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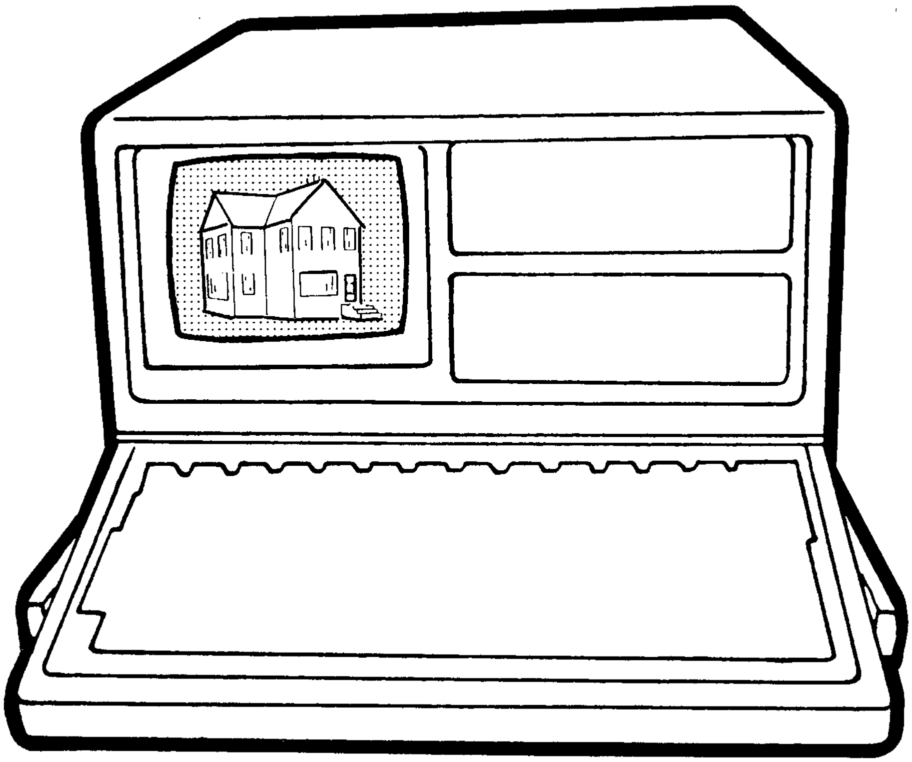

CIRA™ 1.0

REFERENCE MANUAL

March 1982

Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

Pub-442

COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT

C I R A^{TM}

Energy Performance of Buildings Group
Energy and Environment Division
Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

Version 1.0
March 1982

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ACKNOWLEDGEMENTS

As with any project of this magnitude, many people have contributed to the making of CIRA. CIRA was begun late in 1979 as a one-man effort. Research on the future structure of CIRA accelerated in 1980, inspired by Dave Krinkel's contagious enthusiasm in testing different solar algorithms and portions of the dynamic heat load calculations.

At the end of 1980, Jim Dixon and Jean-Yves Garnier joined the effort and were to have crucial influence on CIRA as it is today. Jim Dixon became the principal programmer who writes or edits all software, coordinates the programming developments of all other participants, and oversees the format and the distribution of CIRA. Without Jim, CIRA might just have remained another interesting concept without implementation. Jean-Yves Garnier was responsible for adapting the active solar and greenhouses algorithms from existing literature to the structure of CIRA. He also developed the concept of solar storage factors, implemented the economic optimization methodology and performed numerous comparisons between CIRA and DOE-2.1.

Recently CIRA has greatly benefitted from several new contributors. Vivian Kendon adapted the SLR method for passive solar components to CIRA and patiently wrote many drafts of the section on engineering methodology. Peter Cleary brought his physics background and his crisp prose to bear in rewriting all "help files" and in editing and partially writing this manual. Together with Darryl Dickerhoff, Bruce Dickinson, drawing on his experience as a "house doctor", researched the information on the retrofits. Bruce also contributed to the manual and performed preliminary validation of CIRA against data from actual buildings.

One person that deserves special recognition is Howard Ross of the U.S. Department of Energy. Howard Ross not only initiated and funded this project, but remained a faithful fan through countless delays and technical snags and patiently field tested a succession of "last versions" of CIRA.

Many more persons helped at one time or another in developing CIRA. I wish to thank Brian Smith for his patience in teaching us about microcomputers, Rick Diamond for graphic assistance, Carol Stoker for protecting us from the telephone, Dave Anderson for decoding weather tapes, Maria Kleiss for her efforts in formatting weather data, and David Jacobson for testing inputs. Finally, I wish to thank Dave Grimsrud, Jeff Harris and Art Rosenfeld for continuing moral support.

Robert Sonderegger
March 21, 1982

Section I

GETTING STARTED

CIRA has been designed to be as user friendly as possible. When using CIRA you have instant access to help messages, lists of possible answers, and (if you want) the program will answer a question for you by default. So the best way to become familiar with what CIRA can do for you is to turn on your micro-computer and start using the program immediately. It should only be necessary to refer to this manual when you need an exhaustive explanation of, for example, how the cost of retrofitted storm windows is calculated, or how basement heat loss is treated.

To start:

1. Copy our disks "A", "B" and "C" onto three of your disks with a CP/M system on each. Refer to your CP/M manual for details of how to do this. Store our disks in a safe place.

2. Put your disk "A" into your drive "A" and your disk "B" into your drive "B". (If you use any other setup, see the next page)

3. Press the reset button to load CP/M.

5. Type CIRA

6. Press carriage return

This should now appear on your screen:

```
****************************************************
****                                            ****
**** COMPUTERIZED, INSTRUMENTED RESIDENTIAL AUDIT ****
****                                            ****
****          Version 1.0 - December 1982       ****
****                                            ****
****  (c) Regents University of California  1982 ****
****                                            ****
****        Energy Performance of  Buildings    ****
****         Lawrence Berkeley Laboratory       ****
****           University of California         ****
****          Berkeley,  California  94720      ****
****                                            ****
****************************************************
```

From then on, just follow the instructions that appear on the screen.

MINOR PROBLEMS

PROBLEM #1 If your screen looks strange it's probably because CIRA is set for the wrong type of terminal. Look in Section XI "Utility Programs" to see how to adjust CIRA for your terminal.

PROBLEM #2 The computer has to know where to find the contents of disk A and disk B. You must always log into the drive which contains CIRA disk A. There are three standard places CIRA looks for disk B. These are shown in 1, 2, and 3 below. For any other setup, you must tell CIRA where disk B is.

1. If you have put disk A in drive A, and disk B in drive B, log into drive A and type: **CIRA**

2. If you copied both our disk A and our disk B onto one disk, log into the drive containing that disk and type: **CIRA**

3. If you put disk A in any drive, say J, and disk B in the next higher drive (K, in this case), log into drive J and type: **CIRA**

4. This is the unusual case. If you put disk A into any drive, say F, and disk B into any drive except the next higher, say L, log into the drive which contains disk A and type: **CIRA SL**
or if you put disk B into drive M, type: **CIRA SM**
or if you put disk B into drive N, type: **CIRA SN**
and so on.

PRINTER OUTPUT

CIRA output is formatted for an 80 column printer for the design analysis and for a 132 column printer for the retrofit optimization. If you have an EPSON MX-80 printer, these columns will be set automatically if you start the program by typing: **CIRA 8** (or **CIRA SL8** etc., as appropriate). For all other printers the column size must be changed manually from 80 to 132 or left at 132.

METRIC INPUT AND OUTPUT

If you prefer to answer questions and get answers in metric units, see Section XI, "Utility Programs", which explains how to set up CIRA for these units.

OVERVIEW

INSERT GOLDENROD DIVIDER

"OVERVIEW"

Section II

OVERVIEW

What do a government official, an architect, an energy auditor, an engineer and a contractor have in common? Sooner or later, they all need to know projected energy use in a given house and sometimes they may need to maximize energy savings in an existing house within the constraints of a given budget.

Several paper-and-pencil procedures exist to do both of these tasks. Unfortunately, they always boil down to lengthy sheets of calculations. You've heard of computer programs developed to ease this task: you like their speed -- it's the inputs you could do without. Describing a building to a computer may require strict adherence to a particular format or the knowledge of a special language. Furthermore, you may lack access to a computer system that runs your favorite building energy analysis program.

Two recent trends appear particularly promising as a way out of the burden of calculating energy use in buildings: the introduction of microcomputers and the development of user-friendly programs. Microcomputers are cheap enough to be affordable by the smallest business, and many different brands are capable of running the same wide selection of programs. User-friendly programs don't expect you to tell them about your building in some rigid format or language; they ask questions in plain English and suggest possible answers -- you just point to the answer you like best.

Computerized, Instrumented, Residential Audit (CIRA) is a user-friendly program developed for microcomputers. More precisely, CIRA is a collection of programs related to building energy analysis and designed for a wide variety of microcomputers. It couples the state-of-the-art in interactive features with the latest developments in simplified computer models of building energy analysis. For the novice, CIRA will provide exhaustive explanations of everything it needs, while for the experienced user the questions and responses are more terse.

Below you will find descriptions of how CIRA takes the headaches out of describing the house characteristics needed for energy analysis. For those interested in the more technical aspects of CIRA -- how it figures out heating and cooling energy consumptions or how it determines optimal energy-saving strategies -- we have included a section "Energy Calculations."

Data entry

In developing CIRA, much effort was devoted to facilitating the tedious process of entering the appropriate building data. Prominent among the features that distinguish CIRA from other computer programs are:

Friendliness:

The user does not have to learn a language and does not have to remember any commands. CIRA does the work by asking about wall areas and types, heating system specifications, passive solar features, etc.; the user simply answers the questions displayed on a screen.

Helpfulness:

If the CIRA novice does not understand some of the questions, such as

"Terrain Class.....?",

he or she can call for help with a simple keystroke, to which the computer responds with a more detailed explanation of the question, together with examples when appropriate.

Multiple choice:

If the user understands the question, such as "Window Glazing.....?", but does not remember the possible answers, another keystroke displays a list of options in multiple choice style, in this case

S=Single Pane
D=Double Pane
T=Triple Pane

In fact, this list will appear automatically whenever more than two wrong answers are given.

Dynamic defaults:

Frequently, the user may not know the answer to technical questions, such as the R-value of a wall or the solar-gain factor of a window. What is, for example, the R-value of a 2' x 6' frame wall whose 5.5 inch cavity is insulated with 4 inches of Vermiculite and one inch of exterior insulating sheathing? CIRA provides the answer, in this case R-16.8, at the touch of another special key. We call the values provided by this keystroke dynamic defaults. Defaults, because they provide the most likely answer when the user hasn't a clue, and dynamic, because they usually depend on the user's answers to one or more previous questions. Beyond the lay user, the professional can use dynamic defaults to avoid leafing through voluminous handbooks in search of the heat-loss factor for a basement, for example.

Goof-proofing:

Often, the user may want to alter previous input, or correct mistakes, or re-use a house entered earlier, changing only details such as floor area, the city where it is located, and the window size. As soon as another simple keystroke is hit, the computer enters an editing mode, and displays the desired questions and the answers previously given on the screen, along with a request for the new answers. The computer even keeps track of things you may have forgotten in the process: if you change the city from Denver to San Francisco, for example, it will remind you that, as you leave the mile-high city, you may also want to change the altitude.

The computer accepts entries on a wide variety of house components and related features:

- Walls, windows, doors
- Roof and subfloor
- Active and passive solar features
- Heating and cooling system
- Information on how the house is oriented and shielded
- Occupant behavior related to energy use
- Prices for the various fuels used.

Some of these entries may require the use of specialized instrumentation, such as 1) a tape measure to obtain the relevant dimensions of the house, 2) a solar siting meter to measure the degree of obstruction to solar radiation by trees and adjacent buildings, 3) a combustion efficiency meter to measure furnace efficiency, 4) a blower door to pressurize the house, and 5) a few smoke sticks to find where the air leaks are. Incidentally, most of these instruments can be found in the kit of a "house doctor," who searches a house for hard-to-spot energy leaks and fixes the most conspicuous of them during his or her visit. CIRA was designed with the house doctor-approach in mind. The measurements performed by the house doctor feed directly into CIRA which translates them into practical retrofit recommendations. Thanks to dynamic defaults, however, these measurements and the attendant instruments are not indispensable -- CIRA can function as a "stand-alone" diagnostic program. After all questions about the house have been properly answered, the computer will automatically figure monthly and yearly heating and cooling energy consumptions or, on request, recommend several combinations of energy-saving measures suitable for low, medium and high budgets. Every combination (e.g., storm windows, elimination of air leaks, basement insulation) is chosen to produce the highest energy savings for a given budget. Of course, interest and inflation rates, maintenance costs of the installed measures, and projected period of occupancy are taken into account.

