# COMPARISON OF IMPROVED STOVES: <br> LAB, CONTROLLED COOKING, AND FAMILY COMPOUND TESTS 

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## Ouagadougou, Upper Volta

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The enclosed report, "Comparison of Improved Stoves: Lat, Controlled Cooking, and Family Compound Tests," is an outcome of collaboration by the Voltaic Institute of Energy (IVE), the Wood Stove Group of Eindhoven University, the Deutsche Geseltschaft für Technische Zusammenarbeit (GTZ), The Permanent Interstate Committee against the Sahel Drought (CILSS), and Volunteers in Technical Assistance (VITA).

This report is the thírd in a series of technical reports on performance testing of improved stoves for cooking. It presents results of comparative testing of traditional three stone fires with massive and lightweight stoves. The report concludes that:

1) The thermal performance of the protected three stone fire is much higher than that normally quoted in stove literature, and thus significantly increases the demands on the performance of "improved" stoves.
2) Massive multipot stoves (of concrete, banco, sand/clay, etc., and particularly those which have chimneys and use spherical pots) can sometimes perforn better than an open fire, but they do not show the large wood economies necessary to have a significant impact on the Sahelian wood fuel problem.
3) Lightweight chimneyless stoves of metal or fired clay show the potential of good wood economies and additionally have the advantages of portability, low cost, ease of construction, and ease of quality control during construction due to its being done in centralized facilities. Their potential drawbacks, such as not evacuating smoke from the kitchen, instability when stirring, and short lifetime (fired clay), are now being evaluated.

The CILSS stoves program is coordinated by Baldwin as regional technical coordinator, and Mme. Jacqueline Ki-Zerbo as regional sociological coordinator.

The VITA Wood Conserving Cook Stoves Bibliography is also enclosed for your information. Your comments on the report, as well as your circulating the report and bibliography to other interested readers, will be appreciated by the authors and by VITA. A French larguage version of the report will be available in the near future.

Paula Gubbins<br>Energy Operations Officer

## Foreword

This is the third in a series of field reports on laboratory and field testing of improved stoves. These are not polished, final reports, but rather represent an attempt to get research results into the field quickly in order to aid other onyoing work and to stimulate debate.

This third report is the first in the series to include controlled cooking tests and stove tests in family compounds. The results of the worn presented here permit several important conclusions:

1) The thermal performance of the protected three stone fire is much higher than that normaly fuoted in stove literature, and thus significantly increases the demands on the performance of "improved" stoves.
2) Massive multipot stoves (of concrete, banco, sand/clay, etc., and particularly those which have chimneys and use spherical pots) can sometimes perform better than an open fire, but they do not show the large wood economies necessary to have a significant impact on the Sahelian wood fuel problem.
3) Lightweight chimneyless stoves of metal or fired clay show the potential of good wood economies and additionally have the advantages of portability, low cost, ease of construction, and ease of quality control during construction due to its being done in centralized facilities. Their potential drawbacks, such as not evacuating smoke from the kitchen, instability when stirring, and short lifetime (fired clay), are now being evaluated.

Many thanks go to all those who helped in constructing the stoves, testing them, and providing support throughout this work. In particular,

For stove construction: Association Internationale de Developpement Rural; Centre d'Artisans Handicappés; Foyers Modernes de Kaya; Mission Forestière d'Allemande; Volontaires du Progrès, Titao.

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## TABLE OF CONTENTS

Foreword ..... 111
I. Introduction and Summa:y ..... 1
II. Design of the Stoves Tested ..... 9
III. Laboratory Test Methodology ..... 35
IV. Laboratory Test Sheet and Results ..... 39
V. Controlled Cooking Test Sheets and Results. ..... 53
VI. Heat Recuperation Test Sheet and Results ..... 59
VII. Family Compound Test Sheet and Irsults ..... 63
References ..... 67

## LIST OF TABLES

I. PHUs of Stoves Tested ..... 2
II. Specific Consumption of Stoves Tested ..... 4
III. Average Specific Consumptions and Correlation Coefficients ..... 5
IV. Family Compound Three Stone Fire Efficiencies. ..... 7
V. Summary of Pot Dimensions ..... 9
VI. Wood Moisture Content Test ..... 23
VII. Laboratory Water Boiling Test Data and Results ..... 42
VIII. Controlled Cooking Test Data and Results ..... 55
IX. Heat Recuperation Test Data and Results. ..... 61
X. Family Compound Boiling Water Test Data and Results ..... 65

## I. INTRODUCTION AND SUMMARY

A major effort to test the performance of various improved stoves has begun at the Voltaic Institute of Energy with technical assistance from Eindhoven University, GTZ, and the CILSS/VITA Technical Coordinator. The testing reported tere included:

- High power water boiling tests;
- Controlled cooking tests;
- Heat recuperation tests; and
- High power water boiling tests in family compounds.

The following is a summary of the results to date.

## High Power Water Boiling Tests

Thirteen different stoves were tested using high power water boiling tests. The stoves were built by the same masons who build that particular type of stove in the field. All stoves used $\$ 3$ aluminum pots except the Nouna 31, and the third potholes of the Kaya 3 and the AIDR 3 stoves which needed $\$ 4$ pots. The same species of wood, Eucalyptus camaldulensis, having a moisture content of $6 \%$, was used in all teste. All tests were done side by side in the same hargar using the same balance, accurate to 1 gram over 7 kg , and the same thermometers.

The procedure used was to bring the first pot to a boil, and then simmer it for one hour. Since no covers were used on the pots at any time, the firepower required throughout the tests (even during simmering) remained high. Wood and water weights were recorded before the test began, when the first pot reached the boiling point, and after the one-hour simmering phase was completed. Charcoal was recovered and weighed at the end of the simmering phase. Water temperatures were recorded every five minutes throughout the entire test.

The thermal efficiency of each pot (or percent heat utilized - PHU) was then calculated in two ways. The first calculation did not include the weight of the charcoal remaining at the end of the test sirce it is not at all clear that in practice this charcoal is consistently extinguished and saved for later use. Thus, not taking the remaining charcoal into account gives:

$$
\mathrm{PHU}=\frac{4.186 \mathrm{MT}+2,260 E}{17,150 W} \times 100 \%
$$

where 4.186 is the specific heat of water, $\mathrm{kJ} / \mathrm{kg}, \mathrm{M}$ is che initial mass of water, $T$ is the temperature change of the water, $2260 \mathrm{~kJ} / \mathrm{kg}$ is the latent heat of vaporization of water, and $E$ is the quantity of water evaporated. $W$ is the mass of wood burned during the test and $17,150 \mathrm{~kJ} / \mathrm{kg}$ is its calorific heat. (It must be noted that the
calorific vaiue $17,150 \mathrm{~kJ} / \mathrm{kg}$ is the corrected value considering moisture content. Previous reports, Yameogo, June 1983, and IVE Report \#l, instead used a value of $18,000 \mathrm{~kJ} / \mathrm{k}$. Thus, the PHUs cited here are uniformly slightly higher than those previously reported.)

The second method of calculation did include the charcoal remaining at the end of the test. The formula used for each pot was:

$$
\mathrm{PHU}_{\mathrm{c}}=\frac{4.186 M T+2,260 F}{17,150 W-29,000 \mathrm{C}} \times 100 \%
$$

where $C$ is the mass of the charcoal remaining at the end of the test and $29,000 \mathrm{~kJ} / \mathrm{kg}$ is its calorific value.

The total FHU in each case was then the sum of the individual pot PHUs.

Ten tests were done on each stove. The averages and standard deviations for each ar: recorded in the following table.

TABLE I
PHUs OF STOVES TESTED


Several conclusions can he drawn from these results:

1. The thermal performance of the chree stone fire was much higher than that normally quoted in stove literature, and thus significantly increases the demands on the performance of "improved" stoves.
2. The chimneyless stoves tested perform better than those cested with chimneys. The reasons for this are that chimneyless stoves have (A) more surface area of the pot exposed to the hot gases and, (B) a shape that also forces the hot gases close to the surface of the pot to improve convective heat transfer. (However, it should be noted that the CATRU stove, in spite of the modified pots and banco interior contoured to the shape of the pots, satisfied the conditions needed for convective heat transfer--that is, a large exposed pot surface area and a narrow gap through which the hot gases must pass-but did not perform particularly well due in part to the difficulty of establishing a draft through it.)

Other factors improving the performance of the lightweight stoves in particular are ( $C$ ) grates to improve combustion and (D) low mass to reduce the amount of energy needed to heat the stove body itself.
3. The efficiency of the second pot was much less than that of the first in all the mulii-pot stoves tested. This may he a particular problem in stoves in which the two pots are of such different size they cannot be interchanged. In this case, the second pot must reach boiling temperatures i.f it ls to be useful; however, to reach the boiling point, very high firopowers are necessary which can in turn eliminate potential woud savings (as well as overcook food in the first pot).
4. The efficiency of the third pot in the $A$ IDR 3 stove was too small to be of much use. In addition, the efficiency of the second pot in this stove appeared to be lowered by the presence of the third.
5. The performance of the first pot is slightly higher in the Banfora than in the other muiti-pot stores. It is suspected that this is due to the smaller draft in this stove, and thus a combination of J.ess cooling of the first pot by incoming fresh air; possibly longer retention times of the hot gases against the pot; and perhaps the larger amount of charcnal produced in this stove providing greater radiant transfer.
6. The efficiency of the first pot in the stoves with chimneys is equal to or less than that of the open fire.

## Controlled Cooking Tests

A series of tests was done tu observe the performance of these stoves in actual cooking. All ingredients for both "tô" and gumbo sauce were
weighed out to 1 gram precision and with few exceptions, the same quantities were used in each test. A preliminary series of tests was done by one "animatrice" to survey all the stoves. From these, five stoves were chosen from the group for additional tests. Four different animatrices prepared the meals, each cooking one time on each stove. Table II shows the performance of each stove at least in lerms of the kilograms of dry wood needed to prepare each kilogram of cooked food, or specific consumption.

TABLE II
SPECIFIC CONSUMPTION OF STOVES TESTED

|  | ANIMATR ICE |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
| STOVE | 1 | 2 | 3 | 4 | AVERAGE/ECONOMY |
| Three Stone | 0.265 | 0.293 | 0.270 | 0.242 | $0.268 /+0 \%$ |
| Nouna 2 | $0.24 h^{\prime}$ | 0.244 | 0.243 | 0.216 |  |
|  |  |  |  | 0.270 | $0.242 /+9 \%$ |
| Banfora | 0.258 | 0.239 | 0.199 | 0.259 |  |
| AIDR 3 | 0.314 | 0.317 | 0.261 | 0.324 | $0.304 /-13 \%$ |
| Metallic | 0.164 | 0.164 | 0.155 | $-\cdots$ | $0.161 /+40 \%$ |

The metal stove used much less wood than the others. The two- and three-pot stoves did not perform as well as expected from the laboratory tests because the second pot efficiency was too low to provide effective cooking power. Thus, to cook the food the pots were suitched as needed and actual cooking was done mostly on the first pothole; the second pothole was used to preheat the water before cooking on the first hole or to keep the food warm after it was cooked on the first hole. Alternatively, the rood could have been cooked on the second hole if a very large fire was used, but that would have both drastically overcooked the food on the first pothole as well as consumed even more wood.

Thus, in the limit that the second pothole efficiency goes to zero, the performance is clearly determined only by the first pothole. In the other extreme where the second pothole efficiency increases to that of the first or even higher, the performance of the stove in cooking a meal will be determined by a combination of the efficiency of the two depending on their relative ferformance and the meal being cooked. It should therefore be noted that, in general, cooking several pots simultaneously from a single fire greatly reduces the efficiency with which tine fire can be controlled as well as the flexibility of the stove to handle different cooking tasks.

It is interesting to compare various combinations of laboratory efficiencies to the above wood consumpt: : per kilo of cooked food. Since the specific consumption should decrease as the thermal efficiency increases we will compare the PHU to the value of $1 /$ (specific consumption). Table III gives the average specific consumption (from Table $I I$ ) and its inverse and the correlation coefficient for these (X) values versus (Y) values of: (1) the total PHU of the stove; (2) the PHU of the first pot only; and, (3) the PHU of the first pot plus half that of the second.

TABLE III
AVEPAGE SPECTFIC CONSUMPTIONS AND CORRELATION COEFFICIENTS

| STOVE | SC | 1/SC | (1) | (2) | (3) |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Three Stone | 0.268 | 3.73 | 14.8 | 14.8 | 14.8 |
| Nounr. 2 | 0.242 | 4.13 | 20.2 | 13.9 | 17.1 |
| Banfora | 0.231 | 4.33 | 22.1 | 15.6 | 18.9 |
| AIDR 3 | 0.304 | 3.29 | 19.2 | 13.0 | 15.0 |
| Metal | 0.161 | 6.21 | 26.9 | 26.9 | 26.9 |
| Correlation Coefficient |  | 0.854 | 0.967 | 0.986 |  |
| 1/SC vs (1), (2), (3) |  |  |  |  |  |

We can do the sarue linear regressions including all the stoves in the controlled cooking. (Note that the following were tested only once each.)

TABLE III.A

| STOVE | SC | $1 / \mathrm{SC}$ | (1) | (2) | (3) |
| :--- | :---: | :---: | :--- | :--- | :--- |
| AIDR 2 | 0.323 | 3.10 | 19.6 | 14.3 | 17.0 |
| CATRU | 0.372 | 2.69 | 18.6 | 13.0 | 15.0 |
| Kaya 2 | 0.269 | 3.72 | 17.9 | 12.3 | 15.1 |
| Kaya 3 | 0.511 | 1.96 | 17.5 | 8.9 | 11.5 |
| Nouna 32 | 0.222 | 4.50 | 18.8 | 14.3 | 16.6 |
| Titao | 0.421 | 2.38 | 13.0 | 9.4 | 11.2 |
|  |  |  |  |  |  |
| correlation coefficient |  |  |  |  |  |
| including all the above |  | 0.763 | 0.903 | 0.905 |  |
| eleven stoves |  |  | 0.248 | 0.225 | 0.254 |
| slope |  | $1 / \mathrm{SC}=$ | 23.7 | 23.0 | 24.9 |
| PHU $(\mathrm{y})=100$ |  |  |  |  |  |

Certainly, additional linear regressions could be done with different combinations of the laboratorv efficiencies. However, it is clear that for the tests presented here, there is a good correlation (a perfect correlation would be +1.0 ) between a modified laboratory PHU, such as case 2 above, and the performance of the stove in acturlly preparing a meal as measured by the inverse of iis specific consmption. It must be emphasized, for example, that the Kaya 3 and Titao stoves which had the lowest first hole efficiencies also had by far the highest specific consumption in the kitchen tests. Again, the reason for this is that the second and third pothole do not provide effective cooking power and thus, primary reliance is 1 the first hole. Therefore, even stoves with an overall PHU higher than that of the open fire can still consume more wood than the open fire in cooking (as seen in the case of the AIDR 3 and Kaya 3 stoves above).

