tempting to use the results of the KPT to estimate the fuel saving potential of a new stove before it is widely accepted and used. For this purpose, however, the test would have to be greatly expanded to include:

   - many more households, carefully selected to be representative of the regional population;
   - a period of time that includes all major seasons;
   - a study of stove deterioration rates and repair records; and
   - an economic analysis demonstrating the economic attractiveness of the stove to both the user and the producer.

4. For meaningful results:

   - Households should be selected from approximately the same economic level. This will reduce variation and permit more reliable interpretation of the results.
   - Participating families should use fuelwood for at least 90% of their household cooking needs.
   - A minimum of five participating households is essential. Depending on the expected difference in fuel use between the two stoves tested, a larger number of households may be necessary (see Table I).

TABLE I

Minimum number of households necessary in the KPT relative to expected differences in fuel use

Expected percent difference in fuel use	Minimum number of households
10	54
20	14
30	7
40	5

*Corresponds to COV = 0.4; 10% level of significance

5. For purposes of this test, the "standard adult" will be defined according to a simplified version of the widely used League of Nations formula as shown in Table III. (Guidelines for Woodfuel Surveys, for F.A.O. by Keith Openshaw).

TABLE II

"Standard adult" defined in terms of sex and age

Sex and age	Fraction of standard adult
Child, 0-14 years	0.5
Female, over 14 years	0.8
Male, 15-59 years	1.0
Male, over 59 years	0.8

6. Other information gathered for each family may include:

- the number and types of any other stoves used regularly (for making tea, heating water, cooking manioc, etc.);
- the major activity of the head of the household (a possible indication of family economic level);
- easily observable indicators of social or economic status;
- uses made of fuelwood other than for cooking food; and
- tribal or cultural affiliation.

7. It is recommended that no more fuel be in the inventory area than is likely to be consumed during the one-week test period. If much more fuel is stored than will be used, define a smaller inventory area from which all fuel for the test is taken. Stress to household members that only wood from the small area be used during the test, and that if more wood is needed, the investigator be present when it is added to the pile. The number of visits the investigator must make to the household to weigh the wood will depend on the size and adequacy of the initial inventory.

3. The recommended seven consecutive day test period recognizes that many family activities are conducted according to a weekly routine. Seven days is the shortest time likely to include market days, work days, and any weekly religious observances in their proper proportion.

It often happens that the person conducting the test is unwilling to work on the day of weekly religious observance. In such a case, advance provision should be made for a substitute on that day, if possible.

Note that a seven day test usually requires eight days of measurement (see Data and Calculation Reporting Form on the following page). Similarly, if only a five day test is planned, measurements will be taken for six days.

9. Different types and sizes of wood used by different households may introduce unwanted variation to test results. To avoid this, the tester may consider providing uniform fuelwood to be used for the duration of the test. It is important, however, that this practice not encourage the household to use significantly more or less wood than it would normally.

Attachment S-22-8, Page 6

KITCHEN PERFORMANCE TEST
DATA AND CALCULATION FORM*

Household No.__________ Family Name______________________
Location____

	Number		Standard Adult Equivalents	Other Household information
Children 0-14 yrs.	______	x 0.5 =	______	______
Women over 14 yrs.	______	x 0.8 =	______	______
Men aged 15-59 yrs.	______	x 1.0 =	______	______
Men over 59 yrs.	______	x 0.8 =	______	______

SPECIES (Botanic Name)	Approx. % Total (By weight)	Mean Length	Mean Diameter
______	______	______cm	______cm
______	______	______cm	______cm
______	______	______cm	______cm

Condition of fuelwood: (dry/damp/wet/green) ______________
Fuelwood cost per kg: ______________ or ______________ = $______________
est.collec.time local curr. U.S. Dollars

	Description	Function
Other fuels in use:	______	______
Other stoves in use:	______	______
	______	______
	______	______

	TOTAL WOOD REMAINING IN INVENTORY AREA		WOODED AREA TO INVENTORY AREA		COMMENTS
Day 0	(None)	kg	______	kg	______
Day 1	______	kg	______	kg	______
Day 2	______	kg	______	kg	______
Day 3	______	kg	______	kg	______
Day 4	______	kg	______	kg	______
Day 5	______	kg	______	kg	______
Day 6	______	kg	______	kg	______
Day 7	(B)______	kg	(None)	kg	______

(C) Total Wood Added to Inventory: ______ kg
(D) Total Wood Consumed: C - B = ______ kg
(E) Test Duration: ______ days
Specific Daily Consumption: D/A/E = ______

*This is an example of a form to be used for each participating household.