Energy calculations

To calculate the energy consumed for any given house, CIRA uses heating and cooling algorithms developed at Lawrence Berkeley Laboratory, Princeton University, National Bureau of Standards, Los Alamos National Laboratory and the University of Wisconsin. A brief summary follows below.

For each month, an energy balance is calculated separately for day and night. First, a heat-transmission coefficient is calculated, to determine how much heat the house loses per month and per degree of temperature difference between indoors and outdoors. To this coefficient is added the effect of infiltration, computed on a monthly basis using a method developed at Lawrence Berkeley Laboratory. This method uses information on the leakage area of the house, the type of terrain on which it is located, and the type of shielding surrounding the house, all of which is part of the information requested by CIRA. For terrain and shielding classes, CIRA will display descriptive tables on request. Leakage area is generally measured with a so-called "blower door", a fan-like device that creates an over- or under-pressure in the house and measures the amount of air flow through the fan necessary to reach several special levels of pressure. Alternatively, the leakage area can be estimated from information on the air tightness of windows, walls, doors, and all other building components. As usual, dynamic defaults are available to provide what the user may not know.

Of course, like most other aspects of heating and cooling energy requirements, air infiltration depends on the local temperatures and wind speeds. The user, however, never need be concerned with such tedious detail: the name of the nearest city in CIRA's files is all he or she ever will have to know about local weather patterns. And, naturally, the program will prompt for it and display the available options.

Solar gains are computed by taking into account weather-averaged solar radiation in the city chosen by the user, the shading effects of trees, nearby buildings and overhangs, and the optical characteristics of windows and walls. The shading effects of overhangs and the reflection of glazed surfaces are modeled by using correlation methods developed at Los Alamos National Laboratory. The solar gains, together with other internal gains and radiation losses to the sky, are used to compute an effective outdoor temperature, which is usually higher than the monthly average temperature. The monthly values of effective outdoor temperature, indoor thermostat setting, and heat-transmission coefficient are used to compute monthly heating and cooling loads for day and night. These loads are corrected if night and day thermostat settings are different. Seasonal heating and cooling efficiencies are figured for each month based on 1) heating and cooling loads, 2) specifications of the heating and cooling equipment, 3) part-load efficiencies, and 4) ambient-dependent output capacities. Finally, heating and cooling loads and efficiencies are combined to arrive at monthly energy consumptions for heating and cooling.

The heating and cooling consumptions calculated by this load module were compared with those of the DOE-2.1 program for seven different cities and two thermostat schedules. In general, discrepancies between the two programs were found to be on the order of $\pm$10%.

Viewing the results

After the minute or so that it takes to perform the heating and cooling calculations, CIRA displays monthly values and yearly totals (or means, where appropriate) of several quantities, such as:

- Daily and nightly heating and cooling energy consumption
- Daily and nightly heating and cooling loads
- Air infiltration
- Solar gains
- Dollar expenditures for heating and cooling
- Average and effective daily and nightly outdoor temperatures

These results can be displayed either in tabular form or graphically, depending on the user's wishes. By pressing the appropriate key from a menu displayed at the top of the screen, the user may also plot any arithmetic combinations of these figures (e.g., the sum of daily and nightly heating and cooling expenditures). For users with special needs, CIRA can be easily modified to display other types of output as, for example, infra-red radiation loss to the sky, or the percent change in energy consumption for every percent change in infiltration, in solar gains, or in similar parameters.

Energy-saving retrofits

For energy auditors and energy policy makers, the technical details about yearly energy consumption may be of less interest than determining the most cost-effective strategy to save energy. That is, for a given budget, what is the most energy-saving combination of retrofits or, what is the highest retrofit budget for which the dollar savings still exceed the expenditures (including maintenance costs)? CIRA is able to answer both of these questions in a mostly automated process consisting of two stages: the selection of retrofits, and their economic optimization.

Retrofit selection

The retrofit selection occurs as follows: First, CIRA scans an extensive list on a disk containing several hundred retrofit options and their respective costs per unit, as well as their figures of thermal merit (typically, added thermal resistance, decreased solar gain, decreased leakage area, improved efficiency). CIRA will consider only those items appropriate to the structure in question; that is, cellulose insulation for cavity walls, not for solid masonry walls, and sliding storms for double-hung windows, not for casement windows. This reduced selection of retrofits is briefly shown on the screen for each house component (walls, windows, etc.).

Economic optimization

At the end of this retrofit selection process, the computer determines the best combination of retrofits for the whole house within the constraint of a budget. This process involves multiple yearly energy calculations, and takes about ten to fifteen minutes, depending on the size and complexity of the house, the climate and the number of retrofits involved. Dollar and energy savings in several different economic formats are shown for each retrofit based on the expected period of occupancy for the house under consideration.

Microcomputer requirements to run CIRA

Currently, CIRA can be run on any microcomputer with the following specifications:

- **Z80, 8080 or 8085 family of microprocessors.**
- **CP/M operating system (version 2.0 or greater).**
- **64 k of random access memory.**
- **Two 8" single density disk drives or equivalent (2x240k or 450k bytes total).**
- **80 column video terminal (cursor addressing is necessary).**
- **132 column printer for retrofit output.**

CP/M is a trademark of Digital Research, Inc., P.O.Box 579, Pacific Grove, CA 93950.

Modifications may be made by the user to accomodate most terminals. At the time of this writing (April 1982) a complete system with these specifications, including a terminal or a keyboard and monitor, can be purchased for around $4,000.

INPUT GUIDE

INSERT GOLDENROD DIVIDER

"INPUT GUIDE"

Section III

INPUT GUIDE

CIRA does not use an artificial, buildings language. Information is input in response to questions, grouped by component. The components and the key letters used to identify them are:

G = General	E = Economic	W = Windows
D = Doors	O = Walls	R = Roof/Ceiling
S = Subfloor	P = Passive-Solar	N = Greenhouse
X = Active-Solar	H = HVAC-system	I = Infiltration
L = Landscape	A = Appliances	C = Continue

The user chooses a component by typing in one of the above keyletters when the computer asks:

"WHAT NEXT or Continue?"

The questions for the chosen component then appear on the screen; after one question is answered, the next question appears until the complete list, with answers, is on the screen. Take, for example, the questions for windows; the complete list is:

A) Name of the following windows....................?
B) Which window ORIENTATION.........................?
C) Window TYPE.....................................?
D) GLAZING...?
E) DRAPES & SHUTTERS...............................?
F) Are window covers USED at DAYTIME................?
G) U-value (Btu/sqft/F)............................?
H) Average sash FIT................................?
I) Specific LEAKAGE AREA (sqcm/sqft)................?
J) Summer SOLAR GAIN factor (%).....................?
K) Winter SOLAR GAIN factor (%).....................?
L) Window AREA (sqft)...............................?

For every question there are a list of possible answers, a short explanation, and a default value (a value calculated on the base of previous answers, or a best estimate). Each of these can be called by a keystroke when the question appears. The list is called by <control-L> for List, the explanation by <control-H> for Help, and the default value by <control-D> for Default. A reverse polish notation (RPN) calculator can be used for any numerical question, as shown in the sample input to find window area. The operations that the calculator can do are listed on page 5 of the "Output Guide".

If the user is not technically sophisticated, the computer can be set to automatically use either a default or a pre-set value, and not display the question. For example, the U-value could be automatically calculated using the answers for glazing, covers, and use. If desired, whole sections can be handled in this way; the data for the Economic section, for example, could be pre-set, and the questions on energy prices, discount rates etc. would never appear. Such questions are referred to as "ghost questions".

The answer to a question may be changed at any time. The first chance is immediately after the answer has been entered, when the computer asks for a yes/no confirmation. The second chance is in the middle of entering a component, when the user may interrupt the questions to edit the previous answers by typing <control-E> for Edit. Finally, once a complete component has been entered, and the computer asks "Which menu ITEM?", the user can type in the code letter next to a question and re-answer that question. This last method can be used at any point. The user is led through these steps by instructions which appear on the screen.

Once all the house components have been entered, the program can continue to the energy calculations. If the user attempts to continue with the inputs incomplete, a warning message appears giving the names of the missing components. The user decidess whether to proceed to the design energy calculations or the retrofit optimization calculations. As it calculates, it displays short messages to indicate the stage it has reached, e.g. "Entering ENERGY CALCULATION program", or it shows the savings from each retrofit it is considering. The complete flow diagram of the program set is shown in the "Program Organization and Glossary" section. The design energy calculation takes one or two minutes to complete; the retrofit optimization takes about ten. The exact times vary from house to house and from computer to computer.

Examples of all of these features of the CIRA input structure are shown in the sample input session which follows. In an actual input session, a video terminal would be used, and the input format has been designed for such a terminal. The format includes frequent redrawing of the screen to simplify the input. This is convenient and helpful on a screen, but appears rather clumsy when printed.

Note: The maximum permitted number of component entries is 30. If there are more than that, some will have to be consolidated. For example, if there are a lot of small windows the user will have to combine some of them into one large window.

A SAMPLE INPUT SESSION WITH CIRA

```
*******************************************************
****                                               ****
**** COMPUTERIZED, INSTRUMENTED RESIDENTIAL AUDIT ****
****                                               ****
****            Version 1.0 - March 1982           ****
****               Copyright© 1982                 ****
****        Regents University of California       ****
****                                               ****
****         Energy Performance of  Buildings      ****
****           Lawrence Berkeley Laboratory        ****
****             University of California          ****
****           Berkeley,  California  94720        ****
****                                               ****
*******************************************************
```

Note: In an actual input session a video terminal would be used, and the input format has been designed for such a terminal. The format includes frequent redrawing of the screen to simplify the input. This is convenient and helpful on a screen, but appears rather clumsy when printed.

"L"ong, "S"hort or "N"o INSTRUCTIONS....? L   Long instructio--> OK? YES

The user decides to read the long instructions. He/she types L, and confirms with a carriage return.

WELCOME to the CIRA audit...

In this audit you will be asked a number of questions about your house. Many questions are multiple choice. For them, all you have to do is enter the appropriate code letter. For example, the question might be:

Window GLAZING...............................?

If you type "D", the computer responds

Window GLAZING...............................? D   Double Pane --> OK?

and waits for you to confirm your answer with a "Y" or reject it with an "N". (A carriage return at this point also means "Yes"). Other times, you will be asked for a quantity, such as:

Insulation thickness (inches)................?

In this case, after entering the number of inches, you have to press the "RETURN" key, to indicate your entry is complete. (The computer will

HIT <ANY KEY> TO CONTINUE

The screen is full of instructions and the computer waits for the user to ask to continue.

answer and ask you to confirm or reject it.

Insulation thickness (inches)................? 3   3 inches --> OK?

HELP

If you don't UNDERSTAND a question, ask for HELP by holding down the CTRL while pressing the H key at the same time (just like SHIFT and H). A short explanation will appear.

LIST

If you understand the question, but don't REMEMBER the possible answers, press CTRL and L at the same time for a LIST of possible answers.

DEFAULT

If you do not KNOW the answer to a question, e.g. the U-value of a single pane window, press CTRL and D at the same time. The computer will give the most likely answer, based on the information you have already given. In other words, it will answer for you by DEFAULT, since you don't know the answer.

HIT <ANY KEY> TO CONTINUE

End of the second screenful of instructions.

There are two main levels of questions. First comes the "WHAT NEXT?" question, that you will be asked as soon as this is over. This wants to know which section of the house you are ready to enter, e.g. WALLS, DOORS, or INFILTRATION. Then come more specific questions about each item. If you get frustrated answering questions about, say, WALLS, and want to quit and answer questions about some other item, press CTRL and Q (Q for quit). This will land you up at the WHAT NEXT? level again.

MISTAKES

If you make a mistake, there are a number of ways to correct it. First, when the computer repeats back your wrong answer, press N (for NO!). The computer will ask you the question again. Second, if you change your mind in the middle of any section, you can go back and change any answer by pressing CTRL and E (E for edit). Third, at any time you can go back to a section and re-answer any question, by asking for that "Menu item" again.

Suppose you want to change the glazing of the Bedroom Windows. To start, you ask for the component, WINDOWS, [by typing

HIT <ANY KEY> TO CONTINUE

End of the third screenful of instructions

the code letter W for windows] then you ask for the NAME [by typing the menu number next to the Bedroom Windows] then you ask for the menu item you want to correct [by typing the number next to the question about glazing]. If you make any changes, remember to SAVE the new answers, which erase the old ones.