It is also interesting to note in the linear regressions above that "perfect" stoves, that is those with a PHU of 100 , or equivalently having all the energy released by the wood absorbed by the contents of the pot (ignoring the pot mass), give a value of about 24 for the inverse of the specific consumption, or 0.0419 kg dry eucalyptus wood burned per kg of food produced. The amount of energy needed to heat 1 kg of water from $20^{\circ} \mathrm{C}$ to boiling is equivalent to about 0.0183 kg of wood or an inverse spectfic consumption of 55 . As the energy required for the chemical conversion of food during cooking is negligible (Geller), we can assume that the difference above is due to eva! oration. However, this evaporation is, at least in part, a necessary factor in the overall cooking process, particularly for such foods as tô. It cannot be totally eliminated nor should it be considered in its entirety a loss.

It is hoped that when a sufficient data base is available, similar regressions can be done between field tests and lab tests, and between field tests and controlled cooking tests in order to improve lab and controlled cooking test rethodology and to allow better prediction of field performance.

## Heat Recuperation Tests

After the cooking test was completed, pots of cold water with lids were placed on the stove to warm and to observe how much of the heat held in the stove walls could be recuperated. For these tests, the remaining charcoal was swept from the stove, and the door and chimney blocked. The results indicated that typically only 0.6 to $1.35 \%$ of the energy released by the fire could be recuperated in this manner. This is in notable contradiction to the frequent statement of the potential of massive stoves to recuperate heat. It is likely that heating in this manner is actually done on hot coals left in the stove.

Thus, it is more efficient to use a high efficiency stove to cook with and to then light a fire in it a second time to heat water with than to use a low efficiency massive stove for cooking and attempt to recuperate some of the heat stored in the stove body for heating water later.

## Family Compound Tests

Because the performance of the three stone fire was so high in the laboratory, tests were done to see if these results were representative of three stone fires in family compounds. High power boiling water tests using fixed 1.000 kilogram charges of the Eucalyptus wood from the laboratory were done on the three stone fires in thirty different family crmpounds. In each case, the three stone fireplace was swept clear of ashes and debris and the 1 kg charge of wood was completely burned. The test was stopped when the wood itself had finished burning. The tests were done by the same animatrices who ran the boiling water and cooking tests in the laboratory. All the pots used for the tests were aluminum and were provided by the families themselves. Pot and water weights were measured before and after the test using a balance with 10 gm precision. Charcoal was not recuperated at the end of the test. The results are listed in Table IV.

TABLE IV
FAMILY COMPOUND THREE STONE FIRE EFFICIENCIES

| EFEICIENCY | NO. OF FAMILIES |
| :---: | :---: |
| $8-10 \%$ | 3 |
| $10-12 \%$ | 4 |
| $12-14 \%$ | 6 |
| $14-16 \%$ | 7 |
| $16-18 \%$ | 6 |
| $18-20 \%$ | 3 |
| $20-22 \%$ | 1 |
| Average $=14.5+3.1 \%$ |  |

These results do not include recuperable charcoal and chus have to be compared to the open fire performance not including charcoal of $14.8 \%$ in the laboratory. There was also a strongly observed correlation beL?een the efficiency of the stove and where it was located. For those three stone stoves in the family courtyard, the average efficiency was $12.8 \%$. For those three stone stoves located inside a kitchen the average efficiency was $16.7 \%$. There were no strong observed correlations between pot size nor ground-to-pot distance, perhaps due to the small size of the sample.

## Conclusions

The testing program has shown that massive stoves with chimneys which use spherical pots can (but sometimes do not) perform better than an
open fire, but they do not show the high thermal efficiencies and thus large wood econcmies desired to have a truly significant impact on the Sahelian wood ruel problem.

On the other hand, the lightweight chimneyless stoves show the potential of good wood economies, portability, low cost, ease of construction, and ease of quality control during construction due to it being done in centralized facilities. Their drawbacks, however, include not evacuatiug the smoke from the kitchen, and being less stable when making such dishes as tô. Ouestions also remain concerniny the durability of the lightweight stoves of fired clay in day to day use.

Research is now continuing in two directions. First, lightweight chimneyless stoves are being optimized in the laboratory to further improve their thermal performance and tested in the field to determine how serious the potential drawbacks in terms of smoke, stability, and for fired clay stoves, lifetime really are. Second, an effort is being made to modify the form of the pots (making cylindrical pots) so that good wood eccnomies can be achieved simultaneously with the use of a chimney.

そ̌esults will be forthcoming.

## II. DESIGN OF THE STOVES TESTED

Designs for and the dimensions of each stove tested are shown on the following pages. Below is a brief description of each individual stove. All the stoves were built by the same masons that build such stoves daily in the field for their respective organizations.

The same size pots--\# 3 --were used on all tne stoves except for the third pot in the three-hole stoves-that is the third pot in the AIDR 3, the Kaya 3, stoves and Nouna 31 which used if 4 pots. The nominal dimensions of these pots are summarized in Table $V$ belov.

TABLE V
SUMMARY OF POT DDMENS TONS

| POT | $\$ 3$ | $\# 4$ |
| :--- | :---: | :---: |
| Top diameter | 24.5 | 27.5 |
| Maximum diameter | 27.0 | 30.5 |
| Total height | 19.0 | 2.0 |
| Height from bottom to <br> maximum diameter | 10.0 | 10.0 |
| Volume (liters) | 7.8 | 11.5 |

The values of the pot weights themselves can be seen in the data in section IV.

The three stone fire was made of three rocks placed on a concrete slab with a ground to pot distance of 10 cm .

The fired clay stove is described in detail in the October and February reports as stove "El" and which will not be repeated here.

The metal stove was based on the dimensions of stove $K$ in the February report. Detailed design and production details are given by the Sepps. In brief, the stove was 92 cm in circumference (around a pot 87 cm in circumference) with a grate made of strips of scrap metal welded together and a grate to pot distance of about 10 cm . The metal used tinroughout was 1 mm thick sheet and was formed by hammering and then welding into place.

The AIDR stcuss were formed with walls of standard preformed banco bricks, $a r_{1}$ interior including a baffle of banco, a trapezoidal metal cased doorway, a reinforced concrete ton plate, and a chimney of cement bricks at the bottom and fired clay tubing at the top. For the

AIDR 2 stove, the ground to pot A distance was 11 cm , and the minimum bafile to poi $B$ distance was 7 cm .

The Banfora stove was made of banco bricks and a banco interior subsequently carved out and a rainproofing coating of a cement, sand, and clay mixture. The distance from the ground to pot $A$ was 13 cm and from the baffle to pot $B$ varying with a minimum of roughly 2 cm .

The CATRU stove bas made with preformed reinforced concrete walls, a cast aluminum top plate, and an interior of banco that crudely followed the pot shape several centimeters away. The door was metal clad and the chimney was made of concrete blocks with a rain hat on top. The ground co pot $A$ distance was roughly 13 cm , and typical distances to the second pot were on the order of 2 to 3 cms.

The Kaya 2 hole stove was made with banco brick walls and a banco interior with a rainproofing coating of a mixture of cement, sand, and clay. No metal reinforcing was used anywhere. The chimney was made of concrete blocks. The ground to pnt $A$ distance was 12 cm and the minimur baffle to pot $B$ distance was 2 cm .

The Kaya 3 hole stove was made with banco brick walls, a banco interior and a reinfurced concrete top plate. The chimney was made of concrete blocks. The ground to pot distances for pots $A$ and $B$ was 14 cm ; the baffle to pot $C$ minimum was 2 cm .

The Nouna stoves were all made of concrete block walls, interiors of mortar and broken ceramic bits, and reinforced concrete top plates. The chimneys were made of concrete blocks below and sheet metal tubing above. The ground to pot A distance was 15 cm for the Nouna 31, and 12 cu for the Nouna 32 and Nouna 2 stoves. The minimum baffle to pot $B$ distance was 5 cm in the Nouna 2 and 3.5 cm in the Nouna 32 . It should be noted that because the same chimney was used by the Nouna 31 and the Jouna 32, there could be communication between the two and that the effective chimney height in terms of providing a draft was very small.

The Titao stove was made with banco walls, a banco interior, and a banco chimney, Pot seats were made from donuts (triangular in crosssection) of fired clay. The pot seats had a bottom inner diameter of 23 cm , a peak inner diameter of 33 cm , ald an exterior bottom diameter of 45 cm . The distance from the bottom to the peak was 9 cm . The first pot sat 20 cm off the ground; the second pot sat a minimum of 8 cm above its baffle. (These large gaps and the pot seats wich partially covered the pot bottom accounted for much of its poor performance.) In general, the shape of the stove was fairly irregular.


THREE STONE FIRE - PERSPECTIVE


SPHERICAL POT


CATRU POT



Fired Clay stove

metal stove



BANFORA



CATRU


FRONT VIEW


KAYA 2


NOUNA 2


NOUNA`31/32


TITAO



AIDR 3

$-33-$

KAYA 3

## III. LABORATORY TEST METHODOLOGY

The stoves were all built by the same masons who construct stoves in the field for their respective organizations. All stoves were built or placed side by side in the same hangar against one wall. The protection against the wird was reasonabiy good but certainly not complete. The effect of the wind can be oeen by comparing the laboratory performance of the three stone fire with that found in family compound tests inside the kitchen ( $16.7 \%$ ) or outside ( $12.8 \%$ ).

The same species of wood, Eucalyptus camaldulensis, was used for all tests. Tests done at TNO in the Netherlands Found the gross calorific value for this species to be $19,750 \mathrm{~kJ} / \mathrm{kg}$ and the net calorific value to be $18,325 \mathrm{~kJ} / \mathrm{kg}$. Bomb calorimetric tests done at the Institut Supérieur de l'Université de Ouagadougou established a value uf 18,105 $\mathrm{kJ} / \mathrm{kg}$. The wood moisture content was measured once during the series of tests. Placing the wood in a $105^{\circ} \mathrm{C}$ stove found the following:

TABLE VI
WOOD MOISTURE CONTENT TEST

| DATE | WEIGHT | REMARKS |
| :--- | :--- | :---: |
| Jan. 5 | 824.3 gms | Start |
| Jan. 6 | 787.3 | - |
| Jan. 7 | 779.1 | - |
| Jan. 10 | 777.1 | Finish |

Using the TNO data and the above value of the moisture content, $6 \%$, we find a calorific value per kilogram of wet wood of about $17,150 \mathrm{~kJ} / \mathrm{kg}$.

Four different testers tested the stoves, each person testing each of the stoves to reduce the bias among themselves.

All stoves were used several times before testing began to thoroughly dry them, and all stoves were tested only once per day to ensure that they were cold at the start of the test.

All weights were measured to 1 gram precision using a Sartorius digital balance with a capacity of 7 kg . All temperatures were measured with mercury in glass thermometers accurate to at least $1^{\circ} \mathrm{C}$.

The methodology used generally followed that repcrted previously in the October and February reports. The test methodology is a high power boiling water test modeled after those used by Tim Wood of VITA, Stephen Joseph of ITDG, the draft procedure developed by the "Working group meeting on a woodstove ficld test standard, Marseille, 12-14 May 1982" and others, Results are reported in terms of Percent Heat Utilized or PHU. It should be noted that this work was done before the
provisional international standards, developed at Arlington, Virginia, in December 1902 , became available and has no selation to that methodology or methed of calculation.

The testing procedure was as follows:

1. The stove and area around it are swept clean of ashes and other debris. Stoves are felt to make sure they are cool. Massive stoves are only tested once per day. The lightweight stoves could be tested more frequently because of their low thermal mass.
2. Weather conditions, particularly the wind, are noted.
3. Wood is chopied into pieces roughly $2-4 \mathrm{~cm}$ by about 20 to 30 cm long, along with a number of smaller pieces to start the fire. All wood, including kindling, is then weighed and set to the side of the stove.
4. The pots to be used are weighed and their weight recorded. Approximately 3 kg of water are added to the pot and the total weight of pot plus water is recorded.
5. The wood is then arranged in the stove, a small ( $1-2 \mathrm{ml}$ ) amount of kerosene is adder to the wood, and the wood set on fire. While the fire becomes established (a minute or so), the water temperature is taken. Once the fire is burning well, the pot is placed on the stove, and a stopwatch is started.
6. The temperature of the water is recorded every five minutes until the first pot begins to boil. The wood is pushed in or added in order tc maintain a reasonably steady, but not excessively large, fire. Despite the vagueness of this desired fire size, it can be seen that for the range of firepowers tested there was very little correlation if any with the PHU. It should be noted that no lids are used on any of the pots at any time. Not using lids does increase the necessary firepower for the boiling and particularly for the sinmering phases.
7. As soon as the water starts to boil in the first pot (do not wait for the second pot), the flames are blown out; the wood left in the stove is weighed and recorded; and the pots are then weighed and weights recorded. Charcoal is left in the stove unweighed until the end of the simmering phase.
8. After all wood and pot weights are taken and recorded, the fire is relit, the water tempeatures recorded, the pots returned to the stove, and the timing begun again.
9. The temperatures of the pots are again recorded every five minutes. The fire is maintained at a steady level to keep the water temperature above $95^{\circ} \mathrm{C}$ but below a vigorous boil. Again, lids are not used on the pots.
10. After 60 minutes, the fire is again blown out and the weights of the wood, charcoal, and pots taken and recorded.
11. A sample test sheet is shown in section IV.