KITCHEN PERFORMANCE TEST

TEST SERIES REPORTING FORM*

Organization conducting tests ______________________
Address ______________________
Names of stoves compared: (1) ____________ (2) ____________
Testing Location ______________________
Testing period ________ (months) ________ (year) Name of test supervisor ____________

	Standard Adult Equivalents	Specific Daily Consumption	Fuelwood Cost / Kg
Arithmetic Mean:	______	______	______
Standard Deviation:	______	______	______
Coefficient of Variation	______	______	______
Standard Error	______	______	______
95% Confidence Interval	______	______	______
	(Total number of Tests ______)		
Arithmetic Mean:	______	______	______
Standard Deviation:	______	______	______
Coefficient of Variation	______	______	______
Standard Error	______	______	______
95% Confidence Interval	______	______	______
	(Total number of Tests ______)		

Specific Daily Consumption: t-Value = ________ at ________ % level of confidence and ______ degrees of freedom.

(Attach a full description of both stove models tested)

*This is an example of a form used to summarize and report results from a series of tests of two stoves being compared.

SESSION S-23 **COOKSTOVE PROJECT PRESENTATIONS**

TOTAL TIME: 2 Hours

OBJECTIVES:
* To make an appropriate presentation on a stove: information that can be included — construction method, ease of use, test results
* To provide written documentation of stoves made
* To evaluate the stove performance

RESOURCES: Attachments S-23-1 and S-23-2

MATERIALS: Flip chart, markers

Trainer's Note

If possible make these presentations to people from outside the training. If this is possible you will want to rearrange the session, giving the trainees one hour to evaluate the stoves they made and the rest of the time to prepare the presentations. The presentations can be given at another time.

PROCEDURE:

Step 1 — 5 Minutes
Review objectives and procedures

Step 2 — 15 Minutes
Distribute Attachments S-23-1 and S-23-2. Review different presentation methods using the Selecting Communications Tools handout as a reference. Stress using methods appropriate to the audience (village women as opposed to other Peace Corps Volunteers)

Step 3 — 45 Minutes
Develop presentations.

Step 4 — 55 Minutes
Give the presentations.

Attachment S-23-1, Page 1

EXTENSION SKILLS

Important points to be considered for successful education and communication:

1. Be prepared. Know what you are doing, where you are going and what you want your audience to know when they leave. Don't prepare your talk an hour before you give it.

2. Always do a practice run of whatever it is you are demonstrating before you get up in front of the group to teach.

3. Start off with a very small chunk of information to be taught. For example, "How to Build a Stove" would be too broad a topic. Change it to "Building the Base."

4. People learn best by doing. The more concrete you can be, the better. For example, if you are doing a talk on how to make a particular type of soup, have everyone make it and taste the soup.

5. People remember main points better when they are presented with visual aids. Illustrate your main points and use the drawings during your talk. Also, people tend to understand complex or abstract concepts if they can visualize them. Remember that points or concepts you find simple, others may find difficult. Be sensitive to your audience and explain points thoroughly.

6. Visual aids and/or graphs should be clear, depicting objects with which the people are familiar. Photographs or pictures cut from magazines are often more easily understood than hand drawn pictures.

7. Changing color and lettering can draw more attention to the visual aids. However, visual aids may be distracting, confusing or misunderstood when they do not mirror people's reality.

8. A vocabulary list of important things, steps and materials in the demonstration can be useful to the demonstrator as well as to the audience.

9. The demonstration should never take place above the audience's line of vision.

10. People remember things that are unusual or make them laugh. But don't overdo it.

11. Physical conditions are important. The demonstration should take place in the lightest part of the room or area. Rooms should be free of all other distractions. Effort should be made to make everybody physically comfortable, etc.

12. It's better to have an active audience than a passive one.

13. Don't read your material.

14. Keep eye contact with your audience. In this way you will build a rapport with them. Also, they will feel like you are talking _to_ them and not _at_ them.

15. Respect the audience members who already know how to do that which you are demonstrating and get them involved in helping you with the presentation.

16. Repeat the main points. For example, state them at the beginning of your talk, in the middle and at the end. Again the next day, repeat the main points or elicit them from your group before you go into any new information. In other words, build on the previous information.