If you want to eliminate a component completely, do exactly the same thing as for Bedroom Windows, but when the second menu comes on the screen, choose the number next to the DELETE question.

Finally, if a question is asked that you have already answered, and your answer is the same as last time, try pressing the "RETURN" key. Most of the time, your previous answer will have been retained.

```
                    HIT <ANY KEY> TO CONTINUE

              A SUMMARY OF WAYS TO GET HELP

         <ctrl H>.......Gives HELPful information
         <ctrl L>.......LISTs all possible answers.
         <ctrl D>.......Gives DEFAULT value for the answer.
         <ctrl Q>.......QUITS, and lands you at WHAT NEXT?
         <ctrl E>.......Lets you EDIT your answers to any question.
         <RETURN>.......(Carriage return key) Repeats your last answer.
         ?..............(Question mark) Reprints this summary table.
```

Only this table is printed if you ask for the short instructions

```
                    HIT <ANY KEY> TO CONTINUE
```

End of the long instructions

```
 NO current DISK DATA for this house.
```

There is no pre-existing data on this house. The user asks for a list of components by pressing <ctrl-L>. The computer confirms this by printing List

```
WHAT NEXT or Continue..................? List:

        G = General
        E = Economic
        W = Windows
        D = Doors
        O = Walls
        R = Roof/Ceiling
        S = Subfloor
        P = Passive-Solar
        N = Greenhouse
        X = Active-Solar
        H = HVAC-system
        I = Infiltration
        L = Landscape
        A = Appliances
        C = Continue

WHAT NEXT or Continue..................? W        Windows        --> OK? YES
```

The user decides to start by entering data on the house windows.

```
NO previous WINDOWS data

NAME of the following windows...........? Front      Front            --> OK? YES
```

The user presses S for south

```
Which window ORIENTATION................? S          South            --> OK? YES
```

The user asks for a list of possible window types.

```
Window TYPE.............................? List:

        D = Double hung
        H = Horizontal Sliding
        C = Casement
        T = Tilting
        J = Jalousie
        F = Fixed
        G = Greenhouse
        S = Skylight
        O = Dome

Window TYPE.............................? C          Casement         --> OK? YES
GLAZING.................................? S          Single pane      --> OK? YES
DRAPES & SHUTTERS.......................? N          None             --> OK? YES
U-value (Btuh/sqft/F)...................? Default:    1.1 Btuh/sqft/--> OK? YES
```

By pressing <ctrl-D> the user gets the default value.

```
Average Sash FIT........................? Help:
```

The user presses <ctrl-H> to ask for help about leakage area.

The average SASH FIT is how tightly the window sash fits in its frame. Do not confuse this sash fit with the size of cracks, if any, between the window frame and the wall! The options are:

Loose	if the sash rattles in the frame and/or if you can see light through or around the sash;
Tight	if outdoor noise decreases substantially when you close the window, and if it "feels" snug;
Average	for cases in between.

```
Average Sash FIT........................? List:

        L = Loose
        A = Average
        T = Tight

Average sash FIT........................? A          Average          --> OK? YES
```

```
Specific LEAKAGE AREA (sqcm/sqft).......? Default:    .19 sqcm/sqft --> OK? YES
```

The default is calculated for average sash fit.

```
Summer SOLAR GAIN factor (%)............? Help:
```

The SOLAR GAIN factor is the percentage of solar radiation which would get into the room if all the sunlight struck the glass at right angles. The default values are based on your previous answers about GLAZING, window COVERS and window cover USAGE. This factor will change from summer to winter if you use the window covers differently in the different seasons.

The default value you get by pressing <ctrl-D> is based on your answers to previous questions about GLAZING, COVERS, and USAGE.

```
Summer SOLAR GAIN factor (%)............? Default:   87 %         --> OK? YES
Winter SOLAR GAIN factor (%)............? Default:   87 %         --> OK? YES
Window AREA (sqft)......................? 4!16*     64 sqft       --> OK? YES
```

The user enters the window dimensions using an "RPN" calculator: 4 "enter", 16 "times". The computer responds with the result, 64.

```
Overhang PROTRUSION (inches)............? Help:
```

An OVERHANG is any overhang above a window or solar wall, e.g. awnings, horizontal shades, balconies or the roof itself.

The OVERHANG HEIGHT is measured from the top of the sash to the height of the outer tip of the overhang.

The OVERHANG PROTRUSION is measured horizontally out from the plane of the window.

The OVERHANG PROTRUSION, the HEIGHT of the overhang above the window, and the AZIMUTH, all determine the shading effect of an overhang.

```
Overhang PROTRUSION (inches)............? 12        12 inches     --> OK? YES
HEIGHT above top of window (inches).....? 12        12 inches     --> OK? NO
```

The user slips, and enters 12 instead of 24, and corrects it immediately.

```
HEIGHT above top of window (inches).....? 24        24 inches     --> OK? YES
Average window HEIGHT (feet)............? Edit...
```

The user notices that he/she should have entered 15 for the protrusion, and decides to edit the answer. The computer displays the present answers

```
 Current answers for WINDOWS named Front :

   A) NAME of the following windows...........? 'Front'
   B) Which window ORIENTATION................? 'South'
   C) Window TYPE.............................? 'Casement'
   D) GLAZING.................................? 'Single pane'
   E) DRAPES & SHUTTERS.......................? 'None'
   F) U-value (Btuh/sqft/F)...................? ' 1.1' Btuh/sqft/F
   G) Average sash FIT........................? 'Average'
   H) Specific LEAKAGE AREA (sqcm/sqft).......? ' .19' sqcm/sqft
   I) Summer SOLAR GAIN factor (%)............? ' 87' %
   J) Winter SOLAR GAIN factor (%)............? ' 87' %
   K) Window AREA (sqft)......................? '64' sqft
   L) Overhang PROTRUSION (inches)............? '12' inches
   M) HEIGHT above top of window (inches).....? '24' inches
   Y) < DELETE this Component >...
   Z) < RESUME questioning >...

Which menu ITEM(S)......................? L        L              --> OK? YES
```

The code letter for protrusion in the "menu" is L.

```
Overhang PROTRUSION (inches)............? 15       15 inches      --> OK? YES
```

This is the only answer the user wants to change.

```
 Current answers for WINDOWS named Front :

   A) NAME of the following windows...........? 'Front'
   C) Window TYPE.............................? 'Casement'
   D) GLAZING.................................? 'Single pane'
   E) DRAPES & SHUTTERS.......................? 'None'
   F) U-value (Btuh/sqft/F)...................? ' 1.1' Btuh/sqft/F
   G) Average sash FIT........................? 'Average'
   H) Specific LEAKAGE AREA (sqcm/sqft).......? ' .19' sqcm/sqft
   I) Summer SOLAR GAIN factor (%)............? ' 87' %
   J) Winter SOLAR GAIN factor (%)............? ' 87' %
   K) Window AREA (sqft)......................? '64' sqft
   L) Overhang PROTRUSION (inches)............? '15' inches
   M) HEIGHT above top of window (inches).....? '24' inches
   Y) < DELETE this Component >...
   Z) < RESUME questioning >...

Which menu ITEM(S)......................? Z        Resume/Complete--> OK? YES
```

The user decides that all the other answers are OK, and resumes questioning.

```
Average window HEIGHT (feet)............? 4        4 feet         --> OK? YES
```

That is the last question.

```
 Current answers for WINDOWS named Front :

   A) NAME of the following windows...........? 'Front'
   B) Which window ORIENTATION................? 'South'
   C) Window TYPE.............................? 'Casement'
   D) GLAZING.................................? 'Single pane'
   E) DRAPES & SHUTTERS.......................? 'None'
   F) U-value (Btuh/sqft/F)...................? ' 1.1' Btuh/sqft/F
   G) Average sash FIT........................? 'Average'
   H) Specific LEAKAGE AREA (sqcm/sqft).......? ' .19' sqcm/sqft
   I) Summer SOLAR GAIN factor (%)............? ' 87' %
   J) Winter SOLAR GAIN factor (%)............? ' 87' %
   K) Window AREA (sqft)......................? '64' sqft
   L) Overhang PROTRUSION (inches)............? '15' inches
   M) HEIGHT above top of window (inches).....? '24' inches
   N) Average window HEIGHT (feet)............? '4' feet
   Y) < DELETE this Component >...
   Z) < Changes COMPLETED >...

Which menu ITEM(S).......................? Z        Resume/Complete--> OK? YES
```

The answers are now complete and the user decides to save them. If not saved they are simply deleted.

```
SAVE this information...................? Y        Yes - save this--> OK? YES


  Current WINDOWS kinds are:

                 1) 'Front'
                 2) New WINDOWS...
          <ctrl Q> To quit WINDOWS...

Which menu ITEM (item no.)..............?  QUIT !
```

At this point, all the other house components should be entered.

****

All the other components are now being entered

in a similar fashion to "WINDOWS"

****

```
 Current HOUSE data:

           GENERAL   ( 6435 Hazel )      ECONOMIC  ( MoneyStuff )
           WINDOWS   ( Kitchen)           WINDOWS  ( East side )
           WINDOWS   ( Back yard )        WINDOWS  ( West side )
             DOORS   ( Front )              DOORS  ( Back )
             WALLS   ( Front )              WALLS  ( Garage )
             WALLS   ( East side )          WALLS  ( Back )
             WALLS   ( West side )       ROOF/CEI  ( Above )
          SUBFLOOR   ( Below )           HVAC-SYS  ( Furnace )
          INFILTRA   ( Leaks )           LANDSCAP  ( Area )
          APPLIANC   ( Jim&Marilyn )     ACTIVE-S  ( Water )

WHAT NEXT or Continue..................? O          Walls           --> OK? YES
```

The user decides he/she has made a mistake in WALLS and and asks to see them again, by typing the code letter o

```
  Current WALLS kinds are:

             1) 'Front'
             2) 'Garage'
             3) 'East side'
             4) 'Back'
             5) 'West side'
             6) New WALLS...
        <ctrl Q> To quit WALLS...

Which menu ITEM (item no.).............? 1          1 item no.      --> OK? YES
```

The mistake was thought to be in the front walls.

```
 Current answers for WALLS named Front :

   A) NAME for the following walls............? 'Front'
   B) Which wall ORIENTATION..................? 'South walls'
   C) Wall TYPE...............................? 'Two by Four Frame'
   D) Wall INSULATION.........................? 'None'
   E) INSULATABLE wall THICKNESS (inches).....? '3.5' inches
   F) Exterior INSULATING SHEATHING...........? 'None'
   G) Wall R-VALUE (F-sqft/Btuh)..............? '4.64001' F-sqft/Btuh
   H) Wall AREA wo/ windows & doors (sqft)....? '103' sqft
   I) No. of WINDOWS (No.)....................? '2' No.
   J) No. of VENTS in wall (No.)..............? '0' No.
   K) No. of other PENETRATIONS (No.).........? '2' No.
   L) Specific LEAKAGE AREA (sqcm/sqft).......? '.234466' sqcm/sqft
   Y) < DELETE this Component >...
   Z) < Changes COMPLETED >...

Which menu ITEM(S).....................? D          D               --> OK? YES
```

The user forgot the insulation in the walls, i.e. item D.

```
Wall INSULATION........................? List:

        N = None
        F = Fiberglass batts
        L = Fiberglass loose
        B = Fiberglass boards
        C = Cellulose fill
        U = UF-foam
        P = Polyurethane boards
        S = Polystyrene boards
        V = Vermiculite fill

Wall INSULATION........................? F         Fiberglass batt--> OK? YES

 Current answers for WALLS named Front :

   A) NAME for the following walls............? 'Front'
   B) Which wall ORIENTATION..................? 'South walls'
   C) Wall TYPE...............................? 'Two by Four Frame'
   D) Wall INSULATION.........................? 'Fiberglass batts'
 * E) Insulation THICKNESS (inches)...........? ' ' inches
 * F) INSULATABLE wall THICKNESS (inches).....? '3.5' inches
   G) Exterior INSULATING SHEATHING...........? 'None'
 * H) Wall R-VALUE (F-sqft/Btuh)..............? '4.64001' F-sqft/Btuh
   I) Wall AREA wo/ windows & doors (sqft)....? '103' sqft
   J) No. of WINDOWS (No.)....................? '2' No.
   K) No. of VENTS in wall (No.)..............? '0' No.
   L) No. of other PENETRATIONS (No.).........? '2' No.
   M) Specific LEAKAGE AREA (sqcm/sqft).......? '.234466' sqcm/sqft
   Y) < DELETE this Component >...
   Z) < Changes COMPLETED >...

 * Has DEFAULT value referenced to ITEM 'D' above.

Which menu ITEM(S).....................? EFH       EFH            --> OK? YES
```