It should be noted that this procedure does not provide a good resolution of the high power and low power abilities of the stove; since pot iids are not used, there is a high rate of heat loss from the pot. In order to keep temperatures close to boiling under these circumstances, the tester is obliged, even during the second part of the test--the "low power" simmering phase--to maintain a fairly high power level. This is to be contrasted with the newly released draft international standards which very specifically focus the second, simmering phas of the test on the low power capabilities of the stove. Tests following the draft world standard have been recently done and will be published elsewhere.

## Calculating the Percent Heat Utilized

The procedure used for calculating the percent heat utilized (PHU) has already been discussed in the Introductior as well as in the October and February reports. Error analyses can also be found there.

In more detail, the first half efficiency, or PHU, not including charcoal, is given for pot $A$ by:

$$
N A^{\prime}=\frac{0.004186(C-B)(F-E)+2.26(C-I)}{17.15(D-H)} \times 100 \%
$$

where the letters refer to the line items on the sample test sheet in section IV or in the data tables.

Similarily, we can write the following equation for the second half efficiency not including charcoal:

$$
N A^{\prime \prime}=\frac{0.004186(\mathrm{I}-\mathrm{B})(\mathrm{F}-\mathrm{J})+}{17.15(\mathrm{H}-\mathrm{K})} \frac{2.26(\mathrm{I}-\mathrm{M})}{} \times 100 \%
$$

Similar expressions can be generated for other pots. Average efficiencies are given by taking the values at the very start and the very end of the test. Total efficiencies are given by the sums of individual pot efficiencies. Efficiencies including charcoal are given as indicated in the introduction. Unlike previous reports, efficiencies including charcoal for the boiling and simmering phases were not calculated separtately.

The firepower during the first and second stages was also calculated with and without taking charcoal into account. In general, the firepower can be expressed, taking charcoal into account, as:

$$
P=\frac{17.15 W-29.00 C}{60(\mathrm{el} \text { aps ed time }} \frac{\text { in minutes })}{}
$$

where $P$ is given in units of kilowatt hours. In terms of the sample test sheet, dividing the charcoal equally between the first and second stages, we find, for example:

$$
P_{C}^{\prime}=\frac{17.15(\mathrm{D}-\mathrm{H})-14.50(\mathrm{~L})}{60(\mathrm{G})}
$$

The other values can be derived similarly.

## SAMFLE LABORATORY TEST DATA SHEET



SIMAERING PHASE:


TABLE VII

## LABORATORY WATER BOILING TEST DATA AND RESULTS

ThREE STONE STOVE

| A | B | C | D | E | F | G | H | I | J | K | L | M |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 7 | 1292 | 4286 | 3230 | 27 | 100 | 30 | 2525 | 4015 | 87 | 1410 | 109 | 2570 |
| 33 | 1455 | 4514 | 3275 | 20 | 98 | 35 | 2354 | 9103 | 30 | 662 | 111 | 2541 |
| 44 | 1329 | 4550 | 3370 | 23 | 98 | 15 | 2675 | 4373 | 85 | 1362 | 105 | 2775 |
| 45 | 1418 | 4460 | 3168 | 22 | 99 | 17 | 2299 | 4275 | 34 | 11435 | 102 | 2929 |
| 54 | 1410 | 4271 | 3451 | 21 | 98 | 27 | 2799 | 4026 | 70 | : 481 | 130 | 2530 |
| 77 | 1360 | 4243 | 3080 | 19 | 100 | 55 | 1600 | 3564 | 78 | 08 | 603 | 2228 |
| 105 | 1457 | 4434 | 3506 | 21 | 98 | 18 | 2837 | 4201 | 82 | 1582 | 149 | 2733 |
| $+06$ | 1355 | 4340 | 3437 | 22 | 99 | 28 | 2.751 | 4057 | 80 | 1618 | 111 | $25 ?$ |
| 111 | 1391 | 4320 | 2396 | 22 | 99 | 20 | 1821 | 4117 | 80 | 688 | 101 | 28.2 |
| A | $\mathrm{P}_{\mathrm{c}}$ | $N^{\prime}$ | $\mathrm{P}_{6}$ | $N^{\prime \prime}$ | $\mathrm{N}_{0}$ | $\mathrm{N}_{\mathrm{C}}$ |  |  |  |  |  |  |
| 7 | 5.84 | 12.6 | 4.87 | 17.6 | 15.7 | 17.5 |  |  |  |  |  |  |
| 33 | 6.92 | 11.9 | 6.66 | 14.6 | 13.6 | 14.7 |  |  |  |  |  |  |
| 44 | 11.6 | 11.8 | 5.83 | 16.8 | 15.1 | 16.5 |  |  |  |  |  |  |
| 45 | 14.6 | 9.27 | 3.87 | 23.0 | 15.3 | 17.1 |  |  |  |  |  |  |
| 54 | 5.74 | 13.2 | 5.76 | 15.9 | 15.0 | 16.9 |  |  |  |  |  |  |
| 79 | 5.04 | 9.90 | 4.73 | 12.5 | 11. 2 | 17.0 |  |  |  |  |  |  |
| 105 | 8.62 | 12.9 | 5.38 | 16.3 | 15.1 | 17.4 |  |  |  |  |  |  |
| 106 | 6.04 | 13.6 | 4.95 | 18.2 | 16.4 | 18.3 |  |  |  |  |  |  |
| 111 | 7.00 | 14.2 | 4.99 | 16.3 | 15.6 | 17.3 |  |  |  |  |  |  |

Caption headings A through $M$ are taken from the sample tests sheet. The values $P_{c}, N^{\prime}, P_{c}, N^{\prime \prime}, N_{o}$, and $N_{c}$ are calcuiated as described in the text. $P_{C}$ is the fire power including charcoal remaining during the bciling phase. $P_{C}$ is the corresponding fire power including charcoal during the second phase. $N^{\prime}, N^{\prime \prime}$, and $N_{0}$ are the PHUs of the stove taking into account the charcoal remaining at the end of the test.
fired clay stove

| A | $B$ | c | D | E | F | G | H | I | J | K | L | M |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 25 | 1272 | 4518 | 3491 | 22 | 98 | 15 | 3145 | 4452 | 81 | 2435 | 15 | 2455 |
| 35 | 1287 | 1306 | 2807 | 22 | 98 | 12 | 2501 | 4128 | 81 | 1818 | 16 | 2432 |
| 37 | 1278 | 4253 | 3029 | 21 | 90 | 14 | 2741 | 4100 | 81 | 1960 | 16 | 2154 |
| 42 | 1270 | 4214 | 3531 | 25 | 98 | 15 | 3156 | 4056 | 82 | 2511 | 17 | 2304 |
| 47 | 1こ7 | 4134 | 3448 | 23 | 100 | 12 | 3156 | 3980 | 78 | 1986 | 45 | 1309 |
| 55 | 12P7 | 4319 | 3308 | 22 | 100 | 15 | 3009 | 4172 | 86 | 2202 | 24 | 2002 |
| 68 | $12=1$ | 4277 | $2: 25$ | 23 | 100 | 15 | 1926 | 4117 | 37 | 1173 | 26 | 2381 |
| 72 | 1393 | 4905 | ここ0う | 1 y | 9y | 18 | 1702 | 4203 | 81 | 870 | 23 | 2374 |
| 78 | ： 404 | 4405 | 3493 | 20 | 98 | 27 | 3030 | 4114 | 84 | 2083 | 40 | 20－7 |
| 89 | $: 273$ | 4272 | 2438 | 23 | 98 | 14 | 3094 | 4123 | 81 | 2450 | 13 | ¿362 |


| A |  | P |  |  | P | N |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 25 | 6 | 35 | 24 | 3 | 3． $3 \frac{C}{2}$ | 38 | 34.1 | 5 |
| 35 | 6 | 97 | 26 | 0 | 3.10 | 34 | 31.8 | 32 |
| 37 | 5 | 50 | 27 | Z | 366 | 34 | 32 | 33 |
| 42 | 6 | 87 | 19 | 5 | 3.00 | 36.7 | 30 | 31 |
| 47 | 5 | 03 | 25 | 3 | 5.39 | 30.3 | 29.3 | 31.0 |
| 55 | 5 | 31 | 25 | 8 | 3．75 | 35.2 | 32.6 | 33 |
| 58 | 5 | 28 | 25 | 8 | 3.48 | 31.6 | 29 | 31.2 |
| 72 | 5 | 46 | 23 | 6 | 3.87 | 30．5 | 28 | 29 |
| 78 | 4 | 54 | 20 | 4 | 4.35 | 29.3 | 26．4 | 27.7 |
| 84 | 5 | 80 | 22 | 5 | 302 | 37.9 | 32.5 | 33 |

## NOUNA 31

| A | B | C | D | E | F | G | H | I | J | K | L | M |
| ---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 6 | 1530 | 4683 | 3325 | 27 | 100 | 21 | 2695 | 4404 | 86 | 1458 | 90 | 2809 |
| 22 | 1549 | 4486 | 3090 | 20 | 100 | 19 | 2439 | 4296 | 75 | 1183 | 95 | 2674 |
| 30 | 1663 | 4722 | 3021 | 20 | 98 | 27 | 2264 | 4392 | 75 | 1165 | 97 | 3215 |
| 40 | 1644 | 4629 | 3663 | 21 | 08 | 20 | 2965 | 4397 | 79 | 1501 | 133 | 2604 |
| 48 | 1662 | 4732 | 3070 | 22 | 99 | 17 | 2427 | 4548 | 81 | 1180 | 80 | 3077 |
| 62 | 1527 | 4585 | 3588 | 22 | 98 | 22 | 2903 | 4340 | 73 | 1260 | 135 | 2416 |
| 59 | 1544 | 4685 | 3604 | 19 | 98 | 38 | 2623 | 4234 | 84 | 1237 | 133 | 2501 |
| 87 | 1547 | 4697 | 3614 | 21 | 100 | 17 | 2854 | 4490 | 86 | 1543 | 127 | 3028 |
| 98 | 1595 | 4531 | 3482 | 21 | 98 | 21 | 2698 | 4336 | 76 | 1003 | 148 | 2362 |
| 103 | 16156 | 4666 | 3418 | 22 | 98 | 30 | 2711 | 4367 | 76 | 1204 | 172 | 2567 |


| A | $P_{c}$ | $N$ | $\mathrm{P}_{\mathrm{C}}$ | $N^{\prime \prime}$ | $\mathrm{N}_{0}$ | $\mathrm{N}_{\mathrm{c}}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 6 | 7． 54 | 14.7 | 5.53 | 17.8 | 16.8 | 18.2 |
| 22 | 8． 59 | 13.7 | 5.60 | 17.8 | 16.4 | 17.9 |
| 30 | 7.15 | 13.4 | 4.84 | 15.5 | 14.7 | 16 |
| 40 | 8.37 | 12.4 | 6.44 | 17.0 | 155 | 17 |
| 48 | 100 | 124 | 562 | 16.6 | 151 | 15 |
| 62 | 7.42 | 13.0 | 7． 28 | 16.5 | 15．5 | 17 |
| 67 | 6.53 | 12.0 | 5． 07 | 17．1 | 15.0 | 1 |
| 87 | 11.0 | 11.6 | 5.73 | 15.5 | 135 | 15 |
| 98 | $8 \quad 97$ | 11 5 | 748 | 16.2 | 14.7 | 16 |
| 103 | 5．35 | 13.5 | 6.49 | 16.7 | 15.7 | 18.0 |

METAL STOVE

| A | B | C | D | E | F | G | H | I | J | K | L | M |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 129 | 1413 | 4454 | 2897 | 29 | 97 | 13 | 2538 | 4282 | 85 | 1390 | 97 | 2055 |
| 129 | 1527 | 4578 | 2810 | 20 | $\bigcirc 9$ | 12 | 2442 | 4428 | 82 | . 167 | 84 | 1600 |
| 130 | 1394 | 4374 | 3445 | 22 | 99 | 14 | 3117 | 4197 | 8 C | 2.47 | 52 | 2268 |
| 121 | 13? | 4341 | 2506 | 22 | 98 | 14 | 2112 | 4206 | 72 | 1495 | 53 | 2727 |
| 132 | 1370 | 4415 | 26\% | 22 | 38 | 14 | 2250 | 4106 | 87 | 1205 | 54 | : 350 |
| 133 | 1237 | 4225 | 2380 | 22 | 98 | 11 | 1980 | 4037 | $\bigcirc 0$ | 1071 | 42 | 1 185 |
| 134 | 14:? | 4417 | 2941 | 20 | 99 | 10 | 2500 | 4165 | $\bigcirc 3$ | 1458 | 35 | 1773 |
| 135 | 1376 | 4396 | 3175 | 21 | 99 | 12 | 2793 | 4164 | 83 | 1805 | 50 | 2019 |
| 136 | 1346 | 4347 | 3197 | 20 | 99 | 11 | 2732 | 4016 | 81 | 1720 | 81 | 1762 |


| $A$ | $P_{C}$ | $N^{\prime}$ | $P_{C}$ | $N^{\prime \prime}$ | $N_{O}$ | $N_{C}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 128 | 6.09 | 21.8 | 5.08 | 26.4 | 25.3 | 28.4 |
| 129 | 7.07 | 21.4 | 5.74 | 30.2 | 28.2 | 30.9 |
| 130 | 5.80 | 24.2 | 4.41 | 27.5 | 26.7 | 28.6 |
| 131 | 7.04 | 18.4 | 2.71 | 34.5 | 28.2 | 31.2 |
| 132 | 7.65 | 22.6 | 4.71 | 27.8 | 26.3 | 28.4 |
| 133 | 9.47 | 20.4 | 4.16 | 30.3 | 27.3 | 28.9 |
| 134 | 1.2 .7 | 20.6 | 4.77 | 28.4 | 26.1 | 27.2 |
| 135 | 7.91 | 22.9 | 4.47 | 29.7 | 27.8 | 30.0 |
| 136 | 10.4 | 21.7 | 4.49 | 27.9 | 26.0 | 28.0 |