17. Reinforcement activities following a talk can facilitate learning.

18. Always minimize the cost of whatever is being demonstrated, making sure that the people have the economic resources necessary to do it on their own. Try to utilize materials found in the immediate area.

19. When the demonstration involves making something, it is always a good idea to have a finished example to show to the audience.

20. Variety in presentation styles and environment are important.

21. Your talk should contain an introduction that gives a purpose for the information you are going to give. Set the stage for your talk.

22. Try not to use very technical words in the demonstration.

23. Organize your information. For example, time/order, cause/effect, etc.

24. Whenever possible, relate what you are demonstrating to the local customs.

25. Keep your demonstration short and limited to the time of day and amount of time that the people have free.

26. If the demonstration involves several steps, either write or draw them so the audience has something to follow as you go, but be sensitive to the fact that some people do not know how to read or follow diagrams.

27. Try and involve as many of the people's senses as possible: taste, smell, touch, sight, sound.

28. Smile and be friendly.

29. Speak slowly and clearly. You're probably speaking slowly enough when you think you're going too slow.

30. Don't talk down to your audience. Show them the respect you want them to show you.

31. At the beginning of the demonstration, explain briefly what you are intending to do. At the end, summarize what it is that you have done.

32. Be sensitive to your audience. If they are getting restless, you may be going too fast, going on for too long or they may not be understanding you.

SELECTING COMMUNICATION "TOOLS"

Visual Aid	General Description	Recommended	Advantages	Disadvantages
Chalkboard	Rigid surface painted green or black on which one can write or draw with chalk	10 to 30 people. If used with more, a large board is needed and careful audience placement is necessary	Inexpensive. Can be homemade, easily maintained, minimum of preparation. Used day or night. Audience participation.	Transport can be difficult in remote areas. Limited to the user's artistic ability.
Flannel Board	A piece of flannel, flannelette, terry cloth or felt cloth attached to a rigid surface on which cut-out figures will adhere if backed with flannel or felt cloth, sand paper or glued sand.	15 to 20 people. Audience size depends on the size of the flannel board and the size of the figures that are being used.	Inexpensive. Easily made from local materials. Easily maintained and transported in remote areas. Figures can be used in different presentations. Ideal for showing "sequence of events" and reviewing lesson, as figures can be brought back on the board.	Requires considerable advance preparation. Difficult to use out of doors if there is any wind. Some artistic ability is required if making homemade figures.
Posters	A message on a large sheet of paper, and with an illustration and a simple written message.	No limit, because it is not necessary for everyone to look at a poster at the same time.	Inexpensive. Easy to make. Rquires a minimum amount of time to prepare and use. Easy to transport.	Deteriorate rapidly. Can confuse audience with too much or too little information. Need some artistic ability if making own posters.
Flip Charts	Illustrations on paper or cloth, usually larger than 21 cm by 27 cm; bound together with rings or string. They flip over in presentation.	15 to 30 people. Audience size depends on the size of the flip chart illustration.	Inexpensive. Can be homemade and can be easily transported. Good way to give information in sequence; because they are bound, illustrations stay in sequence.	Deteriorate with constant use. Some artistic ability required if making homemade flip charts.

Visual Aid	General Description	Recommended	Advantages	Disadvantages
Flash Cards	Illustrations made on heavy paper that is usually smaller than 21cm by 27cm. The illustrations are not bound but are arranged in sequence.	5 to 15 people. Because the illustrations are small, no more than 15 people should be in the audience.	Inexpensive. Can be homemade. Very easy to transport. Good way to give information in sequence to small groups.	Deteriorate with constant use. Some artistic ability required if preparing homemade flashcards. Easy to get out of sequence. Limited to small groups.
Bulletin Boards	A surface, at least 3/4m by 1m, into which stick pins can be placed. Drawings, photos and lettering can be displayed on the board.	No limit, because it is not necessary for everyone to look at the bulletin board at the same time.	Inexpensive. Can be homemade from local materials. Good way to present a "changing" message in areas where people gather.	If out of doors, weather damage can occur. Constant supply of good educational material to put on the board is needed.
Demonstration	Using actual ingredients, tools or land, the educator shows how something is done. Either at that time, or soon afterward, each audience member displays an ability to do the new thing.	1 to 30 people. Because it is difficult for an educator to follow up on more than 30 persons, this is the recommended limit.	Excellent way to use actual materials in a real situation. Uses local materials. Easy to understand by people not used to looking at illustrations. Good way to get audience participation.	Takes a lot of planning and preparation.
Film	Color or black & white, 16mm or 8mm cinema film, with sound, projected on a screen or wall.	30 to 100 people. Groups can be larger — but it is difficult to have any discussion with larger groups.	Dramatic and gets the audience's attention. Shows motion and therefore helps explain step-by-step and time sequence very well.	Very expensive; requires expensive equipment, electricity and dark projection area. Difficult to transport and operate.