The computer reminds the user that since there is now some insulation in the walls the defaults will have changed. The user reanswers those questions affected, EFH.

```
Insulation THICKNESS (inches)...........? Default:   3.5 inches     --> OK? YES
INSULATABLE wall THICKNESS (inches).....? Default:   0 inches       --> OK? YES
Wall R-VALUE (F-sqft/Btuh)..............? Default:   14.1242 F-sqft--> OK? YES
```

```
 Current answers for WALLS named Front :

   A) NAME for the following walls............? 'Front'
   B) Which wall ORIENTATION..................? 'South walls'
   C) Wall TYPE...............................? 'Two by Four Frame'
   D) Wall INSULATION.........................? 'Fiberglass batts'
   E) Insulation THICKNESS (inches)...........? ' 3.5' inches
   F) INSULATABLE wall THICKNESS (inches).....? ' 0' inches
   G) Exterior INSULATING SHEATHING...........? 'None'
   H) Wall R-VALUE (F-sqft/Btuh)..............? ' 14.1242' F-sqft/Btuh
   I) Wall AREA wo/ windows & doors (sqft)....? '103' sqft
   J) No. of WINDOWS (No.)....................? '2' No.
   K) No. of VENTS in wall (No.)..............? '0' No.
   L) No. of other PENETRATIONS (No.).........? '2' No.
   M) Specific LEAKAGE AREA (sqcm/sqft).......? '.234466' sqcm/sqft
   Y) < DELETE this Component >...
   Z) < Changes COMPLETED >...

Which menu ITEM(S).......................? Z        Resume/Complete--> OK? YES
```

Having entered those changes the user is finished.

```
SAVE this information...................? Y        Yes- save this---> OK? YES


  Current WALLS kinds are:

                1) 'Front'
                2) 'Garage'
                3) 'East side'
                4) 'Back'
                5) 'West side'
                6) New WALLS...
          <ctrl Q> To quit WALLS...

Which menu ITEM (item no.).............?  QUIT !


 Current HOUSE data:


            GENERAL  ( 6435 Hazel )      ECONOMIC  ( MoneyStuff )
            WINDOWS  ( Front )            WINDOWS  ( East side )
            WINDOWS  ( Back yard )        WINDOWS  ( West side )
              DOORS  ( Front )              DOORS  ( Back )
              WALLS  ( Front )              WALLS  ( Garage )
              WALLS  ( East side )          WALLS  ( Back )
              WALLS  ( West side )       ROOF/CEI  ( Above )
           SUBFLOOR  ( Below )           HVAC-SYS  ( Furnace )
           INFILTRA  ( Leaks )           LANDSCAP  ( Area )
           APPLIANC  ( Jim&Marilyn )     ACTIVE-S  ( Water )

WHAT NEXT or Continue..................? C        Continue        --> OK? YES
```

The user decides to continue to the calculations.

Other house components missing:

PASSIVE-SOLAR
GREENHOUSE

The computer reminds the user that a couple of possible components are missing.

ENTER, CALCULATE, RETROFIT or QUIT......? C

Calculate energ--> OK? YES

The user decides to continue to the energy calculations. The computer shows what it is doing as it proceeds.

Loading DATA COMPRESSION program

CIRA data compression 1.0

--READING DATA--
--COMPRESSING--
--WRITING--

Entering ENERGY CALCULATION program

CIRA energy calculations 1.0

--CALCULATING--
--WRITING--

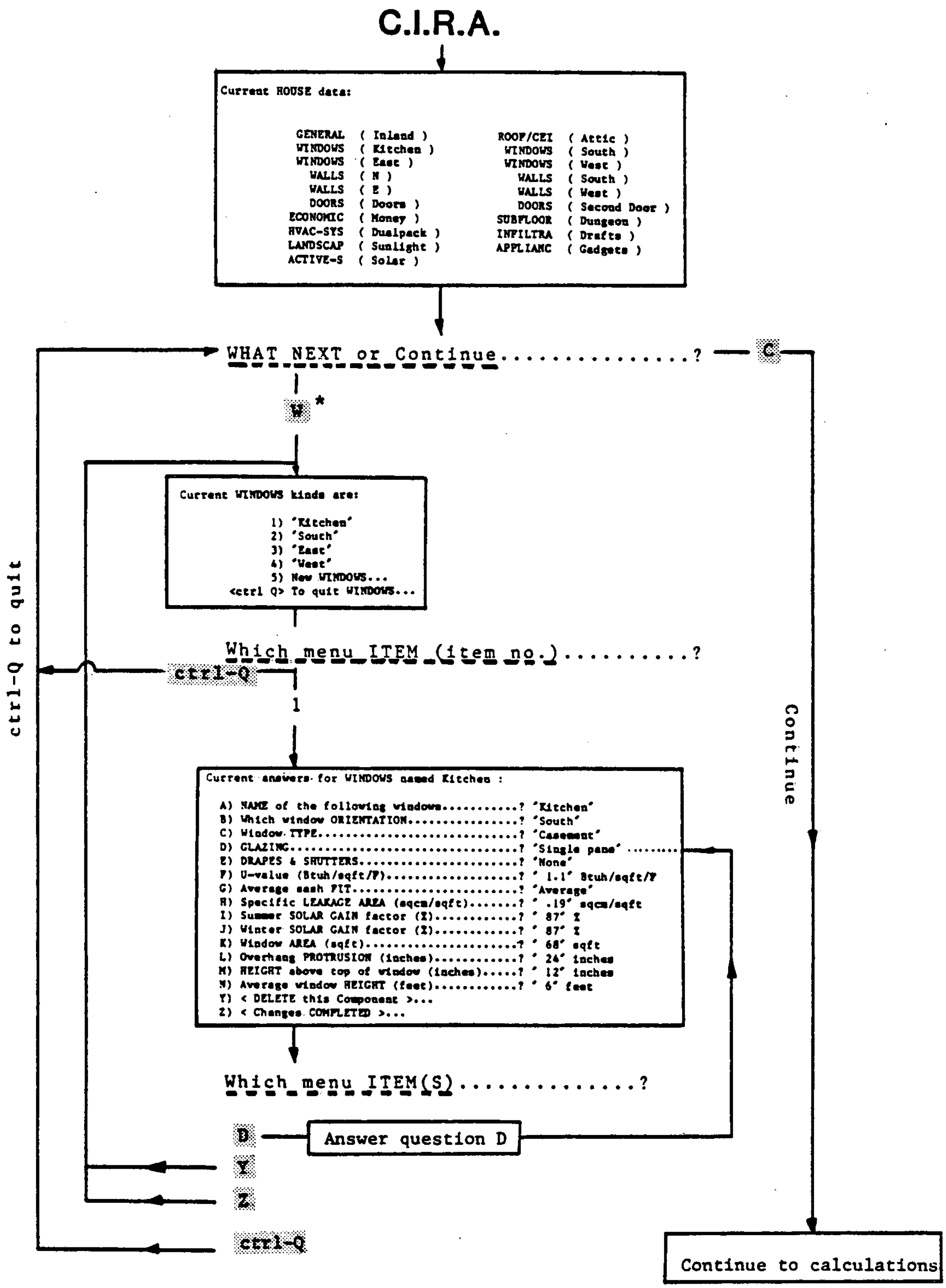
Entering PLOTTING program

CIRA plotting program 1.0

--READING DATA--

****AT THIS POINT THE COMPUTER PRINTS OUT THE RESULTS****

Details of the output are given in the "Output Guide" section.



User inputs

* Code letter. For a complete list, press ctrl-L

OUTPUT GUIDE

INSERT GOLDENROD DIVIDER

"OUTPUT GUIDE"

Section IV

OUTPUT GUIDE

CIRA produces two distinct types of output. The first is a design energy analysis of the building, i.e. data on month by month heating and cooling loads, energy use, infiltration rates and so on. This data is presented in both tabular and graphic forms. The second type of output is a retrofit package. This is the best set of retrofits for the building under consideration, given the investment limit, interest rate etc. that the user has chosen. The method by which this package is assembled is described in the section on economic optimization.

Design Energy Analysis

The output from the design energy analysis is tailored to the needs of the more technical user. A typical set of output data would be month by month values for the following parameters:

Daytime load (Mbtu)	Nighttime load (MBtu)
Daytime energy (MBtu)	Nighttime energy (MBtu)
Sky radiation loss (MBtu)	Free Heat (MBtu)
Infiltration (cfm)	Solar Savings Fraction (%)
Average temperature, day (F)	Average temperature, night (F)
Overall gas use (therms)	Overall gas use ($)
Overall electric use (kWh)	Overall electric use ($)
Solar gain (MBtu)	Space conditioning cost ($)

where M means "Mega", that is 10^6, and k means "kilo", that is 10^3.

The output may either viewed in tabular form, or plots of either one or two parameters may be made. Printouts can be made of both plots and tables. A calculator adds flexibility; arithmetic calculations may be made on the data, and the results placed either in a table or displayed as a plot. For example, cooling loads, which are presented as negative heating loads, may be extracted from the heating loads and plotted on the same graph as infiltration rates. A separate file stores related data on the house, including the city in which it is located, its altitude and latitude, and its UA-value.

The sample output session below illustrates some of the capabilities of this interactive output program.

A SAMPLE OUTPUT SESSION WITH THE CIRA DESIGN ENERGY PROGRAM

```
      ENTER COMMAND
Command/Code choices are as follows:
 'R' - REVIEW/TRANSFER data              'C' - CALCULATE between columns
'D/T' - DISPLAY related data            'L/F' - LIST at printer/file
 'P' - PLOT 1 or 2 columns               'Q' - TERMINATE program
```

	a Dload	b Nload	c D egy	d N egy	e Infil	f Sgain	g Rloss	h Spce$	
Jan:	15.1	12.3	26.9	22.0	391	0.96	1.4	272.8	:Jan
Feb:	9.2	7.3	16.5	13.0	351	1.34	1.2	164.7	:Feb
Mar:	7.2	6.2	12.9	11.1	359	2.32	1.4	133.9	:Mar
Apr:	1.9	1.3	3.3	2.4	294	2.91	1.2	32.0	:Apr
May:	-1.9	-0.0	-1.2	-0.0	270	3.70	1.2	24.9	:May
Jun:	-4.9	-0.8	-3.1	-0.5	251	3.97	1.0	73.9	:Jun
Jul:	-6.0	-1.2	-3.9	-0.8	229	3.73	1.1	95.1	:Jul
Aug:	-4.0	-0.7	-2.6	-0.4	232	3.17	1.1	61.0	:Aug
Sep:	-1.8	-0.2	-1.1	-0.1	232	1.97	1.0	26.4	:Sep
Oct:	3.5	2.4	6.2	4.3	295	1.60	1.3	58.3	:Oct
Nov:	6.4	4.4	11.4	7.8	324	0.85	1.2	107.2	:Nov
Dec:	11.2	8.2	20.0	14.6	384	0.68	1.4	193.2	:Dec
yr(sum):	35.8	39.2	85.4	73.3	3612	27.20	14.5	1243.4	
yr(mean):	3.0	3.3	7.1	6.1	301	2.27	1.2	103.6	

The above is the table which is the first output of the program. The options available to the user are:

a) to review or transfer data, that is, to look at any of the other output parameters which are not displayed here;
b) to display related data, such as location, UA-value and solar apertures;
c) to plot either one or two columns (either from this data set or from any of the other parameters; once they have been transfered to the screen)
d) to calculate using this data set, e.g. extracting the cooling load from the total space heating loads;
e) to send the information displayed on the screen either to a line printer (L) or to save it temporarily in a file (F) with other screenfuls of data and only print the whole file when it has been edited to suit the user's requirements;
or f) to terminate the program.