AIDR 2

| $A$ | $\geq$ | C | D | $E$ | $F$ | $\bigcirc$ | Hi | $I$ | J | $K$ | 亡 | ii |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 1292 | 4315 | 2912 | 28 | 100 | 27 | 2152 | 3975 | 83 | 580 | 126 | 2110 |
| 8 | 1363 | 4923 | 3760 | 25 | 100 | $\therefore 0$ | 3060 | 4211 | 92 | 12.73 | 124 | 2204 |
| 15 | 1403 | 4501 | 3559 | 21 | 98 | 30 | 2661 | 4205 | 87 | 1274 | 94 | 2473 |
| 23 | 1275 | 4273 | 3080 | 36 | 98 | 2.5 | 2223 | 4320 | 82 | 695 | 127 | 2384 |
| 26 | 1295 | 4265 | 3494 | 22 | 100 | 32 | 2711 | 4018 | 83 | 1179 | 127 | 2287 |
| 36 | 1452 | 4959 | 3341 | 20 | 98 | 17 | 2538 | 4278 | 82 | 945 | 145 | 2373 |
| 49 | 1278 | $42 ? 1$ | 3504 | 23 | 98 | 20 | 2635 | 4057 | 78 | 983 | 111 | 2178 |
| 60 | 1450 | 4420 | 3468 | 22 | 98 | 26 | 2691 | 4117 | 80 | 1294 | 79 | 2445 |
| 77 | 1320 | 4315 | 3237 | 20 | 100 | 23 | 2483 | 4094 | 84 | 558 | 188 | 19.3 |
| 81 | 1367 | 4253 | 3229 | 18 | $9 ?$ | 23 | 2474 | 3951 | 74 | 270 | 234 | 1590 |


| $A$ | $O$ | $F$ | $R$ | $R$ | $S$ | $T$ | $U$ | $V$ |
| ---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 1363 | 4375 | 28 | 64 | 4317 | 57 | 90 | 3861 |
| 8 | 1270 | 4344 | 27 | 62 | 4300 | 61 | 90 | 3703 |
| 15 | 1370 | 4365 | 21 | 67 | 4289 | 62 | 74 | 3334 |
| 23 | 1455 | 4506 | 36 | 67 | 4192 | 61 | 85 | 3693 |
| 26 | 1454 | 4436 | 22 | 58 | 4396 | 51 | 82 | 4043 |
| 36 | 1351 | 4028 | 20 | 73 | 3963 | 61 | 84 | 3457 |
| 47 | 1351 | 4398 | 22 | 67 | 4327 | 58 | 81 | 3766 |
| 60 | 1291 | 4152 | 22 | 63 | 4077 | 52 | 72 | 3623 |
| 77 | 1273 | 4416 | 19 | 76 | 4352 | 61 | 96 | 3712 |
| 81 | 1389 | 4314 | 18 | 68 | 4250 | 53 | 88 | 3498 |


| , | , | NA' | $N B^{\prime}$ | $P^{\prime \prime}$ | NA" | $N B^{\prime \prime}$ | NA | NBC | No | Pc' | Pc | MAc | NBC | NC |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 8 | 8.05 | 12.9 | 4. 49 | 7. 49 | 16.3 | 5. 24 | 15 | 5.00 | 20. |  |  | NAC | 5.50 | 22 |
| 8 | 10.0 | 12.0 | 4. 58 | 8.51 | 15.1 | 5.60 | 14 | 5.31 | 19. | 8.51 | $8.01$ | $15$ | $\begin{aligned} & 5.50 \\ & 5.80 \end{aligned}$ | $\begin{aligned} & 22 \\ & 21 \end{aligned}$ |
| 15 | 8.56 9.80 | 10.8 4.57 | 4.86 8.82 | 6.61 | 17.0 | 4.94 | 14.6 | 6 | 1 | 7.80 | 6. 23 | 15 | 5.27 | 20 |
| 26 | 6.99 | 11.4 | 4.02 | 7.30 | 15.6 | 5.35 4.49 |  |  | 19 | 8 | 6.77 -80 | 14 | 7. 25 | 21 |
| 6 | 13.5 | 10.1 | 5.38 | 7.59 | 16.5 | 5 |  | 5 | 19.5 | 0.03 |  | 15.6 | 77 | 20 |
|  | 12 | 9.72 | 4.77 | 7.85 | 15 | 5. 47 | 13 |  | 19. | 11 | 7.41 | 14 | 5. 66 |  |
|  | 54 | 12.2 | 4.96 | 6.66 | 16.6 | 5.26 | 15.0 | 5.15 | 20.2 | 7.81 | 6. 34 | 16 | 5.66 5.99 | 21 |
|  | 937 | 11.6 | 5. 74 | 9.17 | 15.5 | 5.82 | 14.4 | 6.08 | 20.5 | 7.40 | 8.91 | 16.3 |  |  |
|  | 9.38 | !2.8 | 5.64 | 10.5 | 14.8 | 5.60 | 14.3 | 5.67 | 20.0 | 6.92 | 9.56 | 16 | 5. 54 | 23 |

The caption headings " $A$ " through " $V$ " refer to the sample test sheet as before. $P^{\prime}$ and $P^{\prime \prime}$ are the first and second phase firepowere not taking into account the charcoal remaining at the end of the test, while $P_{c}$ and $P_{c}$ are the first and second phase firepowers taking the charcoal into account. $N A^{\prime}, N B^{\prime}, N A^{\prime \prime}$, and $N B^{\prime \prime}$ are the first and second phase efficiencies for pots $A$ and $B$ not taking the remaining charcoal into account. $N A_{0}, N B_{O}$, and $N_{0}$ are the average pot $A$, pot $B$ and total efficiencies over the entire test not taking the charcoal into accounc. $P_{c}$ and $P_{c}$ are the first and second phase firepowers where the charcoal remaining at the end of the test is divided into two equal parts and subtracted from each phase. $N A_{C}, N B_{C}$, and $N c$ are the total (both phases) pot $A$, pot $B$ and the total (sum of pot $A$ and pot B) efficiencies (or $\mathrm{PHU}_{C}$ ) when the quantity of charcoal remaining at the end of the test is taken into accounc.

| A | 2 | $\bigcirc$ | 2 | E | F | $\cdots$ | 1 | I | J | $\because$ | L. | i: |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | 1350 | 4752 | 3574 | 2.2 | 100 | 24 | 2783 | 4504 | 90 | 1593 | 168 | 2846 |
| 17 | 1350 | 4251 | 5242 | 21 | 100 | 28 | 2536 | 3890 | 63 | 1006 | 193 | 2140 |
| 11 | 1353 | 4427 | 3441 | 24 | 100 | 19 | 2882 | 4246 | 80 | 1517 | 18: | 2525 |
| 28 | 1416 | 1479 | 3564 | 20 | 98 | 28 | 2746 | 4195 | 33 | 1365 | 216 | 2445 |
| 38 | 1348 | 4480 | 3477 | 20 | 98 | 23 | 2616 | 4268 | 81 | 126 \% | 178 | 23?8 |
| 52 | 1278 | 4332 | 3334 | 21 | 100 | 23 | 2506 | 4155 | 75 | 796 | 336 | 2335 |
| 54 | 1453 | 1470 | 3213 | 29 | 97 | 27 | 2492 | 4196 | 82 | 1115 | 222 | 23 ? 7 |
| 74 | 1317 | $420 ?$ | 3050 | 20 | 98 | 26 | 2286 | 3930 | 75 | 876 | 194 | 2106 |
| 87 | 1272 | +275 | 3102 | 24 | 98 | 17 | 2735 | 4167 | 83 | 1255 | 248 | 2350 |
| 95 | 1265 | $43: 7$ | 3549 | 22 | 98 | 30 | 2672 | 4014 | 83 | 1227 | 201 | 2323 |


| $\dot{A}$ | Q | $E$ | 2 | $R$ | $S$ | $T$ | $U$ | $V$ |
| ---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | 1451 | 4527 | 22 | 71 | 4462 | 68 | 86 | 3898 |
| 17 | 1273 | 4169 | 21 | 66 | 4086 | 43 | 88 | 3458 |
| 11 | 1275 | 4215 | 24 | 57 | 4182 | 52 | 82 | 3653 |
| 28 | 1353 | 4445 | 20 | 61 | 4397 | 59 | 83 | 3927 |
| 38 | 1414 | 4307 | 22 | 66 | 4247 | 61 | 81 | 3636 |
| 52 | 1450 | 4562 | 21 | 77 | 4468 | 65 | 95 | 3717 |
| 64 | 1410 | 4508 | 24 | 62 | 4464 | 57 | 90 | 3952 |
| 74 | 1396 | 4389 | 20 | 68 | 4304 | 61 | 83 | 3360 |
| 89 | 1319 | 4296 | 24 | 60 | 4248 | 58 | 90 | 3561 |
| 95 | 1344 | 4307 | 22 | 66 | 4231 | 61 | 83 | 3665 |


| A | P | NA' | NB' | P' | NA." | NE" | NAO | NBo | No | $P_{C}{ }^{\prime}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | 9. 42 | 12 | 5.73 | 5.67 | 19 | 7.30 | 16 | 6.71 | 23 |  |
| 17 | 7.21 | 14.7 | 6.02 | 7. 29 | 16.6 | 7.91 | 16.0 | 6.97 | 22 | 5.5 |
| 11 | 8.41 | 14.5 | 5.01 | 6.50 | 17.6 | 6.67 | 16 | 6.19 | 22 |  |
| 28 | 8. 35 | 11 | 4. 55 | 6.58 | 17 | 5.78 | 15 | 5.32 | 20 | 6 |
| 8 | 10.7 | 10. | 4.53 | 6.92 | 19.2 | 7.00 | 15 | 6.0 | 21 | 8.83 |
| 52 | 10.3 | 11.0 | 6.53 | 8. 15 | 15 | 7.08 | 13 | 6.93 | 20 | 6.7 |
| 64 | 7.63 | 12 | 4.79 | 6.56 | 18.0 | 6.69 | 15 | 6.03 | 22 | 5 |
| 74 | 8.40 | 13 | 6. 05 | 6.72 | 17 | 9.93 | 15 | 8.5 | 24 | 6.6 |
| 89 | 11.2 | 12.5 | 4.83 | 7.00 | 17.0 | 7.71 | 15.6 | 6.8 | 22 | 7.69 |
| 5 | 8.35 | 12 | 4.77 | 6.87 | 16 | 6.29 | 14 | 5 | 20 | 6 |

PC" NAC $\because Z C$ Nc

|  | 19 |  |  | 8 | 25 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 5 | 18 | 7 | 8 | 17 | 26 |  |
| 77 | 19 | 9 | 7 | 3 | 2 |  |
| 71 | 18 | 3 | 6 | 3 |  |  |
| 70 | 18 | 1 | 6 | 9 | 25 |  |
| 79 | 17 | 7 | 8 | 9 | 26 |  |
| 67 | 19 | 7 | 7 | 35 |  |  |
| 9 | 18 | 8 |  |  |  |  |
| 0 | 19 | 4 | 8 |  | 2 |  |
| . 74 | 18 | 4 | 7 | 1 |  |  |

## CATRU

| A | E | $\because$ | 5 | $\Xi$ | F | G | !! | I | J | i | L | 0 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 117 | 2207 | 5157 | 3612 | 22 | $9 \%$ | 25 | 2940 | 4867 | 79 | 1167 | 103 |  |
| 118 | 2201 | 5208 | 3072 | 22 | 97 | 18 | 2403 | 4987 | 82 | 1167 775 | 155 | 4613 4382 |
| 119 | 2104 | 5484 | 3225 | 24 | 98 | 20 | 2512 | 5277 | 83 | 531 | 136 | 4221 |
| 120 | 22E5 | 5505 | 3534 | 22 | 99 | 22 | 2789 | 5370 | 03 | 1272 | 116 | 3349 |
| 121 | 2203 | $\therefore 400$ | 3378 | 22 | 99 | 20 | 2687 | 4842 | 77 | 973 | 150 | 2336 |
| 124 | 2201 | 5541 | $324 \%$ | 20 | 99 | 24 | 2562 | 5256 | 8 3 | 959 | 144 | 3281 |
| 125 | 2227 | 5282 | 3601 | 24 | 98 | 23 | 3147 | 5031 | 84 | 1905 | 111 | 3403 |
| 126 | 2275 | 5538 | 3670 | 20 | 99 | 23 | 2961 | 5278 | 78 | 1570 | 126 | 3.56 |


| A | 0 | $\Xi$ | 2 | $R$ | S | $T$ | U | V |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 117 | 2287 | 5308 | 22 | 45 | 5269 | 42 | 81 | 4432 |
| 118 | 2279 | 5281 | 23 | 48 | 5236 | 45 | 61 | 9103 |
| 119 | 2282 | 5514 | 24 | 48 | 5473 | 47 | 7 | 5156 |
| 120 | 2178 | 5488 | 22 | 54 | 5435 | 51 | 78 | 4093 |
| 121 | 2274 | 5200 | 22 | 44 | 5161 | 41 | 70 | 4759 |
| 124 | 2277 | 5521 | 20 | 44 | 5476 | 41 | 89 | 4879 |
| 125 | 2218 | 5155 | 24 | 49 | 5120 | 45 | 90 | 4547 |
| 126 | 2179 | 5372 | 20 | 47 | 5330 | 30 | 73 | 4987 |

$A \quad F^{\prime} M^{\prime} N B^{\prime} P^{\prime \prime} N A^{\prime \prime} N B^{\prime \prime}$ HAO NBO NO PC'

| 117 | 7.61 | 19.1 | 3.32 | 8.47 | 2.61 | 7.79 | 5.73 | 6.58 | 12.3 | 6.62 |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | 18 | 10.9 | 12.4 | 3.52 | 7.76 | 5.61 | 9.88 | 7.63 | 7.99 | 15.6 | 10.2 |
| 1 | 19 | 10.2 | 12.1 | 3.41 | 9.44 | 7.61 | 3.29 | 8.80 | 3.32 | 12.1 | 8.56 |
| 120 | 9.68 | 10.5 | 9.39 | 7.23 | 18.3 | 5.25 | 15.8 | 4.96 | 20.7 | 8.41 |  |
| 121 | 10.2 | 18.8 | 2.92 | 8.17 | 15.5 | 4.27 | 16.4 | 3.88 | 20.3 | 8.35 |  |
| 124 | 8.18 | 19.8 | 3.63 | 7.64 | 17.0 | 7.24 | 16.3 | 6.16 | 22.5 | 6.73 |  |
| 125 | 6.76 | 16.2 | 4.39 | 6.39 | 16.7 | 8.00 | 16.6 | 6.96 | 23.5 | 5.59 |  |
| 126 | 8.81 | 13.7 | 3.73 | 6.63 | 18.4 | 5.12 | 16.8 | 4.65 | 21.4 | 7.49 |  |