Visual Aid	General Description	Recommended	Advantages	Disadvantages
Slides	35mm film in plastic or cardboard mounts 5cm by 5cm. In color or black & white, they are projected on a screen or a wall.	About 30 people. Though slides can be used with more people, the educator can stimulate better discussion among a smaller group.	Dramatic, less expensive than cinema film, excellent way to bring distant things to audience and to show time sequence. Battery-operated projectors available. Local photos easily made.	Easy to damage, easy to get out of sequence and project upside down or sideways. Requires projection equipment, needs electricity or batteries and darkened projection area.
Filmstrips	Strip of 35mm film, color or black and white. Photographs in sequence. Filmstrip projected on screen or wall. Uses projector with filmstrip adapter. Filmstrips horizontal or vertical format.	About 30 people. Though filmstrips can be used with more people, the educator can stimulate better discussion with a group of this size.	Dramatic, less expensive than film and slides. Once inserted correctly in projector, impossible to get out of sequence. Can show photos of the real thing and shows sequence in time. Battery-operated projectors available. Relatively easy to transport.	Requires projection equipment, can be damaged, requires either main or battery-supplied electricity. (Sometimes batteries are expensive.) Requires darkened projection area. Limited appropriate filmstrips available.

Adopted from WORLD NEIGHBORS IN ACTION newsletter.

SESSION S-24 **TRADITIONAL AND IMPROVED COOKSTOVE BANQUET**

TOTAL TIME: An entire afternoon and evening if possible (approximately 6 hours)

OBJECTIVES:

* To allow guests and participants to compare traditional and improved cooking methods
* To cook on new cookstoves built by participants
* To observe the reaction of local people to the improved cookstoves being used
* To enjoy the company of others and to celebrate the completion of the training program

RESOURCES: Guests from nearby areas, food to feed guests, host: family, institution or organization, traditional and improved cookstoves, entertainment if desired.

Trainer's Note

Organize the banquet like a local celebration or party. Don't make any special culinary exceptions or adjustments for new cookstoves. Arrange cooking area so guests can observe new stoves and facilitate subtle points or observations about fuel consumed, lack of smoke and other benefits of stoves.

PROCEDURES:

Step 1 Prepare traditional food in the traditional manner using both old and new ways of cooking.

Step 2 Eat the food and enjoy the evening.

SESSION S-25 **TRAINING PROGRAM EVALUATION**

TOTAL TIME: 2 Hours

OBJECTIVES:
* To review stove dissemination techniques
* To discuss resources available to the participants
* To evaluate the stove training

MATERIALS: Flip chart, markers

PROCEDURE:

Step 1 — 5 Minutes
Review session objectives and procedures

Step 2 — 40 Minutes
Review by brainstorming different methods of dissemination. Discuss which method each participant is considering using. Also discuss which stove model(s) they are interested in. Briefly talk about the pros and cons of the stoves and the different approaches mentioned.

Step 3 — 30 Minutes
Discuss what, if any, financing and technical assistance are available in the country.

Step 4 — 30 Minutes
Have the trainees evaluate the program by talking about what they liked, didn't like, and would like to see added. Be sure to note these suggestions.

Step 5 — 15 Minutes
Final questions and wrap-up.

Trainer's Note

In stateside training the evaluation of the stove training can be done during the overall training evaluation

GLOSSARY

absorptance - the ratio of the radiation absorbed by a surface to the total energy falling on that surface measured as a percentage.

adobe - an air/dried brick of clay/sand mix and sometimes straw, used in construction. Within the United States, adobe is used primarily in the Southwest.

ambient temperature - surrounding temperature, as temperature around a house.

angle of incidence - the angle that energy rays make with a line perpendicular to a surface. The angle of incidence determines the percentage of direct energy intercepted by a surface. The rays that are perpendicular to a surface are said to be "normal" to that surface.

black body - a theoretically perfect absorber and emitter, e.g. the absorption is equal to the emittance.