If the 'R' option is called, by pressing R, the table remains on the screen but the command/code choices are replaced by the following:

```
COLUMN to receive array A      +---------------------------------------+
^U to roll UP, ^D for DOWN     |                                       |
    Type Q to escape           |                                       |
                               |                                       |
          _                    > A) - Dload - Daytime load (MBtu)      <
                               |                                       |
                               | B) - Nload - Nighttime load (MBtu)    |
                               +---------------------------------------+
```

The box on the right should be imagined as a roller which contains the names of all available parameters. Pressing <ctrl-U> moves the roller up (pressing <ctrl-D> moves it down), and the Nighttime load advances to the center position. The item which is in the central position can be transferred to any of the columns in the table by typing the letter that is above that column. For example, imagine the user wants to display and plot overall electricity use. By pressing <ctrl-U>, the roller is advanced to show:

```
COLUMN to receive array O      +---------------------------------------+
^U to roll UP, ^D for DOWN     |                                       |
    Type Q to escape           | N) - Gas$  - Overall Gas use (dollars) |
                               |                                       |
          _                    > O) - TElec - Overall Elec use (kWh)   <
                               |                                       |
                               | P) - Elec$ - Overall Elec use (dollars)|
                               +---------------------------------------+
```

and by pressing, for example, "A", the monthly overall electric use data will be transferred to column "a". To plot data, the user must first escape from the review/transfer mode by pressing "Q". The original set of command/choices will be displayed at the top of the screen. The user can choose the plot mode by pressing "P". The set of command/choices will be replaced by the following:

```
Enter column for 1st PLOT

See prompt for instructions
Type Q to ESCAPE                    _
```

If the user has already transferred $ cost data into columns "g" and "h", they can be plotted by first pressing "G"> Then the prompt says:

```
2nd PLOT or <CR> for none                g _
```

The "g" indicates that the figures in column "g" will be plotted, and the computer is awaiting instructions for the second plot. If the user types "H", the following plot appears:

```
+-G-+---+---+---+---+---+---+---+---+---+---+---+ 300        CIRA PLOT
| g                                             |
| g                                             |      CIRA energy data
|  g                                            |
|  g                                            |              g       h
|   g                                           |            Gas $   Elec$
|   g                                       G   |
|    g                                     g    |      Jan:    291      24
|    g                                    g     |      Feb:    180      22
|     G                                   g     |      Mar:    148      24
|      gg                                g      |      Apr:     44      23
|        gG                              g      + 150  May:     11      49
|         g                             g       |      Jun:     10      97
|          g              H             G       |      Jul:     11     119
|          g            hh h           g        |      Aug:     12      85
|           g         Hh     h        g         |      Sep:     14      50
|           g        h       hH      g          |      Oct:     73      24
|            g      h          h    G           |      Nov:    124      23
|            g     h            h  g            |      Dec:    211      24
|             G   H             hH g            |
|              ghh                hh            | Year(sum):   1128     563
| HhhhHhhhHhhhHhg                G  hHhhhHhhhH |Year(mean):     94      47
+---+---+---+---+gGgggGgggGgggGggg--+---+---+---+ 0

 Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec  <L>print <F>ile <ANY>
```

The user may now make a printed copy of this plot by pressing "L" (for line printer), or by pressing "F" he/she may choose to store this plot in a file until it is convenient to print it. If the user presses "L", the computer will ask if the printer is ready; if the user presses "F" the computer will replace "<L>print <F>ile <ANY>" with "<Adding to HOUSE.PRN>". If any other key is pressed, the screen will return to the command/choice options.

The calculator is called by pressing "C". This replaces the command/choice options with the matrix of operators:

! enter	* multiply	/ divide	+ plus
- minus	¦ invert	@ change sign	^ y^x
> is x > y?	< is x < y?	= is x = y?	L $\log_e(x)$
) is x ≥ y?	(is x ≤ y?	# is x ≠ y?	X exp(x)
~ exchange x and y	' absolute value		

These are standard reverse polish notation (RPN) operators (similar to those used on Hewlett Packard calculators). The logic operators like ">" put +1 in the x register if the statement is true, 0 if it is false, and "roll down" the registers y, z, t into x, y, z, respectively. These operators may be used to carry out arithmetic manipulations of the data in one or more columns. As an example of the use of the logic operators, imagine the user wishes to extract the cooling load from the daytime space conditioning load. The total load is in column "a", so the operation to do this is a!!0>*. This asks if 0 is greater than "a"; if it is, the resulting +1 is multiplied by "a", otherwise the result is zero.

In this way, the data output may be manipulated to obtain the desired outputs from the standard ones, plots and tables made and the output formatted to suit.

Retrofit Package

If the retrofit option is chosen at the end of the inputs the computer will perform the retrofit optimization. When it is ready to print the output on the printer, the menu below appears on the screen. The output of the retrofit program consists of four pages of data; the user chooses which ones to print.

CIRA report generation -1.0-

—READING—

You have the following report options...

1. **General HOUSE summary**
2. **Retrofitting PERCENTAGE CHANGE summary**
3. **1st Retrofit ECONOMIC summary**
4. **2nd Retrofit ECONOMIC summary**

Your choice or 'Q' to quit []

The first page presents general data for the house: its location, floor area, infiltration rate etc. The name at the top of this page (and of the others) is the name given to the house in the "GENERAL" component of the input.

The second page presents the chosen package of retrofits, ordered by decreasing net savings-to-cost ratio. (For an explanation of this and other economic terms, see the "Economic Optimization" section.) There is a brief description of each retrofit, followed by the effect it has on the energy used for heating, cooling, water heating, and for miscellaneous appliances (e.g. the refrigerator). The reductions are all given as percentages of original use, and so the reduction from the whole package is the sum of the individual reductions. This page also shows the energy use of both the house as it now is and of the house as it would be with all the retrofits installed. The units are millions of British thermal units per year (MBtu/yr). To get Therms per year, multiply by ten; to get Gigajoules per year, multiply by 1.055; to get kilowatthours per year, multiply by 292.9.

Pages three and four contain the bulk of the economic data. They give such parameters as initial and maintenance costs, first year and life-cycle savings, discounted payback, and internal rate of return. What these are and how they are calculated are given in the "Economic Optimization" section. Again, the retrofits are listed in order of descending net savings-to-cost ratio. Several economic input variables are listed at the top of this page, such as the dollar limit on the cost of the retrofit package and the real increase (i.e. excluding general inflation) in the price of energy.

Once the chosen reports have been printed, the following menu appears on the screen:

CIRA report generation -1.0-
—READING—
At this point you can....

P: Run CIRA PLOT on the original house
R: RESTART with the original house
Q: Quit CIRA and return to CP/M

Your choice []

The following pages present a sample retrofit output from the CIRA program.

CIRA---------------------------------------COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT---------------------------------------CIRA

'6435 Hazel' house in WASH-DC at 14 feet.

Seasons:

The HEATING season is from October thru April.

The COOLING season is from May thru September.

Physical:

Floor AREA (sqft):	864	House VOLUME (cuft):	6912
Real DISCOUNT rate (%):	3.00	Real MAINT ESC rate (%):	4.00
Azimuth of NORTH face:	17 deg E of NORTH	Economic HORIZON (yr):	20

	Heating	Cooling
Seasonal INFILTRATION (cfm)	111.4	37.4
AIR EXCHANGE RATE (ach)	0.97	0.33

	Overall	Ceiling	Wall	Floor
UA value (Btu/hr/degF)	498.7	45.3	276.4	177.0
Leakage area (sqin)	104.9	41.9	29.2	33.8

	North	East	South	West	Horizontal
Heating SOLAR APERTURE (sqft)	32.51	34.92	15.63	15.19	10.75
Cooling SOLAR APERTURE (sqft)	32.51	34.92	15.63	15.19	10.75

System & Economics:

	Heating	Cooling	Water	Electric
Type of EQUIPMENT	Unit Gas	Room AC	Gas	-na-
Day/night THERMOSTAT (deg F)	68 / 63	78 / 83	130	-na-
Fuel PRICES ($/MBtu)	4.71	17.52	4.71	17.52
Real ESCALATION rate (%)	2.80	1.50	2.80	1.50

CIRA---------------------------------------COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT---------------------------------------CIRA

CIRA--COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT--CIRA

'6435 Hazel' house in WASH-DC at 14 feet.

Spent: $2366.00 Limit: $10000.00

ORIGINAL operating cost: $824.59/yr RETROFITTED op cost: $528.92/yr

	Heating	Cooling	Water	Electric
ORIGINAL house (MBtu/yr)	59.75	8.31	28.47	15.04
RETROFITTED house (MBtu/yr)	25.56	6.23	19.24	11.92
CHANGE in energy	-57.2%	-25.1%	-32.4%	-20.7%

	Retrofit DESCRIPTION	NAME & LOCATION	change in HEATING	change in COOLING	change in WATER HEATER	change in ELECTRIC
1	Lower Htg. THERMOSTAT by 3 F always	6435 Hazel GENERAL	-18.2%	0.0%	0.0%	0.0%
2	Set water htr. thermostat to 120 F	Jim&Marilyn APPLIANC	0.0%	0.0%	-5.7%	0.0%
3	Install R-6 water htr. blanket	Jim&Marilyn APPLIANC	3.2%	-6.7%	-13.7%	0.0%
4	Install LOW FLOW SHOWERHEAD	Jim&Marilyn APPLIANC	0.0%	0.0%	-13.0%	0.0%
5	AUTO. 5 F Htg. & Clg. NIGHT SETBACK	6435 Hazel GENERAL	-9.8%	-0.3%	0.0%	0.0%
6	Hang inside REFLECTIVE DRAPES	Back yard WINDOWS	-2.7%	-6.0%	0.0%	0.0%
7	Hang inside REFLECTIVE DRAPES	East side WINDOWS	-3.1%	-2.6%	0.0%	0.0%
8	Buy new EFFICIENT REFRIGERATOR	Jim&Marilyn APPLIANC	2.6%	-4.2%	0.0%	-20.7%
9	Put 5.5" fiberglass batts und. floor	Below SUBFLOOR	-23.4%	-3.7%	0.0%	0.0%
10	INSULATE with 3.5" blown-in cellulose	West side WALLS	-5.8%	-1.6%	0.0%	0.0%

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CIRA--COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT--CIRA

'6435 Hazel' house in WASH-DC at 14 feet.

Spent: $2366.00 Limit: $10000.00

Real DISCOUNT rate (%): 3.00 Real MAINT ESC rate (%): 4.00

	Heating	Cooling	Water	Electric
Type of EQUIPMENT	Unit Gas	Room AC	Gas	-na-
Fuel PRICES ($/MBtu)	4.71	17.52	4.71	17.52
Real ESCALATION rate (%)	2.80	1.50	2.80	1.50

	Retrofit DESCRIPTION	NAME & LOCATION	Initial COST	1st Year SAVINGS	Annualized MAINTENANCE	Net SAVGS to COST R
1	Lower Htg. THERMOSTAT by 3 F always --------------	6435 Hazel GENERAL	$0.50	$51.11	$0.03	999.9
2	Set water htr. thermostat to 120 F -------------	Jim&Marilyn APPLIANC	$0.50	$7.65	$0.10	294.9
3	Install R-6 water htr. blanket ----------------	Jim&Marilyn APPLIANC	$30.00	$19.22	$3.13	9.5
4	Install LOW FLOW SHOWERHEAD ------------------	Jim&Marilyn APPLIANC	$30.00	$17.39	$3.13	9.0
5	AUTO. 5 F Htg. & Clg. NIGHT SETBACK -------------	6435 Hazel GENERAL	$120.00	$28.17	$6.57	3.4
6	Hang inside REFLECTIVE DRAPES --------------------	Back yard WINDOWS	$123.00	$16.28	$3.21	1.8
7	Hang inside REFLECTIVE DRAPES --------------------	East side WINDOWS	$123.00	$12.59	$3.21	1.4
8	Buy new EFFICIENT REFRIGERATOR -----------------	Jim&Marilyn APPLIANC	$700.00	$53.45	$0.00	1.3
9	Put 5.5" fiberglass batts und. floor -----------------	Below SUBFLOOR	$904.00	$71.28	$11.78	1.2
10	INSULATE with 3.5" blown-in cellulose --------------	West side WALLS	$335.00	$18.54	$0.00	1.1

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CIRA---------------COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT---------------CIRA

'6435 Hazel' house in WASH-DC at 14 feet.