Po" NAC IOC Mc
$8.05 \quad 6.17 \quad 7.08 \quad 13.2$
$7.53 \quad 7.95 \quad 8.3216 .3$
$8.89 \quad 9.62 \quad 3.6313 .2$
$\begin{array}{lllll}6.76 & 17.3 & 5.93 & 22.7\end{array}$
7. $5618.4 \quad 4.33 \quad 22.7$
$7.0618 .3 \quad 6.89 \quad 25.2$
$\begin{array}{lllll}5.95 & 18.9 & 7.73 & 26.1\end{array}$
$\begin{array}{lllll}6.12 & 18.7 & 5.17 & 23.9\end{array}$

KAYA 2

| $\therefore$ | $\Xi$ | 5 | 0 | $E$ | $\square$ | O | 11 | I | J | K | L | $i$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1398 | 4531 | 3124 | 31 | 100 | i 2 | 2007 | 4097 | 84 | 885 | 81 | 2730 |
| 9 | 1393 | 4304 | 3277 | 26 | 100 | 35 | 2320 | 3925 | 87 | 618 | 145 | 2408 |
| 16 | 1354 | 4497 | 3358 | 22 | 100 | 25 | 2229 | 4262 | 84 | 546 | 159 | 2625 |
| 18 | 1270 | 9256 | 3417 | 20 | 98 | 35 | 2152 | 3879 | 72 | 792 | 105 | 2378 |
| 27 | 1323 | 4342 | 3351 | 20 | 98 | 45 | 2157 | 3933 | 79 | 350 | 155 | 2246 |
| 46 | 1373 | 4316 | 3533 | 29 | 98 | 42 | 2250 | 3843 | 81 | 307 | 154 | 2333 |
| 57 | 1347 | 4359 | 3780 | 21 | 100 | 29 | 2355 | 4033 | 77 | 486 | 233 | 2243 |
| 73 | 1272 | 4370 | 3047 | 18 | 100 | 37 | 1710 | 3940 | 78 | 255 | 153 | 2219 |
| 86 | 17.84 | 4297 | 3550 | 21 | 98 | 28 | 2249 | 3925 | 78 | 863 | 115 | 2301 |
| 97 | 140? | 4507 | 3494 | 21 | 98 | 61 | 2067 | 3527 | 70 | 1050 | 20? | 2339 |


| $A$ | $C$ | $P$ | $Q$ | $R$ | $S$ | $T$ | $U$ | $V$ |
| ---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 3 | 1280 | 4420 | 31 | 71 | 4309 | 68 | 76 | 3974 |
| 9 | 1276 | 4206 | 25 | 67 | 4115 | 65 | 83 | 3520 |
| 16 | 1270 | 4257 | 24 | 84 | 4118 | 75 | 86 | 3436 |
| 18 | 1450 | 4430 | 23 | 77 | 9231 | 65 | 72 | 3709 |
| 27 | 1400 | 4546 | 19 | 71 | 4447 | 64 | 89 | 3807 |
| 46 | 1449 | 4340 | 24 | 76 | 1176 | 68 | 75 | 2693 |
| 57 | 1316 | 4345 | 21 | 87 | 4165 | 64 | 88 | 3450 |
| 73 | 1272 | 4362 | 18 | 86 | 4197 | 72 | 84 | 3529 |
| 86 | 1390 | 4301 | 22 | 77 | 4118 | 65 | 72 | 3582 |
| 97 | 1341 | 4472 | 21 | 62 | 1324 | 59 | 76 | 3960 |


|  |  |  | NB |  |  |  |  |  | $\bigcirc$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 7.60 | 9.84 | 4.05 | 5.35 | 17 |  | 1 |  | 17.7 |  |
| 9 | 7.82 | 10.7 | 4.39 | 8.11 | 12.2 | 5.34 | 11 | 5.00 | 16.7 | 6.81 |
| 6 | 13.3 | 7.83 | 5.35 | 8.02 | 13.5 | 5.79 | 11.2 | 5.6 | 16 | 11 |
| 18 | 10.3 | 8.42 | 5.18 | 6.98 | 15.8 | 5.4 | 12 | 5. 30 | 17 | 9.60 |
| 27 | 7. 58 | 9.33 | 4 | 8.42 | 13.3 | 5.82 | 11.7 | 5.2 | 16 | 6.75 |
| 6 | 8.73 | 8. | 9.54 | 6 | 4 | 13 | 11.9 | 9. |  | 7.85 |
|  | 14 | 7.08 | 5. 10 | 8.90 | J | 5.? 3 | 10.7 | 5. 5 | 10 | 12 |
| 73 | 10 | 8 | 5.46 | 6.93 | 6 | 6.64 | 12.9 | 6.07 | 18 | 9.33 |
| 85 | 13 | 8.00 | 86 | 6.60 | 6 | 5.43 | 12.3 | 5. 15 | 17 | 12 |
| 7 | 6.69 | 13 | 3.56 | 4.75 | 7 | 6. 05 | 14.8 | 4. 58 | 19. | 5.8 |


|  | ${ }^{\text {c }}$ | $\mathrm{NA}_{c}$ |  | ${ }^{1}{ }_{c}$ | c |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | 02 | 14 | 3 | 53 | 18 |
|  | 52 | 12 | 9 | 5. 51 | 18 |
|  | 38 | 12 | 4 | 6.20 | 18 |
|  | 05 | 13 | 1 | 558 | 18 |
|  | 7 ? | 12 | 8 | 70 | 18 |
|  | 29 | 13 | 2 | 10 | 23 |
|  | 97 | 12 | 1 | 6.33 | 18 |
|  | 32 | 14 | 2 | 6.69 | 20 |
|  | 14 | 13 | 3 | 5. 56 | 18 |
|  | 92 | 17 | 3 | 5. 36 | 2 |

NOUNA 2

| $\therefore$ | 三 | $\square$ | . | E | $\stackrel{\square}{ }$ | $1 ;$ | ! 1 | I | S | K | L | $\therefore$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 4 | 1454 | 4575 | 3553 | 26 | 100 | 33 | 2595 | 4314 | 88 | 851 | 0 | 2597 |
| 13 | 1454 | 4407 | 3663 | 22 | 98 | 29 | 2928 | 4417 | 94 | 1202 | 162 | 2384 |
| 17 | 1450 | 4502 | 3612 | 22 | 98 | 44 | 269 ¢ | 4084 | 76 | 1231 | 86 | 2384 |
| 31 | 1370 | 4356 | 3408 | 20 | 100 | 30 | 2545 | 4026 | 74 | 901 | 124 | 2307 |
| 51 | 1462 | 4920 | 3174 | 21 | 98 | 22 | 2454 | 4203 | 80 | 710 | 13 ? | 2440 |
| 56 | 1280 | 4387 | 3445 | 22 | 78 | 27 | 2320 | 4137 | 79 | 1177 | 119 | 2579 |
| 75 | 1395 | 4413 | 3554 | 20 | 97 | 25 | 2655 | 4135 | 87 | 1175 | 140 | 2368 |
| 88 | 1290 | 4332 | 3517 | 25 | 98 | 20 | 2737 | 4127 | 81 | 1309 | $11 \%$ | 2524 |
| 94 | 1358 | 4426 | 3571 | 20 | 97 | 22 | 2865 | 4198 | 77 | 1269 | 174 | 2541 |
| 102 | 1391 | 4420 | 3554 | 20 | 99 | 30 | 2775 | 4108 | 78 | 1361 | 101 | 2474 |


| $A$ | 0 | $\bar{\square}$ | 2 | R | S | T | U |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 4 | 1324 | 4500 | 26 | 72 | 4393 | 08 | 92 | 3686 |
| 13 | 1914 | 4392 | 22 | 63 | 4394 | 57 | 87 | 3632 |
| 17 | 1318 | 4494 | 22 | 78 | 4372 | 61 | 83 | 3393 |
| 31 | 1330 | 4285 | 19 | 65 | 4214 | 57 | 98 | 3486 |
| 51 | 1344 | 4421 | 21 | 64 | 4381 | 59 | 84 | 3770 |
| 66 | 1346 | 4384 | 23 | 70 | 4320 | $\bigcirc 3$ | 83 | 3746 |
| 76 | 1362 | 4446 | 20 | 58 | 4359 | 66 | 82 | 3826 |
| 88 | 1295 | 4338 | 24 | 66 | 4279 | 64 | 84 | 3607 |
| 94 | 1388 | $450 \%$ | 20 | 68 | 4446 | 59 | 89 | 3796 |
| 102 | 1286 | 4335 | 20 | 63 | 4271 | 58 | 78 | 3786 |

$A \quad E^{\prime} \quad \because A ' \quad!E \prime$ P' NA" NE" NAO NBO No PC'

| , | 8. 30 | 11.0 | 5.19 | 8.31 | 5 | 7 | 12.6 | 5.95 | 18.5 | 8 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 13 | 7.24 | 3.11 | 4.91 | 8.22 | 15.7 | 5.68 | 13.7 | 6.15 | 19.7 | 5 |
| 19 | 5.93 | 12.2 | 6.51 | 6.99 | 16.2 | 9.90 | 14.7 | 8. 60 | 23 | 5 |
| 31 | 8. 22 | 12.0 | 4.93 | 7.83 | 14.8 | 7.59 | 13.8 | 6.67 | 20 | 7 |
| 51 | 9.61 | 11.4 | 5.07 | 7.36 | 15.8 | 6.41 | 14.4 | 5.98 | 20 | 8 |
| 66 | 11.9 | 8.05 | 3.85 | 5.35 | 17.5 | 8. 03 | 13.8 | 5.94 | 9.7 | 10 |
| 75 | 10.3 | 10.5 | 4.46 | 7.05 | 16.3 | 5.54 | 14.1 | 5.13 | 9. 2 |  |
| 88 | 11 | 10.4 | 4.99 | 6.80 | 15.6 | 7.22 | 13.8 | 6.43 | 20 | 9 |
| 94 | 10.5 | 10.9 | 5. 53 | 7.60 | 14.5 | 6.77 | 13.3 | 6.35 | 19.7 | 8 |
| 102 | 7.92 | 12.8 | 5.19 | 6.74 | 16.2 | 5.55 | 15.0 | 5.42 | 20 | 6 |

Pc" $\because A C$ $\because B C$ Nc

| 8.31 | 12.6 | 5.95 | 18.5 |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 7.57 | 15 | 4 | 6.92 | 22 | 4 |
| 6.65 | 15.6 | 9.16 | 24.8 |  |  |
| 7.33 | 15.1 | 7.28 | 22.4 |  |  |
| 6.80 | 16.0 | 6.67 | 22.7 |  |  |
| 4.87 | 15.1 | 6.52 | 21.7 |  |  |
| 6.48 | 15.7 | 5.70 | 21.4 |  |  |
| 6.33 | 15.1 | 7.07 | 22.2 |  |  |
| 6.90 | 15.2 | 7.24 | 22.4 |  |  |
| 6.33 | 16.3 | 5.88 | 22.1 |  |  |


| $A$ | 3 | 9 | D | E | F | C | H | $I$ | J | $K$ | I | $\because$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 10 | 1460 | 4154 | 3032 | 24 | 98 | 30 | 2311 | 3792 | 78 | 568 | 152 | 2119 |
| 14 | 1355 | 4492 | 3212 | 21 | 100 | 23 | 2422 | 4293 | 85 | 953 | 140 | 2702 |
| 21 | 1276 | 4519 | 3131 | 21 | 98 | 26 | 2406 | 4269 | 76 | 891 | 170 | 2377 |
| 34 | 1279 | 9461 | 3258 | 23 | 98 | 18 | 2570 | 4260 | 77 | 1136 | 121 | 2642 |
| 43 | 1397 | 4203 | 3376 | 25 | 100 | 15 | 2720 | 3962 | 75 | 242 | 350 | 1579 |
| 50 | 1366 | 4416 | 3592 | 21 | 98 | 17 | 2608 | 4205 | 78 | 1296 | 165 | 2638 |
| 63 | 1298 | 429? | 3206 | 22 | 98 | 30 | 2376 | 3910 | 64 | 877 | 200 | 2334 |
| 71 | 1459 | 4483 | 3195 | 19 | 98 | 25 | 2294 | 4207 | 84 | 877 | 153 | 2481 |
| 90 | 1370 | 4372 | 3272 | 24 | 99 | 23 | 2434 | 4099 | 78 | 1184 | 123 | 2525 |
| 104 | 1342 | 4339 | 3659 | 20 | 98 | 39 | 2909 | 4010 | 96 | 1597 | 142 | 2470 |


| $\hat{A}$ | $C$ | $P$ | $Q$ | $P$ | $S$ | $T$ | $U$ | $V$ |
| ---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 10 | 1397 | 4130 | 26 | 56 | 4068 | 52 | 77 | 3610 |
| 14 | 1277 | 4297 | 21 | 63 | 4252 | 57 | 81 | 3855 |
| 21 | 1354 | 4470 | 20 | 48 | 4440 | 42 | 80 | 4403 |
| 34 | 1400 | 4126 | 23 | 61 | 4079 | 52 | 83 | 3696 |
| 43 | 1293 | 4220 | 24 | 57 | 4182 | 55 | 97 | 3419 |
| 50 | 1394 | 4429 | 21 | 69 | 4378 | 62 | 76 | 3935 |
| 63 | 1398 | 4382 | 22 | 62 | 4293 | 48 | 75 | 3888 |
| 71 | 1410 | 4525 | 19 | 60 | 4466 | 56 | 76 | 4021 |
| 90 | 1357 | 4315 | 24 | 66 | 4302 | 60 | 73 | 3818 |
| 104 | 1271 | 4279 | 22 | 48 | 4245 | 45 | 68 | 3937 |


|  |  | $\cdots$ | NB | $P^{\prime}$ | NA" | NB' | NAO | NBo | No | Pc' |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 10 | 6.87 | 13.4 | 3. 91 | 8. 30 | 13 | 4.40 | 1 | 4.25 | 17.6 | 5. 65 |
| 14 | 9.82 | 11.0 | 4. 67 | 7.00 | 15.0 | 4. 75 | 13.6 | 9. 72 | 18.3 | 8. 35 |
| 2 | 7.97 | 12.9 | 3.48 | 7.22 | 17. | 2.21 | 16 | 2.62 | 18 | 6. 39 |
| 34 | 10.9 | 12.3 | 4.57 | 6.53 | 15. | 4.93 | 14 | 4.82 | 19.6 | 9.30 |
| 43 | 12.5 | 12.7 | 4.57 | 11.8 | 13. | 5. 25 | 13. | 5.11 | 18 | 6.86 |
| 50 | 16.5 | 8.65 | 4.29 | 6.25 | 16.8 | 5. 23 | 13 | 4.83 | 18 | 14.2 |
| 63 | 7.91 | 12.9 | 4.92 | 7.14 | 15.3 | 4.83 | 14 | 9. 86 | 19.3 | 6.30 |
| 71 | 10.2 | 10.6 | 4.37 | 6.75 | 16.7 | 5.19 | 14. | 4.87 | 19.2 | 8.71 |
| 90 | 10.9 | 10.8 | 3.82 | 5.95 | 17.7 | 5.85 | 15.0 | 5.04 | 20.0 | 9.12 |
| 04 | 5.50 | 13 | 3.14 | 6.25 | 16.1 | 4.37 | 15. | 3.92 | 19.0 | 4.62 |