BTU (British Thermal Unit) - a unit used to measure quantity of heat; technically, the quantity of heat required to raise the temperature of one pound of water 1°F. One Btu = 252 calories. One Btu is approximately equal to the amount of heat given off by burning one kitchen match.

calorie - a unit of heat (metric measure); the amount of energy equivalent to that needed to raise the temperature of one gram of water 1°C. One calorie is approximately equal to .004 Btu's.

centigrade degrees (°C) - a temperature scale consisting of or divided into 100 degrees. The freezing point of water at standard conditions - liquid to solid - (32°F) equals 0°C, and the boiling point liquid to gas (212°F) equals 100°C. Centigrade temperatures are related to Fahrenheit temperatures by the equation $C = (F-32)(.56)$.

chimney effect - the tendancy of air or gas to rise when heated, owing to its lower density compared with that of the surrounding air or gas. (See convection)

climate - the meteorological conditions including temperature, precipitation, humidity and wind that characteristically prevail in a particular region. (It should be noted that climate is not synonymous with weather.)

condensation - beads or drops of water, and frequently frost in extremely cold weather, that accumulate on the inside of the exterior covering of an object when warm, moisture-laden air from the interior reaches a point where the temperature no longer permits the air to sustain the moisture it holds.

conductance (C) - the quantity of heat (Btu's) which will flow through one square foot of material in one hour, when there is a 1°F temperature difference between both surfaces. Conductance values are given for a specific thickness of material, not per inch of thickness. For homogeneous materials, such as concrete, dividing the conductivity (k) of the material by its thickness (X) gives the conductance (C).

conduction - the process by which heat energy is transferred through materials (solids, liquids or gases) by molecular excitation of adjacent molecules.

conductivity (k) (thermal) - the measure of the rate of heat flow in a substance
Cal.Sec. $C_m 2$ (^{o}c/cm) x 10^3

convection - the transfer of heat between a moving fluid medium (liquid or gas) and a surface, or the transfer of heat within a fluid by movements within the fluid.

dead air space (still air space) - a confined space of air. A dead air space tends to reduce both conduction and convection of heat. This fact is utilized in virtually all insulating materials and systems, such as rigid foam panels, fur and hair, and loose-fill insulations like pumice, vermiculite, rock wool and goose down. This principle is applied specifically in the double walled stove.

delta T or **ΔT** - a difference in temperature.

density (p) - the mass of a substance which is expressed in pounds per cubic foot.

diffuse radiation - radiation that has traveled an indirect path from the source because it has been scattered by particles in the atmosphere, such as air molecules, dust and water vapor, or reflected by a diffusing surface.

direct radiation - light that has traveled a straight path from the source to the absorber.

dry bulb temperature - a measure of the sensible temperature of air (the one with which we are most familiar).

efficiency - the ratio of the amount of energy realized in the masses cooked to the amount of energy available in the fuel (see cookstove boiling test for more detail).

emissivity - the property of emitting heat radiation; possessed by all materials to a varying extent. "Emittance" is the numerical value of this property, expressed as a decimal fraction, for a particular material. Normal emittance is the value measured at 90° to the plane of the sample, and spherical emittance is the total amount emitted in all directions. We are generally interested in spherical, rather than normal emittance. Emittance values range from 0.05 for brightly polished metals (aluminum) to 0.96 for flat black paint. Most nonmetals have high values of emittance.

energy - the capacity for doing work; taking a number of forms which may be transformed from one into another, such as thermal (heat), mechanical (work), electrical and chemical; in customary units, measured in kilowatt hours (kwh) or British thermal units (Btu); or in joules (j), where 1 joule = 1 watt-second.

<u>direct energy</u> - energy used in its most immediate form; that is, natural gas, electricity, oil.

indirect energy - energy that is converted into goods which are then consumed. Example: food through photosynthesis, fibers, plastics, chemicals.

net energy - the energy remainder or deficit after the energy costs of extracting, concentrating and distributing are subtracted.

net reserves - an estimate of the net energy that can be delivered from a given energy resource.