Spent: $2366.00 Limit: $10000.00

Real DISCOUNT rate (%): 3.00 Real MAINT ESC rate (%): 4.00

	Heating	Cooling	Water	Electric
Type of EQUIPMENT	Unit Gas	Room AC	Gas	-na-
Fuel PRICES ($/MBtu)	4.71	17.52	4.71	17.52
Real ESCALATION rate (%)	2.80	1.50	2.80	1.50

	Retrofit DESCRIPTION	NAME & LOCATION	Discounted PAYBACK	Cost CONSV FUEL (/MBtu)	Int RATE of RETURN	Net LIFE SAVINGS
1	Lower Htg. THERMOSTAT by 3 F always	6435 Hazel GENERAL	0.0yr	$0.01	999.9%	$999.63
2	Set water htr. thermostat to 120 F	Jim&Marilyn APPLIANC	0.1yr	$0.08	999.9%	$146.94
3	Install R-6 water htr. blanket	Jim&Marilyn APPLIANC	1.9yr	$1.32	56.4%	$253.83
4	Install LOW FLOW SHOWERHEAD	Jim&Marilyn APPLIANC	2.1yr	$1.39	51.2%	$241.12
5	AUTO. 5 F Htg. & Clg. NIGHT SETBACK	6435 Hazel GENERAL	5.7yr	$2.45	20.0%	$284.84
6	Hang inside REFLECTIVE DRAPES	Back yard WINDOWS	10.1yr	$3.50	10.3%	$103.81
7	Hang inside REFLECTIVE DRAPES	East side WINDOWS	14.3yr	$4.42	6.3%	$43.28
8	Buy new EFFICIENT REFRIGERATOR	Jim&Marilyn APPLIANC	14.9yr	$4.64	5.8%	$202.33
9	Put 5.5" fiberglass batts und. floor	Below SUBFLOOR	15.9yr	$4.83	5.3%	$217.51
10	INSULATE with 3.5" blown-in cellulose	West side WALLS	18.7yr	$5.79	3.7%	$22.65

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ENGINEERING METHODS

Section V

ENGINEERING METHODS

Table of Contents

INTRODUCTION

This section describes the heating and cooling methods developed for CIRA. The algorithms were designed to be as accurate and flexible as possible within the limitations of memory size and speed imposed by the microcomputer. To reduce computing time some of the calculations, such as those for air infiltration, total solar radiation distribution and degree-day coefficients, are done in advance for "standard conditions." The precalculated values are corrected to reflect the building and site characteristics under consideration.

Highlights of the heating and cooling algorithms are:

the calculation of effective conductances for below-ground walls and floors, in addition to a conventional "UA" approach for all other envelope components;

the concept of an effective leakage area and a leakage distribution of the house that, together with terrain information, is used to correct air infiltration values pre-calculated for standard condition;

the use of solar apertures and information on overhangs, to compute monthly average solar gains; solar apertures are calculated on the basis of window, wall and roof types and dimensions;

the concept of effective outdoor night and day temperatures that are functions of outdoor temperature, solar and other internal gains, sky radiation losses;

variable-base heating and cooling degree-days calculated from effective monthly temperatures using an empirical correlation formula. The loads calculated using the degree-days are further modified to account for thermostat setbacks, if any, using the concept of effective thermal mass of the house;

the calculation of output capacities and seasonal efficiencies of heating and cooling equipment, as functions of indoor and outdoor temperature and of part-load.

Previous papers [1,2] described aspects of an earlier version of this program. The method described here is a continuation of that work. Algorithms for treating overhangs, radiation loss to the sky and HVAC equipment efficiencies have been added. Moreover, the concept of dynamic degree-days has been improved to one of variable-base degree-days correlated to outdoor temperature.

What follows is a step by step review of the calculation algorithms used in CIRA. The basic calculation time step is one calendar month. Unless otherwise stated, all variables are monthly averages. Several variables are divided between day and night, defined, respectively, as the periods separated by 8 a.m. and 8 p.m.

HEAT CONDUCTION

A heat conduction coefficient, K, is computed as a sum of the conduction through all individual envelope components, such as walls, windows, doors, etc. For all components except subfloors, the standard assumption of one-dimensional heat flow is made.

$$K = \sum_{\text{all } i} U_i A_i \tag{1}$$

where: K is the overall heat conduction coefficient [W/°C]

U_i is the U-value of the i-th component [W/m^2-°C]

A_i is the area of the i-th component [m^2]

Subfloor Conduction

The assumption of one-dimensional heat flow, almost universal in calculating non-steady heat flow within buildings, is not acceptable for heat flow through the ground (especially for detached domestic buildings) because the edge effects are too important to ignore. To calculate U_{sf}, the effective subfloor U-value, we use separate algorithms for basements, crawl spaces and slab-on-grade floors.

For below-grade walls, the U-value is determined as follows. At a depth h below ground level there are two contributions to the R-value: the R-value, R_w, of the wall itself, and the R-value of the soil along the line of the heat flow. One finds (see for example [3]) that the lines of heat flow can be approximated by circular arcs with center at the point where the ground meets the wall. So the length of the line of heat flow is the length of this circular arc i.e. /2 h, and the R-value and U-value at a depth h is given by

$$R(h) = R_w + \frac{\pi h}{2K_g} \qquad U(h) = \left\{R_w + \frac{\pi h}{2K_g}\right\}^{-1} \tag{2}$$

where: R_w is the R-value of the wall [m^2-°C/W]

K_g is the soil thermal conductivity [W/m-°C]

To get the average U-value for the entire below-grade wall, U_{wb}, the U-value must be integrated over the depth below ground level, h, then divided by the total height, H.

$$U_{wb} = \frac{1}{H} \int_0^H \frac{dh}{R_w + \frac{\pi h}{2K_g}} = \frac{2K_g}{\pi H} \ln \left\{ 1 + \frac{\pi H}{2K_g R_w} \right\} \quad (3)$$

where: H is the total depth below grade [m]

This has been shown to give adequate agreement with the results of detailed three-dimensional, transient computer modeling [4].

Basements and Crawl Spaces

For basements and crawl spaces U_{sf}, the equivalent subfloor U-value, is calculated by combining the U-values of the components:

$$U_{sf} = \left\{ \frac{1}{U_f} + \frac{A_f}{A_{wa}U_{wa} + A_{wb}U_{wb} + A_f U_g} \right\}^{-1} \quad (4)$$

where: U_f A_f are the U-value and area of the floor above grade [W/°C-m², m²]

U_{wa} A_{wa} are the U-value and area of the part of the subfloor wall that is above grade [W/°C-m², m²]

U_{wb} A_{wb} are the U-value and area of the part of the subfloor wall that is below grade [W/°C-m², m²]

U_g is the U-value of the ground [W/°C-m²]

To calculate U_{wb}, equation (3) is used for basements, while for crawl spaces we use U_{wb} = 1.33 W/m²-°C (calculated from reference [5] assuming the depth of the foundation below ground to be 0.9m). To calculate U_g for the basement subfloor we use reference [6]:

$$U_g = (2.11 + R_{slab})^{-1} \quad (5)$$

For crawl spaces we use:

$$U_g = (4.23 + R_{slab})^{-1} \quad (6)$$

where: R_{slab} is 0.176 m²-°C/W (air film) plus the R-value of a slab, or insulation, or any other material on top of the ground.

Slab-on-grade

The U-values for slab-on-grade floors are determined using an algorithm developed by Muncey and Spencer [7] and adapted to microcomputer use by Kusuda [8]:

$$R_s = \frac{pF_c}{K_g}\left\{0.1208 + 0.0195\ \ln\left(\frac{K_g}{pC_f}\right) + 0.0011\left[\ln\left(\frac{K_g}{pC_f}\right)\right]^2 \right. \tag{7}$$

$$\left. + 0.2347\ \frac{t}{p} - 20.336\ \left(\frac{t}{p}\right)^2 - 0.1421\ \frac{t}{p}\ \ln\left(\frac{K_g}{pC_f}\right)\right\}$$

where: R_s is the modified soil thermal resistance [m^2-$^oC/W$]

t is the average wall thickness [m]

(which we assume to be 0.127m)

K_g is the soil thermal conductivity [W/m-^oC]

P is the slab perimeter length [m]

C_f is the slab thermal conductance between the room air and the slab soil interface, i.e. $(R_{slab})^{-1}$, [W/m^2-^oC]

F_c is the non-dimensional shape correction factor:

$$F_c = 0.0904 + 1.1115\ x - 0.2038\ x^2 \tag{8}$$

and:

$$x = \frac{\text{floor area}}{(p/4)^2} \tag{9}$$

R_s is combined with the slab thermal conductance to get the overall subfloor U-value for slab-on-grade, U_{sf}:

$$U_{sf} = (R_s + R_{slab})^{-1} \tag{10}$$

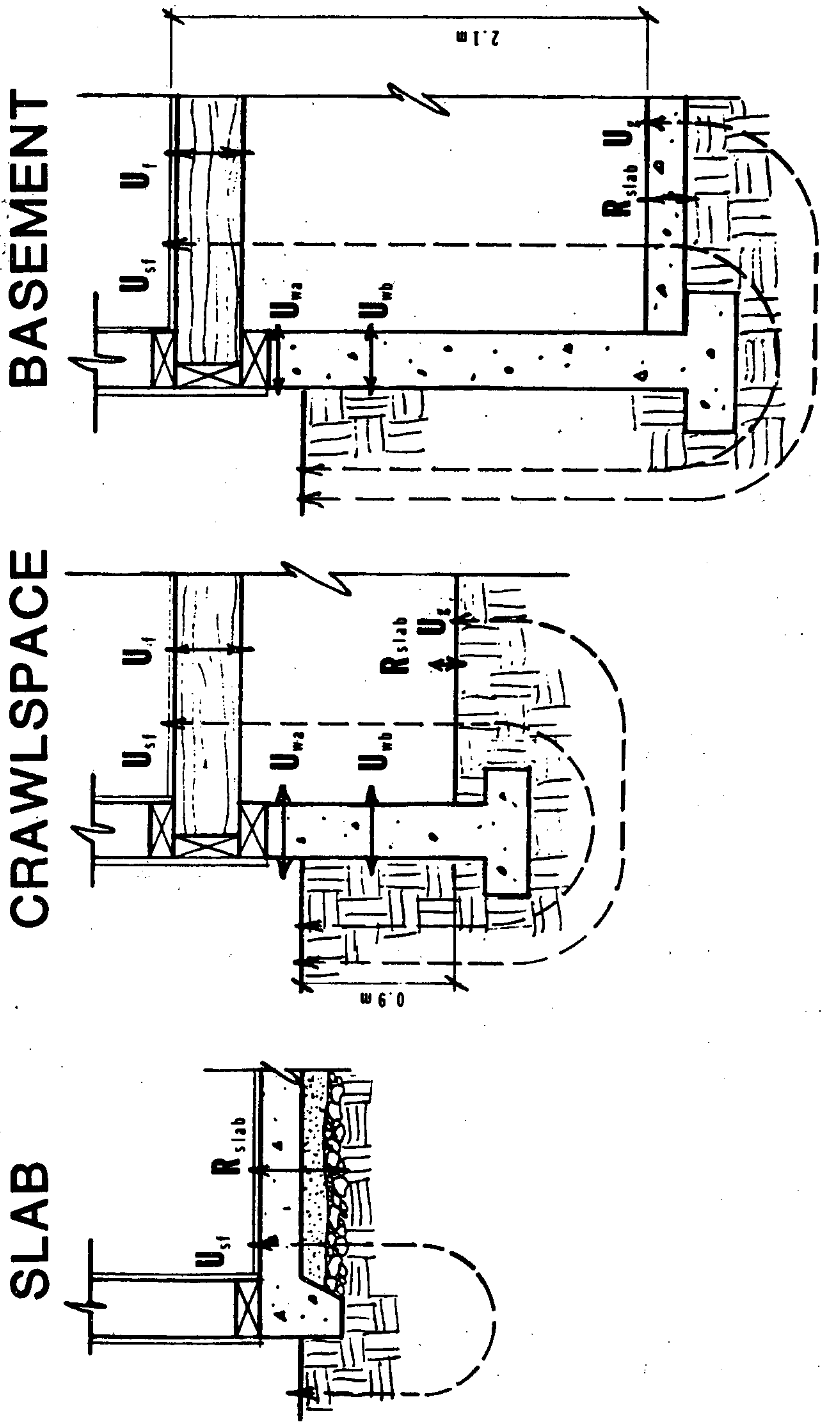


Figure 1. Illustration of terms used in equations 4 through 10.