PC" IVAC NEC NC

| 7.69 | 14.9 | 4.75 | 19.6 |
| :--- | :--- | :--- | :--- | :--- |
| 6.43 | 15.2 | 5.27 | 20.5 |
| 6.53 | 18.4 | 3.01 | 21.4 |
| 6.34 | 16.3 | 5.33 | 21.7 |
| 10.4 | 16.2 | 6.30 | 22.5 |
| 5.59 | 15.1 | 5.49 | 20.6 |
| 6.34 | 16.9 | 5.69 | 22.6 |
| 6.13 | 16.2 | 5.49 | 21.7 |
| 5.46 | 16.6 | 5.59 | 22.2 |
| 5.68 | 17.1 | 4.44 | 21.5 |

## TITAO

| $A$ | $\Xi$ | $C$ | D | E | F | G | H | I | J | K | I | M |
| ---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 67 | 1392 | 4436 | 4555 | 22 | 98 | 43 | 2990 | 3952 | 80 | 384 | 452 | 2054 |
| 70 | 1348 | 4390 | 4341 | 19 | 98 | 50 | 2471 | 3727 | 79 | 782 | 268 | 2283 |
| 83 | 1359 | 4462 | 3535 | 19 | 98 | 50 | 1701 | 3922 | 74 | 386 | 287 | 2585 |
| 92 | 1462 | 4535 | 3719 | 22 | 93 | 30 | 2334 | 4093 | 78 | 721 | 323 | 2866 |
| 93 | 1285 | 4329 | 4600 | 18 | 98 | 55 | 2385 | 3605 | 78 | 90 | 517 | 1598 |
| 109 | 1450 | 4522 | 3595 | 24 | 98 | 45 | 2425 | 3985 | 81 | 939 | 278 | 2994 |
| 100 | 1449 | 4424 | 3495 | 25 | 99 | 37 | 2541 | 4173 | 78 | 795 | 269 | 3092 |
| 101 | 1388 | 4408 | 4199 | 21 | 95 | 55 | 2473 | 3809 | 80 | 444 | 288 | 2358 |
| 112 | 1285 | 4130 | 4698 | 23 | 98 | 53 | 2748 | 3436 | 79 | 1357 | 267 | 2236 |
| 113 | 1448 | 4478 | 3984 | 20 | 92 | 60 | 2052 | 3845 | 72 | 407 | 323 | 2612 |


| $A$ | $O$ | $=$ | $Q$ | $P$ | $S$ | $T$ | $U$ | $V$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 67 | 1458 | 4446 | 22 | 68 | 4317 | 63 | 92 | 3690 |
| 70 | 1450 | 4519 | 19 | 68 | 4167 | 59 | 68 | 3745 |
| 83 | 1406 | 4522 | 22 | 74 | 4318 | 58 | 65 | 3969 |
| 92 | 1397 | 4423 | 22 | 69 | 4313 | 68 | 68 | 3953 |
| 93 | 1272 | 4225 | 18 | 78 | 3936 | 68 | 86 | 3186 |
| 109 | 1278 | 4339 | 24 | 63 | 4435 | 50 | 68 | 4147 |
| 100 | 1361 | 4429 | 25 | 57 | 4362 | 47 | 63 | 4060 |
| 101 | 1341 | 4348 | 22 | 66 | 4176 | 59 | 66 | 3648 |
| 112 | 1312 | 4228 | 24 | 72 | 4039 | 65 | 65 | 3615 |
| 113 | 1359 | 4319 | 20 | 67 | 4075 | 62 | 69 | 3631 |


| A | $p^{\prime}$ | NA' | NB' | P' | NA" | NB" | NA | N | No | Pc' |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 67 | 10.4 | 7.68 | 3. 23 | 12.4 | 10.0 |  |  | 3.68 | 12.8 |  |
| 70 | 10.7 | 7.81 | 4.44 | 8. 05 | 11.7 | 3.65 | 9.76 | 4.00 | 13.8 | 7.86 9.39 |
| 83 | 10.5 | 7.14 | 3.62 | 6.26 | 14.5 | 3.88 | 10.2 | 3.73 | 14.0 |  |
| 92 | 13. 2 | 8.05 | 3. 55 | 7.68 | 10.6 | 2.9 | 9.43 | 3.22 | 12.7 | 10 |
| 93 | 11.5 | 6.99 | 3. 67 | 10.9 | 12.0 | 4.82 | 9.55 | 4.25 | 3.8 | 9.24 |
| 09 | 7.43 | 10.8 | 1. 41 | 7.08 | 9. 50 | 3.49 | 10.1 | 2.57 | 12.6 | 5.94 |
| 100 | 6.98 | 9.60 | 3.63 | 8. 32 | 8.96 | 2.95 | 9.18 | 3.18 | 12 | 5.23 |
| 101 | 8.97 | 7.73 | 3.18 | 9.67 | 9.86 | 3.67 | 8. 88 | 3.45 | 12.3 | 7.70 |
| 112 | 10.5 | 7.36 | 3.03 | 6.63 | 12.1 | 4.02 | 7. 33 | 3.44 | 12.8 | 9.30 |
| 113 | 9. 20 | 7.07 | 3.42 | ?. 84 | 10.6 | 3.84 | 8. 69 | 3.61 | 12.3 | 7.90 |

Pc" VAc NEC Nc

|  |  |  |  |
| :---: | :---: | :---: | :---: |
| 6.97 | 11. 2 | 4.59 | 15.8 |
| 5.11 | 12 | 4.9 | 16 |
| 38 | 1 | 3 |  |
| 85 | 11.8 | 5.28 | 17 |
| 6 | 12 | 3. 12 |  |
| 23 | 11 | 3.8 |  |
| 5 | 10.2 | 3.7 |  |
| 5 | 10 | $3 . ?$ |  |
| . 4 | 0 |  |  |

AIDR 3

| $\therefore$ | E | 3 | $\bigcirc$ | $\pm$ | 5 | 9 | $1 i$ | I | $J$ | $\because$ | L | $\cdots$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 5 | 14.4 | 4457 | 3112 | 27 | 100 | 27 | 2161 | 4241 | 35 | 397 | 160 | 2466 |
| 12 | 1377 | 4890 | 3774 | 21 | 98 | 23 | 2610 | 4303 | 82 | 91 | 223 | $164 \%$ |
| 24 | 1414 | 4456 | 3340 | 26 | 99 | 18 | 2491 | 4266 | 82 | 878 | 163 | 2457 |
| 27 | 1463 | 4531 | 3957 | 20 | 98 | 18 | 3175 | 4354 | 77 | 1225 | 188 | 2380 |
| 41 | 1462 | 4203 | 2392 | 20 | 98 | 20 | 2532 | 4047 | 89 | 151 | 294 | 1312 |
| 56 | 1282 | 4310 | 4374 | 22 | 98 | 15 | 3284 | 4095 | 80 | 896 | 267 | 1726 |
| 65 | 1322 | 4297 | 3249 | 24 | 99 | 15 | 2310 | 4069 | 70 | 318 | 192 | 1912 |
| 80 | 1352 | 4415 | 3921 | 20 | 98 | 30 | 2857 | $\bigcirc 023$ | 76 | 912 | 211 | 2032 |
| 91 | 1447 | 4423 | 3256 | 22 | 99 | 30 | 2289 | 402.9 | 30 | 565 | 128 | 2135 |
| 108 | 1392 | 4398 | 3786 | 23 | 98 | 21 | 3081 | 4250 | 84 | 1385 | 205 | 2315 |


| $A$ | 0 | $P$ | $Q$ | $R$ | $S$ | $T$ | $U$ | $V$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 5 | 1270 | 4371 | 27 | 61 | 4328 | 61 | 31 | 3857 |
| 12 | 1408 | 4354 | 21 | 67 | 4278 | 62 | 84 | 3523 |
| 24 | 1317 | 4343 | 25 | 57 | 4308 | 55 | 75 | 3927 |
| 29 | 1350 | 9411 | 20 | 49 | 4385 | 46 | 82 | 3973 |
| 41 | 1395 | 4416 | 20 | 49 | 4385 | 48 | 82 | 3831 |
| 56 | 1398 | 4395 | 22 | 68 | 4399 | 52 | 92 | 3586 |
| 65 | 1348 | 4365 | 23 | 62 | 4307 | 53 | 82 | 3703 |
| 80 | 1295 | 4332 | 20 | 55 | 4275 | 49 | 76 | 3814 |
| 71 | 1450 | 4540 | 23 | 55 | 4465 | 50 | 68 | 4028 |
| 108 | 1412 | 4445 | 24 | 47 | 4421 | 46 | 72 | 4103 |


| $A$ | $X$ | $\because$ | $Z$ | $A A$ | $A B$ | $A C$ | $A D$ | $A E$ |
| ---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 5 | 1660 | 4664 | 27 | 43 | 4636 | 41 | 63 | 4446 |
| 12 | 1649 | 4959 | 22 | 47 | 4017 | 45 | 72 | 4561 |
| 24 | 1660 | 4680 | 26 | 43 | 4654 | 42 | 59 | 4493 |
| 29 | 1535 | 4648 | 20 | 38 | 4622 | 36 | 61 | 4449 |
| 41 | 1532 | 4665 | 20 | 36 | 4646 | 34 | 68 | 4408 |
| 56 | 1661 | 4588 | 22 | 46 | 4559 | 38 | 72 | 4227 |
| 65 | 1647 | 4345 | 23 | 44 | 4309 | 41 | 63 | 4059 |
| 80 | 1533 | 4659 | 20 | 40 | 4616 | 38 | 61 | 4394 |
| 91 | 1660 | 4697 | 23 | 43 | 4646 | 39 | 55 | 4424 |
| 108 | 1644 | 4640 | 24 | 36 | 4622 | 35 | 54 | 4474 |

$A \quad P^{\prime} N^{\prime} N B^{\prime} N C^{\prime} \quad P^{\prime \prime} N A^{\prime \prime} N B^{\prime \prime} N^{\prime \prime}$
$\begin{array}{lllllllllll}5 & 10.1 & 8.69 & 3.30 & 1.62 & 8.40 & 13.8 & 4.36 & 2.32\end{array}$
$1214.512 .3 \quad 3.70 \quad 2.2112 .0 \quad 14.3 \quad 4.56 \quad 2.72$
$2413.5 \quad 9.33 \quad 3.241 .88 \quad 7.6815 .44 .02 \quad 2.09$
$\begin{array}{llllllllll}29 & 12.6 & 10.3 & 3.17 & 2.16 & 9.29 & 14.1 & 4.15 & 2.13\end{array}$
$41 \quad 12.310 .0 \quad 2.95 \quad 1.7311 .312 .64 .1122 .40$
$\begin{array}{llllllllll}56 & 20.8 & 7.75 & 3.64 & 1.92 & 11.4 & 13.6 & 5.42 & 2.84\end{array}$
$6517.9 \quad 9.01 \quad 3.871 .98 \quad 9.49 \quad 15.2 \quad 5.05 \quad 2.37$
$80 \quad 10.110 .3 \quad 3.141 .97 \quad 9.2714 .24 .1312 .39$
$01 \quad 9.2111 .2 \begin{array}{llllllll} & 3.51 & 2.23 & 8.21 & 15.2 & 4.11 & 2.37\end{array}$
$108 \quad 9.60 \quad 10.6 \quad 2.861 .58 \quad 8.08 \quad 15.6 \quad 3.60 \quad 1.96$
A MAO NBO NCD NO PC' FC" NAC NBC NCC NC

|  | 2. | 3.99 | 2.08 | 1 | 8.64 |  |  |  | 2. 31 | 20.1 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 12 | 13.7 | 4.2.9 | 2. 56 | 20.5 | 12.1 | 11.1 | 15.3 | 78 | 2.85 | 22 |
| 24 | 13.3 | 3.75 | 2. 01 | 19 | 11.3 | 7.03 | 15.0 | 4. 22 | 2.27 | 21.5 |
| 29 | 13.0 | 3.87 | 2.19 | 19.0 | 10 | 8.53 | 14.7 | 4.37 | 2.42 | 21 |
| 41 | 11.9 | 3.80 | 2.22 | 18.0 | 8.74 | 10.2 | 14.1 | 4.49 | 2.63 | 21.2 |
| 56 | 11.8 | 4.86 | 2.55 | 19 | 16.5 | 10 | 13.5 | 5. 5 | 2. | 22.0 |
| 65 | 13.2 | 9. 67 | 2. 24 | 20.2 | 19.8 | 8.72 | 14.9 | 5. 25 | 2. 52 | 22 |
| 80 | 12.8 | 3.78 | 2.24 | 18. | 8.44 | 8. 42 | 14.6 | 4.29 | 2. 54 | 21 |
| 91 | 13.7 | 3.89 | 2.32 | 19 | 8.18 | 7.69 | 14.9 | 4.23 | 2. 52 | 1 |
| 108 | 14.1 | 3.38 | 1.85 | 19.4 | 7.24 | 7.25 | 16.5 | 3.95 | 2.16 | 22 |