Fahrenheit degrees (°F) - a temperature scale which registers the change of state of water at standard atmospheric pressure, from a liquid to a solid (the freezing point) as 32°F (0°C) and the change of state from a liquid to a gas (the boiling point) as 212°F (100°C). The name of this scale is derived from Gabriel Daniel Fahrenheit, who developed the use of mercury in thermometry. Fahrenheit temperatures are related to centigrade temperatures by the equation $F = 1.8\ C + 32$.

heat capacity (volumetric) - the number of Btu's a cubic foot of material can store with a one degree increase in its temperature.

heat loss - a decrease in the amount of heat contained in a space, resulting from heat flow through walls, pot or in evaporation.

heat sink - a substance which is capable of accepting and storing heat, and therefore may also act as a heat source.

incidence - the falling of radiation on a surface.

insolation - the total amount of solar radiation—direct, diffuse and reflected—striking a surface exposed to the sky. This incident solar radiation is measured in langleys per minute, or Btu's per square foot per hour or per day.

insulation - materials or systems used to prevent loss or gain of heat, usually employing very small dead air spaces to limit conduction and/or convection.

latent heat - a change in heat content that occurs without a corresponding change in temperature, usually accompanied by a change of state.

radiation - the direct transport of energy through space by means of electromagnetic waves.

radiation, infrared - electromagnetic radiation, whether from the sun or a warm body, that has wavelengths longer than the red end of the visible spectrum (greater than 0.75 microns). We experience infrared radiation as heat; 49% of the radiation emitted by the sun is in the infrared band.

radiation, ultra-violet - electromagnetic radiation, usually from the sun, that consists of wavelengths shorter than the violet end of the visible spectrum (less than 0.15 microns). Five percent of the sun's radiation is emitted in the ultra-violet band.

reflectance - the ratio or percentage of the amount of light reflected by a surface to the amount incident. The remainder that is not reflected is either absorbed by the material or transmitted through it. Good light reflectors are not necessarily good heat reflectors.

refraction - the change in direction of light rays as they enter a transparent medium such as water, air or glass. Rays bend more the farther perpendicular the light hits, the greater the density or the longer the wavelength.

relative humidity - the ratio of the amount of water vapor in the atmosphere at a given temperature to the maximum amount of water vapor that could be held.

resistance (R) - R is the reciprocal of conductivity or X/k. (X = thickness of the material in inches.)

R-factor - a unit of thermal resistance used for comparing insulating values of different materials; the reciprocal of the conductivity; the higher the R-factor of a material, the greater its insulating properties. See resistance (R).

selective surface - a surface or coating that has a high absorptance of incoming radiation but low emittance of longer wavelengths (heat).

sensible heat - heat that results in a temperature change.

solar radiation - electromagnetic radiation emitted by the sun.

specific heat (Cp) - the number of Btu's required to raise the temperature of one pound of a substance 1°F in temperature.

specular - resembling, or produced by, a mirror, polished metal plate or other reflector device.

stratification - the formation of layers in a substance where the top layer is warmer than the bottom.

thermal admittance (q) - the number of Btu's a square foot of surface will admit in one hour.

thermal break (thermal barrier) - an element of low heat conductivity placed in such a way as to reduce or prevent the flow of heat.

thermal conductance - see conductance.

thermal inertia - the tendency of an object with large quantities of heavy materials to remain at the same temperature or to fluctuate only very slowly.

thermal mass - the amount of potential heat storage capacity available in a given assembly or system. Concrete and adobe are examples of thermal mass.

thermocirculation - the convective circulation of fluid which occurs when warm fluid rises and is displaced by denser, cooler fluid in the same system.

time lag - the period of time between the absorption of radiation by a material and its release into a space.

translucent - the quality of transmitting light but causing sufficient diffusion to eliminate perception of distinct images.

transmittance - the ratio of the radiant energy transmitted through a substance to the total radiant energy incident on its surface.

transparent - having the quality of transmitting light so that objects or images can be seen as if there were no intervening material.

U value (coefficient of heat transfer) - the number of Btu's that flow through one square foot of roof, wall or floor, in one hour, when there is a 1°F difference in temperature between the inside and outside air, under steady state conditions. The U value is the reciprocal of the resistance or R-factor.

vapor barrier - a component of construction which is impervious to the flow of moisture and air and is used to prevent condensation in walls and other locations of insulation.

viscosity - the resistance of a fluid to movement. Airflow which is unimpeded has a viscosity coefficient of 0.

weather - the state of the atmosphere at a given time and place, described by the specification of variables such as temperature, moisture, wind velocity and pressure. (It should be noted that weather is not synonymous with climate.)

wet bulb temperature - the lowest temperature attainable by evaporating water into the air without altering the energy content.