Roof/Ceiling Conduction

The U-value of the roof/ceiling when there is a pitched roof and an attic space is given by:

$$U_{rc} = \left\{ \frac{1}{U_c} + \left(U_r \sqrt{1 + (\alpha/100)^2} + \rho c V_r \right)^{-1} \right\}^{-1} \quad (11)$$

where:
- U_{rc} is the U-value of the roof plus ceiling [W/°C-m²]
- U_c is the U-value of the ceiling [W/°C-m²]
- U_r is the U-value of the roof [W/°C-m²] (which we assume to be 1.04 W/°C-m²)
- ρc is the volumetric specific heat capacity of the air [Wh/°C-m²]
- V_r is the roof ventilation rate per unit area [m³/h-m²]
- α is the pitch of the roof [%]

For cathedral ceilings this becomes:

$$U_{rc} = \left\{ \frac{1}{U_c} \cdot \frac{1}{\sqrt{1+(\alpha/100)^2}} + \left(U_r \sqrt{1+(\alpha/100)^2} + \rho c V_r \right)^{-1} \right\}^{-1} \quad (12)$$

AIR INFILTRATION

Review

To compute air infiltration we use the model developed by Sherman and Grimsrud [9]. The leakage model used assumes the flow to be dominated by inertial effects (turbulent flow), implying that an area, L, can be defined to characterize the leakage:

$$Q = L\sqrt{\frac{2\Delta P}{\rho}} \tag{13}$$

where: Q is the air flow rate through the house [m^3/s]

ρ is the density of air [kg/m^3]

P is the average pressure difference across the house envelope [Pa]

The infiltration for each month is calculated as a superposition of flows from stack and wind effects, which are given by:

$$Q_{stack} = L\, f^{*}_{s}\, ((gH\Delta T)/T)^{1/2} \tag{14}$$

$$Q_{wind} = L\, f^{*}_{w}\, v \tag{15}$$

where: Q_{stack} is the stack induced infiltration [m^3/s]

Q_{wind} is the wind induced infiltration [m^3/s]

L is the total house leakage area [m^2]

g is the acceleration due to gravity [9.81 m/s^2]

H is the house height [m]

T is the absolute outside temperature [K]

ΔT is the inside to outside temperature difference [K]

v is the windspeed [m/s]

f^*_s is the reduced stack parameter:

$$f^*_s = \frac{1}{3}\left(1 + \frac{R_L}{2}\right)\left\{1 - \frac{X_L^2}{(2-R_L)^2}\right\}^{3/2} \qquad (16)$$

f^*_w is the reduced wind parameter:

$$f^*_w = C'\ (1 - R_L)^{1/3}\left\{\frac{\alpha\left[\frac{H}{10}\right]^{\gamma}}{\alpha_w\left[\frac{H_w}{10}\right]^{\gamma_w}}\right\} \qquad (17)$$

X_L and R_L are defined as:

$$R_L = (L_C + L_F) \div L \qquad X_L = (L_C - L_F) \div L \qquad (18)$$

where:

L_C and L_F	are the ceiling and floor leakage areas [m^2]
α and γ	are terrain parameters for the house
α_w and γ_w	are terrain parameters for the weather station site
C'	is a local shielding parameter
H_w	is the measurement site height [m]

Since the stack and wind effects interact through pressure, and since the infiltration is a function of the square root of pressure, it is assumed that the effects add as the square root of the sum of the squares of the individual wind and stack infiltration rates, i.e.:

$$Q = (Q^2_{wind} + Q^2_{stack} + Q^2_{unbalanced})^{1/2} \qquad (19)$$

where: $Q_{unbalanced}$ is the flow from unbalanced mechanical ventilation sources such as ventilator fans

The terrain and shielding parameters used in equation 17 are given below:

Terrain parameters for standard terrain classes

Class	gamma	alpha	Description
I	0.10	1.30	Ocean or other body of water with at least 5 km of unrestricted expanse
II	0.15	1.00	Flat terrain with some isolated obstacles (e.g. buildings or trees well separated from each other)
III	0.20	0.85	Rural areas with low buildings, trees, etc.
IV	0.25	0.67	Urban, industrial or forest areas
V	0.35	0.47	Center of big city (e.g. Manhattan)

Local shielding parameters

Class	C'	Description
I	0.324	No obstructions or local shielding whatsoever, e.g. desert.
II	0.285	Light local shielding with few obstructions. Perhaps a few trees or a small shed.
III	0.240	Moderate local shielding, some obstructions within two house heights. A thick hedge or a solid fence, or one neighboring house.
IV	0.185	Heavy shielding; obstructions around most of perimeter. Buildings or trees within 30ft in most directions. Typical suburban shielding.
V	0.102	Very heavy shielding, large obstructions surrounding perimeter within two house heights. Typical downtown shielding.

Leakage Area

The model computes air infiltration on the basis of leakage area, leakage distribution, building height, indoor-outdoor temperature difference and wind speed, and terrain and shielding classes. Normally, the leakage area is measured using a blower door, whereby a house is pressurized at several different pressure differences and the low-pressure region of the resulting curve of flow vs. pressure fitted to a turbulent flow equation. The leakage area is defined as:

$$L = Q_4\sqrt{\frac{\rho}{2\Delta P}} \tag{20}$$

where: Q_4 is the air flow extrapolated to a pressure difference of 4 Pa [m^3/s]

In the absence of actual measurements with a blower door, the floor ceiling and total leakage areas are calculated using specific leakage information on all envelope components:

$$L = \sum_{\text{all } i} l_i A_i \qquad L_F = \sum_{\text{all } i_F} l_{i_F} A_{iF} \qquad L_C = \sum_{\text{all } i_C} l_{i_C} A_{i_C} \tag{21}$$

where: L L_F L_C are the total, floor and ceiling leakage areas [m^2]

l_i is the specific leakage area of the i-th envelope component [m^2], of area A_i [m^2]

F C indicate that the component is part of the floor or ceiling

Specific leakage area, l_i, is the average amount of leakage associated with the i-th envelope component per unit component area, even though the leakage area will not usually be evenly distributed over the component. Measured (or where necessary estimated) values of specific leakage area are used to estimate the leakage area of components of the same type but different area.

The calculated leakage areas from equation (21) are used to divide up the total leakage area when component leakage areas are not measured. A correction ratio, r, is first calculated. It is the measured total leakage area divided by the calculated total leakage area, i.e. $r = L^m/L^c$. This factor is used as shown in the table below. L is the total leakage area, L_C is the ceiling leakage area, and L_F is the floor leakage area. Superscript c means calculated; no superscript means actual, i.e. measured.

Table 1: Floor and Ceiling Leakage areas

Areas measured:	None	Total only	Total+floor	Total+ceiling	All
Total leakage	L^c	L	L	L	L
Ceiling leakage	L_C^c	rL_C^c	rL_C^c	L_C	L_C
Floor leakage	L_F^c	rL_F^c	L_F	rL_F^c	L_F

Specific Air Infiltration for Reference Conditions

Temperature and average wind speed will vary for each month of CIRA's monthly calculations, while the reduced stack and wind parameters won't. Stack and wind effects are precalculated for a reference house in reference surroundings and are corrected to reflect actual circumstances and actual temperature difference. The reference house is a single-story dwelling (height=2.5m) with average leakage distribution (i.e., ceiling and floor leakage areas together are equal to the wall leakage area). The reference surroundings are terrain class III (rural areas with low buildings and trees) and shielding class III (some obstructions within two house heights). Thus for the reference house, R = 0.5, X = 0, H = 2.5 [m], T = inside temperature [K], T_o = outside temperature [K], and V = wind speed [m/s]. For the stack effect, the specific infiltration, Q/L, is given by:

$$\frac{Q}{L} = 2.0625 \left(\frac{\Delta T}{T}\right)^{0.5} \qquad (22)$$

where Q/L is in $m^3/s\text{-}m^2$. To get Q/L in $m^3/hr\text{-}cm^2$:

$$\frac{Q}{L} = 0.7425 \left(\frac{\Delta T}{T}\right)^{0.5} \qquad (23)$$

We calculate Q/L on an hour-by-hour basis, using an inside temperature of 20°C when the outside temperature is less than 20°C. When the outside temperature is greater than 25°C we use an inside temperature of 25°C. For periods when outside temperatures are between 20°C and 25°C we set ΔT equal to zero since the temperature in many houses "floats" under these mild temperature conditions. The 12 average monthly values are calculated by adding all hourly values and dividing by the number of hours per month.

For wind driven infiltration:

$$\frac{Q}{L} = f^*_w \, V \tag{24}$$

where:

$$f^*_w = C' \, (1 - R_L)^{1/3} \left[\frac{\alpha \left[\frac{H}{10}\right]^{\gamma}}{\alpha_w \left[\frac{H_w}{10}\right]^{\gamma_w}} \right] \tag{25}$$

For the reference house, C' = 0.24 (Shielding Class 3), alpha = 0.85, gamma = 0.20 (Terrain Class 3), R = 0.5 and H = 2.5 [m]. For the weather measurement site, common values are $alpha_w$ = 1.0 and $gamma_w$ = 0.15 (Terrain Class 2). H_w is the height of the wind sensor above grade [m].

Therefore, for these conditions:

$$\frac{Q}{L} = 0.1227 \left(\frac{V}{(0.1\, H_w)^{.15}} \right) \tag{26}$$

where Q/L is in $m^3/s\text{-}m^2$. To get Q/L in $m^3/hr\text{-}cm^2$,

$$\frac{Q}{L} = 0.0442 \left(\frac{V}{(0.1\, H_w)^{.15}} \right) \tag{27}$$

We find the monthly average value of the windspeed [m/s] from hourly values. The total air infiltration for any house is then given by:

$$Q = L \left(\{C_s q_s\}^2 + \{C_w q_w\}^2 + \{q_{unbalanced}\}^2 \right)^{1/2} \tag{28}$$

where: q_s q_w are the monthly specific stack and wind induced infiltrations $[m^3/h\text{-}cm^2]$

C_s C_w are factors to correct for the non-standard house in non-standard surroundings.

The correction factors are:

$$C_w = 8.15\ C' \left(1 - R_L\right)^{1/3} \alpha \left[\frac{H}{10}\right]^{\gamma} \quad (28)$$

$$C_s = 1.60 \left(1 + \frac{R_L}{2}\right) \left\{1 - \left(\frac{X_L}{2-R_L}\right)^2\right\}^{3/2} \sqrt{\frac{H}{10}} \quad (29)$$

The monthly specific infiltrations q_s and q_w [m^3/h-cm^2] for this reference house have been calculated for a number of cities using weather tapes; the values are stored in the weather files. Table 2 shows the values for Minneapolis and Los Angeles.

Table 2: Monthly specific infiltration [m^3/h-cm^2]

Minneapolis	Stack	Wind	Los Angeles	Stack	Wind
January	.244	.241	January	.108	.158
February	.228	.205	February	.111	.138
March	.203	.280	March	.110	.179
April	.137	.245	April	.090	.188
May	.096	.287	May	.069	.177
June	.056	.220	June	.058	.174
July	.042	.191	July	.033	.184
August	.042	.212	August	.031	.135
September	.093	.187	September	.037	.152
October	.129	.199	October	.062	.142
November	.187	.206	November	.088	.154
December	.226	.208	December	.107	.113

RADIATIVE HEAT EXCHANGES

Solar gains

The solar gains, S, for 5 orientations (including horizontal) are computed as a product of a solar aperture, a solar exposure modifier and the solar flux for that orientation. The total solar gain for the house is computed for each month as the sum of the above five solar gains.

$$S = \sum_{v=1}^{5} \sigma_v \, \psi_v \, \theta_v \left(I_v + \frac{1}{2} \rho_g \, I_5 \right) \quad (31)$$

where: v is a subscript denoting nominal orientation

σ_v is the solar aperture for the v-th orientation [m^2]

ψ_v is the solar exposure modifier for the v-th orientation

θ_v is the overhang modifier for the v-th orientation

I_v is the daily average total solar flux on a flat surface with orientation v [W/m^2]

I_5 is the daily average direct solar flux on a horizontal surface [W/m^2]. It is set to zero for horizontal surfaces, where v=5.

ρ_g is the ground reflectivity [fraction]

The solar apertures are calculated for walls, windows and roofs:

$$\sigma = SGF \; A \text{ (windows)} \qquad \sigma = \alpha_w \frac{UA}{h_o} \text{ (walls and roofs)} \quad (32)$$

where: SGF is the solar gain factor for a window [m^2]

A is the area of the window, wall or roof [m^2]

α_w is the short wave absorptivity of the wall or roof surface [fraction]

U is the U-value of the wall or of the roof/ceiling combination [W/m^2-^oC]

h_o is the outside film coefficient $[W/m^2\text{-}^oC]$

The solar gain factor, SGF, is defined as the ratio of transmitted solar heat gain to incident solar flux. It is similar to the concept of a shading coefficient, except that while SGF is 0.87 for a single pane window, the shading coefficient is defined to be 1.0 for the same case.