| 5 | 0 | $\bar{z}$ | 2 | $\cdots$ | S | T | U | V |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 20 | 1412 | 4535 | 22 | 68 | 3602 | 69 | 98 | $2432$ |
| 32 | 1236 | 4076 | 1 . | 51 | 4030 | 49 | 80 | 3632 |
| 53 | 1412 | 4430 | 23 | 90 | 3983 | 72 | 97 | 2783 |
| 39 | 1452 | 4473 | 22 | 76 | 4286 | 63 | 97 | 3561 |
| 75 | 1348 | 4413 | 19 | 39 | 4377 | 37 | 64 | 4081 |
| 85 | 1301 | 4307 | 22 | 82 | 4003 | 58 | 98 | 2968 |
| 36 | 1449 | 4456 | 22 | 84 | 4123 | 74 | 92 | 2040 |
| 107 | 1314 | 4431 | 20 | 62 | 4342 | 50 | 82 | 3944 |
| 110 | 1390 | 4323 | 22 | 66 | 4137 | 60 | 89 | 3536 |
| 114 | 1275 | 4275 | 22 | 71 | 4185 | 67 | 89 | 3456 |
| $\therefore$ | $\%$ | $\because$ | 2 | $A A$ | $A B$ | $\therefore \mathrm{S}$ | $\therefore \mathrm{D}$ | AE |
| 20 | 1660 | 4572 | 22 | 67 | 4297 | 59 | 74 | 3928 |
| 32 | 1652 | 4552 | 19 | 49 | 4500 | 41 | 72 | 4109 |
| 59 | 1642 | 4448 | 23 | 73 | 4209 | 6.5 | 76 | 3569 |
| 39 | 1557 | 4744 | 21 | 65 | 4614 | 58 | 81 | 4157 |
| 75 | 1667 | 4619 | 19 | 56 | 4541 | 52 | 69 | 4077 |
| 85 | 1647 | 4564 | 22 | 70 | 4422 | 58 | 92 | 3697 |
| 96 | 1639 | 4674 | 22 | 70 | 4183 | 62 | 78 | 382 u |
| 107 | 1523 | 4432 | 22 | 60 | 4341 | 44 | 74 | 3943 |
| 110 | 1533 | 4479 | 22 | 52 | 4419 | 49 | 78 | 4064 |
| 114 | 1657 | 4627 | :2 | 68 | 4548 | 64 | 60 | 4023 |


| 4 | $\because$ | $\because A^{\prime}$ | :13' | $\therefore C^{\prime}$ | $p^{\prime \prime}$ | $\because A "$ | UB' | NC" |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 20 | 11.2 | 5.06 | 6.32 | 2.73 | 9.84 | 5.41 | 3. 22 | 2.82 |  |  |
| 32 | 8.01 | 10.3 | 3. 00 | 3.04 | 9.23 | 11.1 | 3.77 | 3.77 |  |  |
| 59 | 12.0 | 6.54 | 5.16 | 3. 13 | 10.2 | 9.28 | 8.14 | 4.33 |  |  |
| 39 | 12.3 | 7.47 | 4.27 | 3.33 | 9.41 | 9.99 | 6.03 | 3.89 |  |  |
| 75 | 12.8 | 9.11 | 1.76 | 3.29 | 9. 48 | 11.0 | 2.96 | 3.67 |  |  |
| 85 | 11.6 | 7.65 | 4.74 | 3. 32 | 12.2 | 7.68 | 6.05 | 4.61 |  |  |
| 96 | 17.3 | 5.70 | 4. 22 | 4.73 | 11.5 | 8. 52 | 7.50 | 2.40 |  |  |
| 107 | 7.77 | 8.81 | 3.21 | 2.86 | 7.57 | 13.4 | 4.79 | 4.60 |  |  |
| 110 | 7.41 | 9.22 | 5.07 | 2.64 | 9.04 | 10.3 | 5.22 | 3.34 |  |  |
| 119 | 16.4 | 7.20 | 3.47 | 3.18 | 8.89 | 11.5 | 5.79 | 3.90 |  |  |
| A | $\therefore 00$ | $1!\geq 0$ | $\therefore!\mathrm{Co}$ | :10 | $P C^{\prime}$ | F':" | NAc | NBc | NCc | NC |
| 20 | 5.22 | 7. 18 | 2.77 | 15.2 | 10.5 | 9. 14 | 5.58 | 7.67 | 2.96 | 16.2 |
| 32 | 10.8 | 3. 52 | 3.53 | 17.9 | 6.39 | 8.34 | 12.4 | 4.05 | 4.06 | 20.6 |
| 59 | 7.92 | 6.66 | 3.79 | 18.3 | 10.7 | 9.12 | 8.84 | 7.44 | 4. 17 | 20.5 |
| 37 | 8.70 | 5. 27 | 3.65 | 17.8 | 10.6 | 8.51 | 9.97 | 5.90 | 4.09 | 20.0 |
| 75 | 10.3 | 2.53 | 3.54 | 16.4 | 9.94 | 0.28 | 12.3 | 3.02 | 4. 22 | 17.5 |
| 85 | 7.67 | 5.47 | 4.04 | 17.2 | 9.62 | 10.6 | $\bigcirc .00$ | 6.43 | 4.75 | 20.2 |
| 96 | 7.20 | 5.96 | 3.99 | 16.7 | 14.3 | 9.71 | 8. 62 | 7.13 | 9.17 | 19.9 |
| 107 | 11.3 | 4.06 | 3.80 | 17.1 | 6.47 | 6.48 | 13.4 | 4.80 | 4.49 | 22.7 |
| 10 | 9.87 | 5.16 | 3.21 | 18.2 | 6.11 | 8.11 | 11.3 | 5.93 | 3.69 | 21.0 |
| 14 | 9.67 | 4.92 | 3.59 | 18.2 | 13.8 | 7.85 | 11.2 | 5.68 | 4.15 | 21.0 |

## SAMPLE CONTROLLED COOKING TEST SHEET



REMARKS:

| $\therefore$ | $\Xi$ | － | $=$ | $\pm$ | $\because$ | G | H | I | u | $\because$ | L |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| ！SEL | $\cdots 3$ | －1\％ | 1347 | 100 | 400 | 300 | 50 | 2000 | 50 | 70 | 100 |
| ISBL | 113 | J：0 | 1275 | 100 | 450 | 300 | 50 | 2000 | 50 | 70 | 100 |
| 15E： | N2 | jこ： | 1275 | 100 | 450 | 300 | 50 | 2000 | 50 | 70 | 100 |
| 158： | 3 | 324 | 1320 | 100 | 450 | 300 | 50 | 2000 | 50 | 70 | 100 |
| －5日L | TRAD | Jこ5 | 1315 | 100 | 450 | 300 | 50 | 2000 | 50 | 70 | 100 |
| 153！ | MT： | $\therefore 26$ | 1516 | 100 | 450 | 300 | 50 | 2000 | 50 | 70 | 100 |
| ！S 5 | $K i$ | うこ？ | 12こ1 | 100 | 450 | 3010 | 50 | 2000 | 50 | 70 | 100 |
| 153L | A ${ }^{\text {S }}$ | うこ8 | 1230 | 100 | 450 | 300 | 50 | 2000 | 50 | 70 | 100 |
| SEL | － 3 | \21 | ここここ | 100 | 450 | 300 | 50 | 21000 | 50 | 70 | 100 |
| ：ミEL | T | 5： | 1315 | 100 | 450 | 300 | 50 | 2000 | 50 | 70 | 100 |
| ：5sL | $\square$ | 52 | 2296 | 100 | 450 | 300 | 50 | 2000 | 50 | 70 | 100 |
| AL：C | B | 57 | 1317 | 100 | 450 | 300 | 50 | 2500 | ここ | 70 | 104 |
| Mi．di | TAMD | E9 | 1407 | 100 | 450 | 300 | 50 | 2500 | 50 | 70 | 101 |
| AL： 0 | N2 | F11 | 1274 | 100 | 450 | 300 | 50 | 2500 | 50 | 70 | 100 |
| ALS | $\cdots \mathrm{T}$ | E15 | 1332 | 100 | 451 | 300 | 50 | 2500 | 51 | 70 | 100 |
| ALIU | $\therefore 3$ | E15 | 1410 | 100 | 450 | 300 | 50 | 2500 | 50 | 70 | 100 |
| Eか口！ | A3 | F 7 | 1520 | 100 | 450 | 300 | 50 | 2500 | 54 | 70 | 104 |
| CAD： | 12 | 58 | 1456 | 100 | 450 | 300 | 50 | 2500 | 50 | 70 | 100 |
| CADI | $\square$ | $F 9$ | 1393 | 100 | 450 | 300 | 50 | 2500 | 50 | 70 | 100 |
| CAD： | TRAD | 510 | 1528 | 100 | 450 | 300 | 50 | 2500 | 50 | 70 | 100 |
| CADI | MT： | F11 | 1528 | 100 | 450 | 300 | 50 | 2500 | 50 | 70 | 100 |
| CADI | E | F15 | 1495 | 100 | 150 | 300 | 50 | 2500 | 50 | 70 | 100 |
| CAD： | MTL | F15 | $13 ? 5$ | 100 | 450 | 300 | 50 | 2500 | 51 | 70 | 100 |
| CADI | N2 | 517 | 1344 | 100 | 450 | 300 | 50 | 2500 | 50 | 70 | 100 |
| TENE | MTL | 57 | 1234 | 100 | 400 | 300 | 50 | 2000 | 45 | 70 | 50 |
| TENE | A3 | F8 | 1394 | 100 | $\therefore 50$ | 300 | 50 | 2500 | 50 | 50 | 100 |
| TENE | N2 | 59 | 1407 | 100 | 450 | 300 | 50 | 2500 | 50 | 70 | 100 |
| TENE | E | F10 | 1320 | 100 | 450 | 300 | 50 | 2500 | 50 | 70 | 100 |
| TENE | TRAD | F11 | 1394 | 100 | 450 | 300 | 50 | 2500 | 50 | 70 | 100 |
| TENE | IRAD | F15 | 1288 | 100 | 450 | 300 | 50 | 2500 | 50 | 70 | 100 |
| TENE | N2 | F15 | 1235 | 100 | 450 | 300 | 50 | 2500 | 50 | 70 | 100 |
| TENE | B | F17 | 1396 | 100 | 450 | 300 | 50 | 2500 | 50 | 70 | 100 |

Column＂B＂listing the stove type has the following definitions：
A2，A3－－AIDR 2， 3
B－－Banfora
C－－CATRU
K2，K3－－Kaya 2，3
N2，N32－－Nouna 2，Nouna 32
MTL－－Metal stove
i－－Ticao
Trad－－Traditional three stone stove

Note chat che ceramic stove was never tested in cooking performance due to cracking during laboratory testing．

Note that cests，CADI，Fll，TENE F？，and TENE Fll，are not included in the analysis．Because the quantity of water that was added was roo much or too little，the water was either boiled away or other ingredients adjusted to make the meal palatable．

| $\therefore$ | こ | $\because$ |  | 0 | $F$ | $\alpha$ | 2 | 5 | T | U |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| ISEL | j1\％ | 1294 | 0002 | 910 | 500 | 388？ | 3481 | 5572 | 391 | 8 |
| ISEL | J20 | 130： | 4000 | 904 | 500 | 3471 | 3220 | 5786 | 1800 | 65 |
| 15EL | J2： | 140 ？ | 4000 | 070 | 500 | 3904 | 3738 | 5170 | 2007 | 55 |
| ISEL | J24 | 1270 | 4000 | 1036 | 500 | 2545 | $3+30$ | 6247 | 528 | 7 |
| ISEL | 」こら | 1347 | 4900 | 1058 | 500 | 258i | $3+70$ | 6315 | 55？ | 00 |
| IEBL | コこ5 | ： 3 43 | 4000 | 027 | 500 | 3776 | 3576 | 5075 | 2550 | 20 |
| ISEL | 32？ | 1320 | 4010 | 750 | 500 | 33？ | 3610 | 0101 | 1344 | 5 |
| ISBL | 128 | 1520 | 4000 | 905 | 500 | 2925 | 3156 | 6050 | 717 | 7 |
| $15 B L$ | J31 | 1450 | 40010 | 988 | 500 | 2505 | 3371 | 5788 | 290 | 80 |
| ISBL | E1 | 1575 | 4000 | 050 | 500 | 3521 | 347 ？ | 5770 | 575 | 85 |
| 15EL | $F=$ | ここつら | 3788 | $? 10$ | 500 | 3870 | 4111 | 5370 | 1522 |  |
| ALIC | E7 | ：270 | 4000 | 1000 | 500 | 3000 | 1203 | 6488 | 040 |  |
| ALIC | 58 | 1347 | 4000 | 1000 | 500 | $304+$ | 3813 | 勺こ？ | 754 | 3 |
| ALIC | E11 | 1448 | 9000 | 1000 | 500 | 3000 | 3642 | 6433 | 1095 | 78 |
| ALIC | F15 | 1375 | 4000 | 1022 | 500 | 3000 | 3536 | 5403 | 1746 | 88 |
| ALIC | E16 | 1345 | ＋000 | 1009 | 500 | 3000 | 3723 | 6090 | 509 |  |
| CMDI | 5 ？ | 1405 | 4000 | 1000 | 500 | 3000 | 40？2 | 5341 | 715 |  |
| CADI | F8 | 1524 | 9000 | 1000 | 500 | 3000 | 4511 | 6425 | 1023 | 80 |
| CADI | E\％ | 1452 | 4000 | 1000 | 500 | 3000 | 4100 | 6374 | 1370 | 89 |
| CADI | E：0 | 1244 | 4000 | 1000 | 500 | 3000 | 4142 | 6131 | 820 |  |
| CADI | E11 | 1340 | 5000 | 1250 | 500 | 3000 | 3735 | ¢895 | 1461 | 103 |
| CADI | F15 | 1404 | 4000 | 1000 | 500 | 3000 | 4120 | 5398 | 1437 | 80 |
| CADI | 515 | 1389 | 4000 | 1000 | 500 | 3000 | 419 1 | 5267 | 1748 | 66 |
| CACI | E17 | 1290 | 4000 | 1000 | 500 | 3000 | 3738 | 6221 | 1101 | 0 |
| TENE | 57 | 1456 | 4000 | 951 | 500 | 3000 | 2558 | 5416 | 1625 |  |
| TENE | 58 | 1392 | 4000 | 1000 | 500 | j000 | 3774 | 6308 | 475 |  |
| TENE | 5 | 1233 | 4000 | 1000 | 500 | 3000 | 4027 | 5.150 | 1261 | 5 |
| TENE | F10 | 1275 | 4000 | 1000 | 500 | 3000 | 3352 | 6276 | 1053 | 73 |
| IENE | F11 | 1410 | 5000 | 1250 | 500 | 3000 | 3677 | 7464 | 1021 | 3 |
| TENE | E15 | 1275 | 4000 | 1000 | 500 | 3000 | 3837 | 6324 | 1036 | 3 |
| TENE | E15 | 1393 | 4000 | 1000 | 500 | 3000 | 3712 | 6279 | 880 | 85 |
| TENE | 517 | 1270 | 4000 | 1000 | 500 | 3000 | 4204 | 5053 | 1103 | 3 |