CONVERSION TABLES

1. CONVERSION FACTORS

Multiply	By	To Obtain
acres	43,560	square feet
acres	0.004047	square kilometers
acres	4,047	square meters
acres	0.0015625	square miles
acres	4,840	square yards
acre-feet	43,560	cubic feet
acre-feet	1,233.5	cubic meters
acre-feet	1,613.3	cubic yards
barrels (petroleum, (U.S.) (bbl.)	5.6146	cubic feet
barrels	35	gallons (imperial)
barrels	42	gallons (U.S.)
barrels	158.98	liters
barrels	5,800,000	Btu (energy)
board feet	0.0833	cubic feet
brick number of common	5.4	pounds
British thermal unit (Btu)	251.99	calories, gram
Btu	777.649	foot-pounds
Btu	0.00039275	horsepower-hours
Btu	1,054.35	joules
Btu	0.000292875	kilowatt-hours
Btu	1,054.35	watt-seconds
Btu	0.55556	centigrade heat units
Btu/hr	4.2	cal/min
Btu/hr	777.65	ft-lb/hr
Btu/hr	0.0003927	horsepower
Btu/hr	0.000292875	kilowatts
Btu/hr	0.292875	watts (or joule/sec)
Btu/lb	7.25×10^{-4}	cal/gr
Btu/sq ft	0.271246	cal/sq cm (or langleys)
Btu/sq ft	0.292875	watt-hr/sq ft
Btu/sq ft/hr	3.15×10^{-7}	kilowatts/sq meter
Btu/sq ft/hr	4.51×10^{-3}	cal/sq cm/min (or langleys/min)
Btu/sq ft/hr	3.15×10^{-8}	watts/sq cm
Btu/hr/sq ft/°F	5.682×10^{4}	watts/cm^2/°C
Btu/hr/sq ft (°F/in)	1	chu/hr/sq ft (°C/in)
calories (cal)	0.003968	Btu
calories	3.08596	foot-pounds
calories	1.55857×10^{-6}	horsepower-hours
calories	4.184	joules (or watt-sec)
calories	1.1622×10^{-6}	kilowatt-hours
calories, food unit (Cal)	1,000	calories
cal/min	0.003968	Btu/min
cal/min	0.06973	watts

Multiply	By	To Obtain
cal/sq cm	3.68669	Btu/sq ft
cal/sq cm	1.0797	watt-hr/sq ft
cal/sq cm/min	796,320	Btu/sq ft/hr
centimeters (cm)	0.032808	feet
centimeters	0.3937	inches
centimeters	0.01	meters
centimeters	10.000	microns
cords	8	cord-feet
cords	128 (or 4x4x8)	cubic feet
cubic centimeters	3.5314667	cubic feet
cubic centimeters	0.06102	cubic inches
cubic centimeters	1×10^{-6}	cubic meters
cubic centimeters	0.001	liters
cubic centimeters	0.0338	ounces (U.S. Fluid)
cubic feet (ft^3)	0.02831685	cubic meters
cubic feet	7.4805	gallons (U.S., liq)
cubic feet	28.31685	liters
cubic feet	29.922	quarts (U.S., liq)
cubic feet	0.037037	cubic yards
cubic feet of common brick	120	pounds
cubic feet of water (60°F)	62.366	pounds of water
cubic feet/second	448.83	gallons
cubic inches (in^3)	16.387	cubic centimeters
cubic inches	0.0005787	cubic feet
cubic inches	0.004329	gallons (U.S., liq)
cubic inches	0.5541	ounces (U.S., fluid)
cubic meters	1×10^{6}	cubic centimeters
cubic meters	35.314667	cubic feet
cubic meters	264.172	gallons (U.S., liq)
cubic meters	1,000	liters
cubic yard	27	cubic feet
cubic yard	0.76455	cubic meters
cubic yard	201.97	gallons (U.S., liq)
cubic yards of sand	2,700	pounds
feet (ft)	30.48	centimeters
feet	12	inches
feet	0.00018939	miles (statute)
foot-pounds (ft-lb)	0.001285	Btu
foot-pounds	0.324084	calories
foot-pounds	5.0505×10^{-7}	horsepower-hours
foot-pounds	3.76616×10^{-7}	kilowatt-hours
gallons (U.S., dry)	1.163647	gallons (U.S., liq)
gallons (U.S., liq)	3,785.4	cubic centimeters
gallons	0.13368	cubic feet
gallons	231	cubic inches
gallons	0.0037854	cubic meters
gallons	3.7854	liters
gallons	8	pints (U.S., liq)
gallons	4	quarts (U.S., liq)
gallons of water	8.3453	pounds of water at 60°F