| A | $\pm$ | 0 | rou | $\because \because 2$ | $\because C O D$ | SC |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| ISEL | $k 3$ | J19 | 8482 | 2072 | 3496 | 511 |
| 159L | N32 | $\therefore 20$ | 8521 | 1385 | 1691 | 222 |
| 158 L | $\because こ$ | j21 | 8530 | 1364 | 1895 | 246 |
| ISEL | 3 | J 24 | 8 ¢56 | 1596 | 1917 | 258 |
| 1 EEL | -nin | j25 | 8678 | 1535 | 2019 | 265 |
| 15BL | MTL | 126 | 8547 | 1534 | 1226 | . 164 |
| 15BL | K .2 | j27 | 8580 | 1440 | 2048 | . 259 |
| I5EL | A2 | J 28 | 8525 | 2118 | 2208 | . 323 |
| 15EL | A 3 | 321 | 8608 | 1991 | 2210 | 314 |
| I514 | T | F1 | 8570 | 2014 | 2045 | . 421 |
| 1SEL | - | F2 | 8518 | 2539 | 2377 | 372 |
| ALIC | 3 | 57 | 9126 | 1042 | 2060 | 234 |
| ALIC | TFAD | F 8 | 9121 | 1796 | 2270 | 293 |
| ALIC | N 2 | F11 | 9120 | 1767 | 1915 | 244 |
| ALIC | MTL | F15 | 9142 | 1990 | 1254 | 164 |
| ALIC | $\therefore 3$ | F16 | 9120 | 2053 | 2391 | 317 |
| CAD: | A 3 | 57 | 9128 | 1641 | 2085 | 261 |
| CADI | N2 | F8 | 9120 | 1164 | 1977 | 233 |
| CADI | 8 | 59 | 9120 | 1462 | 1630 | 199 |
| CADI | IRAD | F10 | 9120 | 1569 | 2180 | 270 |
| CAD] | MTL | F11 | 10370 | 2613 | 1539 | . 186 |
| CADI | B | F15 | 9120 | 1951 | 1563 | . 191 |
| CADI | MTL | F16 | 9120 | 1576 | 1252 | . 155 |
| CADI | N2 | 517 | 9120 | 1795 | 1899 | . 243 |
| TENE | MTL | 57 | 8465 | 2081 | 1374 | . 202 |
| TENE | A 3 | F8 | 9100 | 1809 | 2525 | . 324 |
| TENE | N2 | F9 | 9120 | 1583 | 1739 | . 216 |
| TENE | B | r10 | 9120 | 2087 | 1947 | . 259 |
| TENE | TRAD | F11 | 10370 | 2033 | 1979 | . 222 |
| TENE | TRAC | F15 | 9120 | 1522 | 1964 | . 242 |
| TENE | N2 | 516 | 9120 | 1757 | 2120 | . 270 |
| TENE | B | 「17 | 9120 | 1619 | 1897 | . 237 |

The column captions "A," "B," and "C" are given on the preceding sample tests sheet. "TOT" is the total amount of food-asauce and "tō"--before cooking begins. "EVAP" gives the amount of water evaporated during the test. "WOOD" gives the amount of wood used during the test. "SC" gives the specific consumption detined as the equivalent diy wood consumed divided by the fond processed or

$$
S C=\frac{\frac{17150}{18322}(\text { WOOD })}{(\text { TOT }- \text { EVAP })}
$$



Weight of wood used during preceding controlled cooking test "Q"

[^0]
## heat recuperation test data and results

| $A$ | $B$ | $C$ | $D$ | $E$ | $F$ | $G$ | $H$ | $I$ | $J$ | $K$ | $L$ | $M$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 1 | $N 32$ | $J 20$ | 1408 | 1346 | 0 | 4400 | 4245 | 0 | 23 | 24 | 0 | 39 |
| 2 | $N 2$ | $J 21$ | 1394 | 1315 | 0 | 4375 | 4318 | 0 | 20 | 20 | 0 | 39 |
| 3 | $B$ | $J 24$ | 1280 | 1392 | 0 | 4268 | 4356 | 0 | 24 | 23 | 0 | 39 |
| 4 | $K 2$ | $J 27$ | 1295 | 1235 | 0 | 4276 | 4204 | 0 | 27 | 24 | 0 | 37 |
| 5 | $A 2$ | $J 28$ | 1415 | 1276 | 0 | 4400 | 4273 | 0 | 21 | 20 | 0 | 39 |
| 6 | $A 3$ | $J 31$ | 1351 | 1271 | 1776 | 4365 | 4305 | 4776 | 29 | 24 | 23 | 36 |
| 7 | I | F | 1395 | 1347 | 0 | 4409 | 4323 | 0 | 22 | 22 | 0 | 38 |


| $i v$ | 0 | $P$ | $Q$ | $R$ |
| :--- | :--- | :--- | :---: | :---: |
| 34 | 0 | 45 | 1691 | 1.11 |
| 36 | 0 | 45 | 1895 | 1.35 |
| 29 | 0 | 45 | 1917 | .797 |
| 32 | 0 | 30 | 2048 | .638 |
| 32 | 0 | 45 | 2208 | .991 |
| 29 | 35 | 35 | 22166 | .962 |
| 31 | 0 | 50 | 2945 | .621 |

Column captions are given on the preceding sample test sheet. All weights are given in grams and all temperat;ures are given in degrees centigrade. Column 'R" gives the percentage of heat given off by burn* ing the wood "Q" during the preceding controlled cooking test that is captured by the pots of cold water placed cat the hot stove.


[^1]TABLE X

FAMILY COMOUND BOILING WATER TESTS DATA AND RESILTS

| $\therefore$ Ai.jce | $C$ 1 | 5 | $20 \stackrel{5}{\square} 0$ | $1{ }_{1}$ | $40 \Gamma_{0}$ | $40 \stackrel{H}{i}$ | 23 | $\begin{aligned} & 0 \\ & 9 \end{aligned}$ | $0$ | IJ 15 | 70 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2AlJCE | 0 | 3 | 2060 | 12 | 4600 | 3750 | 25 | 100 | 100 | 50 | 55 |
| 3ALICE | - | 3 | 2060 | 16 | 4600 | 3840 | 25 | 100 | 100 | 20 | 45 |
| ATENE | 1 | 4 | 2479 | 10 | 4900 | 3800 | 25 | 98 | 90 | 17 | 55 |
| 5TENE | 0 | 2 | 1550 | 11 | 4000 | 3600 | 25 | 88 | 70 | 0 | 45 |
| ¢TENE | 2 | 4 | 2620 | 15 | 4800 | 4050 | 25 | ? 8 | $7{ }^{\text {\% }}$ | 15 | 33 |
| TCADIE | 1 | 3 | 1990 | 13 | 1820 | 3850 | 27 | 99 | 89 | 22 | 55 |
| 8СADIE | 0 | 3 | 1990 | 15 | 4850 | 4350 | 21 | 99 | 73 | 27 | 37 |
| ?CADE | 0 | 2 | 1700 | 12 | 4500 | 3640 | 29 | 99 | 90 | 12 | 47 |
| 10ALICE | 1 | 3 | 2050 | 16 | 4640 | 3450 | 26 | 100 | 93 | 15 | 45 |
| 11ALICE | 0 | 3 | 2050 | 16 | 4550 | 3700 | 22 | 100 | 90 | 15 | 45 |
| 12ALICE | 0 | 3 | 2050 | 14 | 4700 | 4350 | 21 | 8 ? | 83 | 0 | 45 |
| 13ALICE | 1 | 3 | 2050 | 0 | 4455 | 3560 | 25 | 100 | 93 | 15 | 35 |
| 1ACADIE | 1 | 4 | 2570 | 16 | $46 ? 0$ | 3970 | 27 | 09 | 85 | 32 | 55 |
| 15CADIE | 0 | 4 | 2680 | 14 | 4960 | 4470 | 27 | $\bigcirc 2$ | 90 | 0 | 30 |
| 16EADIE | 0 | 3 | 2000 | 10 | 4360 | 3500 | 25 | 98 | 82 | 22 | 63 |
| 17CADIE | 0 | 4 | 2580 | 18 | 4800 | 4250 | 22 | 79 | $? 0$ | 18 | 30 |
| 18TENE | 1 | 3 | 2400 | 14 | 4500 | 3690 | 23 | 90 | 80 | 17 | 57 |
| 1PTENE | 0 | 2 | 1950 | 10 | 9350 | 3320 | 25 | 79 | 78 | 17 | 52 |
| 20TENE | 0 | 3 | 2010 | 13 | 4510 | 3910 | 24 | 98 | 94 | 22 | 35 |
| 21TENE | 0 | 4 | 2600 | 15 | 9600 | 3830 | 27 | 95 | 91 | 0 | 39 |
| 22ALICE | 1 | 3 | 2080 | 16 | 4660 | 3640 | 25 | 100 | 90 | 10 | 40 |
| 23ALICE | 0 | 3 | 2065 | 16 | 4980 | 3480 | 24 | 97 | 82 | 15 | 45 |
| 24ALICE | 0 | 3 | 2080 | 12 | 4455 | 3850 | 21 | 98 | 85 | 25 | 40 |
| 26 IENE | 1 | 2 | 1650 | 9 | 4050 | 2830 | 25 | 98 | 93 | 15 | 63 |
| 27 TENE | 1 | 2 | 1860 | 10 | 4010 | 3080 | 19 | 98 | 91 | 15 | 58 |
| $28 T E N E$ | 0 | 2 | 1670 | 12 | 4150 | 3710 | 23 | 95 | 94 | 0 | 41 |
| $30 C A D I E$ | 0 | 3 | 2010 | 11 | 4740 | 4160 | 23 | 98 | 96 | 20 | 37 |
| 31 CADIE | 1 | 3 | 2000 | 13 | 4760 | 3660 | 25 | 98 | 87 | 21 | 57 |
| 32 CADIE | 1 | 3 | 2010 | 15 | $48 ?$ | 4270 | 25 | 98 | 92 | 24 | 44 |

Column captions are given on the preceding sample test sheet. Column "C" gives whether the test was held inside, "l", or outside "0". Column "D" gives the size of the pot and corresponds to the dimensions given previously for different pot sizes. Column "F" gives the height from the ground to the bottom of the pot in centimeters when in place rn the three stone fire. All weights above are given in grams and all temperatures are given in degrets centigrade.

| A $\quad$ I | C | [) | F | Fo | 1io |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1ALICE | 1 | 3 | 19 | 4.08 | 17.0 |
| 2AILCE. | 0 | 3 | 12 | 5. 20 | 15 B |
| 3 ALICE | 1 | 3 | 16 | 6.35 | 14.7 |
| 4 TENE | 1 | 4 | 10 | 5. 20 | 183 |
| STENE | 0 | 2 | 11 | 6.35 | $\varepsilon 50$ |
| 万TENE | 2 | 4 | 15 | B. 65 | 13.7 |
| 7CADIE | 1 | 3 | 13 | 5.20 | 17.1 |
| BCADIE | 0 | 3 | 15 | 7.73 | 11.5 |
| PCADIE | 0 | 2 | 12 | 6. 08 | 15.5 |
| 10ALICE | 1 | 3 | 16 | 6.35 | 19.9 |
| 11ALICE | 0 | 3 | 16 | 6.35 | 15.3 |
| 1 $\because$ ALICE | 0 | 3 | 14 | 6.35 | 8. 62 |
| 13ALICE | 1 | 3 | 0 | 8.17 | 15.8 |
| 14CADIE | 1 | 4 | 16 | 5. 20 | 15.4 |
| 15 CADIE | 0 | 4 | 14 | 9. 53 | 9.96 |
| 16 CADIE | 0 | 3 | 10 | 4. 54 | 14.6 |
| 17CADIE | 0 | 4 | 18 | 9. 53 | 10.9 |
| 18 IENE | 1 | 3 | 14 | 5.01 | 13.6 |
| 19 TENE | 0 | 2 | 10 | 5. 50 | 17.8 |
| 20 TENE. | 0 | 3 | 13 | 7. 52 | 12.2 |
| 21 TENE | 0 | 4 | 15 | 7. 33 | 13.3 |
| ? 2ALICE | 1 | 3 | 16 | 7.15 | 17.5 |
| 23 ALICE | 0 | 3 | 16 | 6.35 | 16.6 |
| 24 ALICE | 0 | 3 | 12 | 7.15 | 11.7 |
| 2 OTENE | 1 | 2 | 9 | 4.2: | 20.1 |
| 27 TENE | 1 | 2 | 10 | 4.93 | 15.0 |
| $28 T E N E$ | 0 | 2 | 12 | 6.97 | 10.1 |
| $30 C A D I E$ | 0 | 3 | 11 | 7.73 | 12.5 |
| 31 CADIE | 1 | 3 | 13 | 5.01 | 18.7 |
| 32 CADIE | 1 | 3 | 15 | 6.50 | 12.9 |

Column captions "A" through "F" are as described on the sample test sheet. "Po" is the average fire po"er during the test not taking the remaining charcoal into account. " $N_{0}$ " is the average PHU or thermal efficiency during the test not taking the charcoal into account.

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[^0]:    * Time and temperatures chosen for when all temperatures are at their maximums.

[^1]:    * The time to reach boiling and/or the maximum temperature reached.
    **The time and temperature when the $1 \cdot \mathrm{~kg}$ charge of wood is completely burned. Charcoal is not recuperated and left to burn out.