Multiply	By	To Obtain
grams (gr)	0.035274	ounces (avdp.)
grams	0.002205	pounds (avdp.)
grams-centimeters	9.3011×10^{-8}	Btu
horsepower	42.4356	Btu/min
horsepower	2.546	Btu/hr
horsepower	33,000	ft lb/min
horsepower	1.014	metric horsepower
horsepower-hours	2,546.14	Btu
horsepower-hours	0.7457	kilowatt-hours
horsepower, metric (chevalvapeur)	0.9863	horsepower
inches	2.54	centimeters
inches	0.83333	feet
joules	0.0009485	Btu
joules	0.73756	foot-pounds
joules	0.0002778	watt-hours
joules	1	watt-seconds
kilo calories/gram	1,378.54	Btu/lb
kilograms	2.2046	pounds (avdp.)
kilometers	1,000	meters
kilometers	0.62137	miles (statute)
kilometer/hour	54.68	ft/min
kilowatts	56.90	Btu/min
kilowatts	3,414.43	Btu/hr
kilowatts	737.56	ft-lb/sec
kilowatts	1.34102	horsepower
kilowatt hours	3,414.43	Btu
kilowatt hours	2.66×10^{6}	foot-pounds
kilowatt hours	1.34102	horsepower-hours
liters	1,000	cubic centimeters
liters	0.0353	cubic feet
liters	0.2642	gallons (U.S., liq)
liters	1.0567	quarts (U.S., liq)
lumens	0.079577	candle power (spherical)
meters	3.2808	feet
meters	39.37	inches
meters	1.0936	yards
micron	10,000	angstroms
micron	0.0001	centimeters
miles (statute)	5,280	feet
miles	1.6093	kilometers
miles	1.760	yards
milliliter	1	cubic centimeters
millimeter	0.1	centimeter
months (mean calendar)	730.1	hours
ounces (avdp.)	0.0625	pounds (avdp.)
ounces (U.S., liq)	29.57	cubic centimeters
ounces	1.8047	cubic inches
ounces	0.0625 (or 1/16)	pint (U.S., liq)
pints (U.S., liq)	473.18	cubic centimeters

Multiply	By	To Obtain
pints	28.875	cubic inches
pints	0.5	quarts (U.S., liq)
pounds (avdp.)	0.45359	kilograms
pounds	16	ounces (avdp.)
pounds of water	0.01602	cubic feet of water
pounds of water	0.1198	gallons (U.S., liq)
pounds of water evaporated at 212°F	970.3	Btu
quarts (U.S., liq)	0.25	gallons (U.S., liq)
quarts	0.9463	liters
quarts	32	ounces (U.S., liq)
quarts	2	pints (U.S., liq)
square centimeters	0.0010764	square feet
square centimeters	0.1550	square inches
square feet	2.2957×10^{-5}	acres
square feet	0.09290	square meters
square inches	6.4516	square centimeters
square inches	0.006944	square feet
square kilometers	247.1	acres
square kilometers	1.0764×10^{7}	square feet
square kilometers	0.3861	square miles
square meters	10.7639	square feet
square meters	1.196	square yards
square miles	640	acres
square miles	2.788×10^{7}	square feet
square miles	2.590	square kilometers
square yards	9 (or 3 x 3)	square feet
square yards	0.83613	square meters
therms	1×10^{5}	Btu
tons (long)	1,016	kilograms
tons	2,240	pounds (avdp.)
tons (metric)	1,000	kilograms
tons	2,204.6	pounds (avdp.)
tons (short)	907.2	kilograms
tons	2,000	pounds (avdp.)
tons	0.907185	metric tons
tons of refrigeration	12.000	Btu/hr
watts	3.4144	Btu/hr
watts	0.05691	Btu/min
watts	14.34	cal/min
watts	0.001341	horsepower
watts	1	joule/sec
watts/sq cm	3,172	Btu/sq ft/hr
watt-hours	3.4144	Btu
watt-hours	860.4	calories
watt-hours	0.001341	horsepower-hours
yards	3	feet
yards	0.9144	meters

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