The overhang modifier, θ_v, describes the effects of overhangs, such as awnings and roof overhangs. A value of one indicates no obstruction; a value of 0.5 indicates that half as much solar flux reaches the house surface as in a totally unobstructed situation. It is set equal to unity for all directions except South, for which we use the correlations developed by Balcomb et al. [10]. The modifier is given as a function of the difference between latitude and monthly values of sun declination, with coefficients depending on the values of the separation and the overhang ratios. A sample of values of the coefficients for a vertical separation of zero is given in Table 3.

$$\theta_v = B_0 - B_1.X + B_2.X^2 - B_3.X^3 + B_4.X^4 - B_5.X^5 + B_6.X^6 \quad (33)$$

where: X = (Latitude - Declination)/100

Table 3.
Correlation Coefficients for the Overhang Modifier
Adapted from Passive Solar Design Handbook [10] for separation = 0

Parameter	B_0	B_1	B_2	B_3	B_4	B_5	B_6
P/H = 1/8	1.113	5.1346	34.787	110.97	188.87	164.35	57.283
1/4	1.389	10.2350	57.238	153.67	223.11	167.96	51.280
3/8	1.349	7.8189	28.720	42.75	27.37	5.710	
1/2	1.325	6.7539	19.550	20.28	6.90		

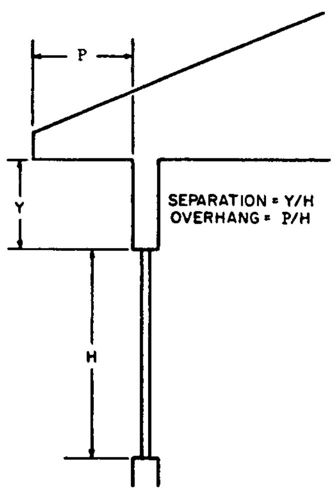


Figure 2. Geometry for overhang modifier; from reference [13].

The solar exposure modifier, ψ_V , (which describes obstruction by landscape features) is, whenever possible, measured using a solar site meter. (Otherwise it must be eyeballed.) Typically, such a device projects the view from the house in a particular direction on a flat surface that also carries the drawing of the apparent solar path for different months of the year. The proportion of the solar path not covered by the projected landscape features is the solar exposure modifier.

Day-night distribution of solar gains

So far we have only examined daily average solar gains. Most of these gains will be felt during daytime, some of them at night. If the indoor temperature is kept constant day and night, the partition between nighttime and daytime solar gains is not overly important, except for the swing months. If, however, the thermostat is set back at night (8pm to 8am), the partition becomes very important, especially for the spring and fall months. We model this partition by use of a solar storage factor, β , the fraction of the solar gain received over 24 hours released during the night period. How this factor is used will be shown in the section on internal gains. Numerical values for the solar storage factor, dependent mostly on the house's thermal storage, are derived from correlations of computer runs using the BLAST program [11] and are summarized below.

The energy data for various houses in various climates from the BLAST program is used to perform the following calculation. The exact energy consumption per hour as predicted by BLAST is compared to the energy gained/lost through steady state infiltration and conduction alone. In the absence of thermostat setbacks and any other internal gains, the difference is ascribed to solar storage.

$$\Delta_i = (K + \rho c Q)(T_i^{in} - T_i^{out}) - E_i \qquad (34)$$

where:

Δ_i	is the energy absorbed/released by solar storage [Wh]
E_i	is the "exact" energy consumption of the house [Wh]
K, $\rho c Q$	are the conduction and infiltration losses [W/^oC]
T^{in} T^{out}	are the inside and outside temperatures [^oC]
i	runs from 1 to 24 and indicates hourly quantities

The solar storage factor is defined as the "extra" energy released during the night period:

$$\beta = \frac{\sum_{8pm}^{8am} \Delta_i}{\sum_{all\ i} \Delta_i} \qquad (35)$$

β varies with the climate, in particular with outside temperature. An empirical correlation between β and outside temperature was developed for use in the program.

$$\beta = \beta_m \left(1.64 - T_m/38.7\right)^{\frac{0.44}{\beta_m}} \qquad \text{for } T_m > 21 \qquad (36)$$

$$\beta = \beta_m \left(.56 + T_m/38.7\right)^{\frac{0.44}{\beta_m}} \qquad \text{for } T_m \leqslant 21 \qquad (37)$$

$$T_m = T + \frac{S + F - \Delta R}{K + \rho c Q} \qquad (38)$$

where:

- β_m is a first approximation to the solar storage factor based on house mass: light, β_m= 22; medium, β_m= .28 heavy; β_m= .34.
- T is the daytime average outdoor temperature [°C]
- S is the daily solar gain [W]
- F is the daily "free heat" [W]
- ΔR is the daytime sky radiation loss [W]
- K is the building conduction constant [W/°C]
- ρcQ is the building infiltration heatloss constant [W/°C]

Sky Radiation Losses

The heat losses to the sky are calculated using the concept of an equivalent sky temperature, T_{sky}, related to the sky emissivity and the outdoor temperature through the equation:

$$T_{sky} = \varepsilon_{sky}^{1/4} \; T_o \qquad (39)$$

where: T_o is the outside air temperature [K]
ε_{sky} is the clear sky emisssivity

The clear sky emissivity is estimated from the water vapor pressure, P_v, [Pa] using the equation from Brunt [12a], as validated and differentiated into day and night by Berdahl and Fromberg [12b]:

$$\varepsilon_{sky} = 0.556 + 0.0059 \, \{P_v^{0.5}\} \quad \text{Daytime} \qquad (40)$$

$$\varepsilon_{sky} = 0.572 + 0.0059 \, \{P_v^{0.5}\} \quad \text{Nighttime} \qquad (41)$$

The vapor pressure is estimated from the monthly average dry bulb and wet bulb temperatures and from the site altitude. Standard ASHRAE psychrometric routines are used [13]. Excluding solar terms that are lumped into the concept of solar aperture, we can write an energy balance for the roof:

$$q_r = h_c \left(T_r - T_o\right) + \sigma \left(\varepsilon_r \, T_r^4 - \varepsilon_{sky} \, T_o^4\right) \qquad (42)$$

where: q_r is the total heat flow from the roof [W/m^2]

h_c is the convective film coefficient [$W/m^2\text{-}^oC$]

ε_r is the roof emissivity

σ is the Stephan-Boltzmann constant [$5.67 \; 10^{-8}$ $W/m^2\text{-}K^4$]

T_r is the roof surface temperature [K]

Expanding the last term in equation 42 as the difference of two squares, twice, and using the approximation for T^3_o:

$$4\,T_o^3 \approx \left\{T_r^2 + \left(\frac{\varepsilon_{sky}}{\varepsilon_r}\right)^{1/2} T_o^2\right\}\left\{T_r + \left(\frac{\varepsilon_{sky}}{\varepsilon_r}\right)^{1/4} T_o\right\} \qquad (43)$$

then the heat flow from the roof is:

$$qr \approx h_c \left(T_r - T_o\right) + 4\sigma\, \varepsilon_r\, T_o^3 \left\{ T_r - \left(\frac{\varepsilon_{sky}}{\varepsilon_r}\right)^{1/4} T_o \right\} \quad (44)$$

Using the approximation $T_o^4 \simeq T_o^3 T_r$, this can be rewritten as:

$$q_r = h_o \left(T_r - T_o\right) + 4\sigma\, \varepsilon_r\, T_o^4 \left\{ 1 - \left(\frac{\varepsilon_{sky}}{\varepsilon_r}\right)^{1/4} \right\} \quad (45)$$

where h_o is the familiar radiative-convective film coefficient [W/m^2-^{o}C]:

$$h_o = h_c + 4\sigma\, \varepsilon_r\, T_r^3 \quad (46)$$

The heat flow into the roof is given by:

$$q_r = U^* \left(T_i - T_r\right) \quad (47)$$

where: U^* is the U-value from inside the roof to the roof outer surface, i.e. without the film coefficient [W/m^2-^{o}C]

$$U = \frac{U^* h_o}{U^* + h_o} \quad (48)$$

T_i is the inside temperature [^{o}C]

Equating the expression for heat flow into the roof and that for heat flow out of the roof:

$$T_r = \frac{U\, T_i}{h_o} + \frac{U\, T_o}{U^*} - \frac{4\sigma\, \varepsilon_r\, T_o^4}{U^* + h_o} \left\{ 1 - \left(\frac{\varepsilon_{sky}}{\varepsilon_r}\right)^{1/4} \right\} \quad (49)$$

Solving for q_r:

$$q_r A = U\, A \left(T_i - T_o\right) + \frac{U\, A\, 4\sigma\, \varepsilon_r\, T_o^4}{h_o} \left\{ 1 - \left(\frac{\varepsilon_{sky}}{\varepsilon_r}\right)^{1/4} \right\} \quad (50)$$

The first term is already included in our overall conduction coefficient, K [W/^{o}C]. The second term is a radiative loss term, which we treat as a negative internal gain.

The foregoing analysis is for horizontal surfaces; it can be shown that the radiative loss per unit surface for a vertical surface is approximately one-third that for a horizontal surface because of the smaller aspect ratio. Then the total radiation loss to the sky, ΔR [W], can be expressed as:

$$\Delta R = 4\sigma T_o^4 \left\{1 - \left(\frac{\varepsilon_{sky}}{\varepsilon_r}\right)^{1/4}\right\} \left\{\sum_{roof} U_r A_r \varepsilon_r + \frac{1}{3}\sum_{walls} U_w A_w \varepsilon_w\right\} \quad (51)$$

where: ε_r ε_w are the long wave emissivities of the roof and walls

A_r A_w are the areas of the roof and walls [m^2]

U_r U_w are the U-values of the roof and walls [W/m^2-^oC]

("Walls" include all vertical envelope components.)

As shown in the next section, we include the radiative term by lumping it with the internal and solar gains. The conductive term we include with the overall conduction coefficient, K.

INTERNAL GAINS AND EFFECTIVE OUTSIDE TEMPERATURE

Internal gains are computed on a month-by-month basis, separately for night and day, as the sum of solar gains, S, and other gains from appliances, lighting and people, referred to as "free heat," F^d by day and F^n by night, minus the radiation loss to the sky, ΔR^d by day and ΔR^n by night. The ratio of internal gains and the overall building loss coefficient (encompassing both conduction and infiltration) has dimension of a temperature: it describes the outdoor temperature increase equivalent to the internal gains. This suggests the definition of effective outdoor temperature:

$$T_{eff}^{day} = T_o^d + \frac{2(1-\beta)S + F^d - \Delta R^d}{K + \rho c Q} \qquad (52)$$

where:

T_{eff}	is the effective daytime outdoor temperature [°C]
T_o^d	is the actual daytime outdoor temperature [°C]
β	is the solar storage factor, as defined above
S	is the average daily solar gain [W]
F^d	is the average daily free heat [W]
ΔR^d	is the average daily sky radiation loss [W]
K	is the building conduction heatloss constant [W/°C]
ρcQ	is the building infiltration heatloss constant [W/°C]

and similarly for the nighttime effective temperature:

$$T_{eff}^{night} = T_o^n + \frac{2\beta S + F^n - \Delta R^n}{K + \rho c Q} \qquad (53)$$

The effective outdoor temperature is that outdoor dry-bulb temperature that would produce the same heat transfer through the envelope by conduction and convection only, under steady-state conditions, as the superposition of conductive, convective and radiative heat transfer (short and long-wave) and internal "free heat" actually occuring. The effective temperature is related to the conventional indoor base temperature, T_b, and the average indoor temperature, T_a, by the equation:

$$T_{eff} - T_o = T_a - T_b \qquad (54)$$

THERMOSTAT SETBACKS

If there were no changes in indoor temperature between night and day, one could now proceed and calculate monthly loads, part-load efficiencies and energy consumptions. In the case of a change in indoor temperature between night and day, however, one must calculate average daytime and nighttime indoor temperatures and the quantities of heat released and absorbed by the house during such indoor temperature changes.

We define several temperatures [°C] as indicated in Fig. 3:

T_s^d is the thermostat setting for the day.

T_b^d is the room temperature at the beginning of the day.

T_e^d is the room temperature at the end of the day.

T_a^d is the average indoor temperature throughout the day.

T_{inf}^d is the indoor temperature that would be reached after infinite time.

T_{eff}^d is the effective outdoor temperature throughout the day.

An identical series of temperatures is defined for the nighttime.

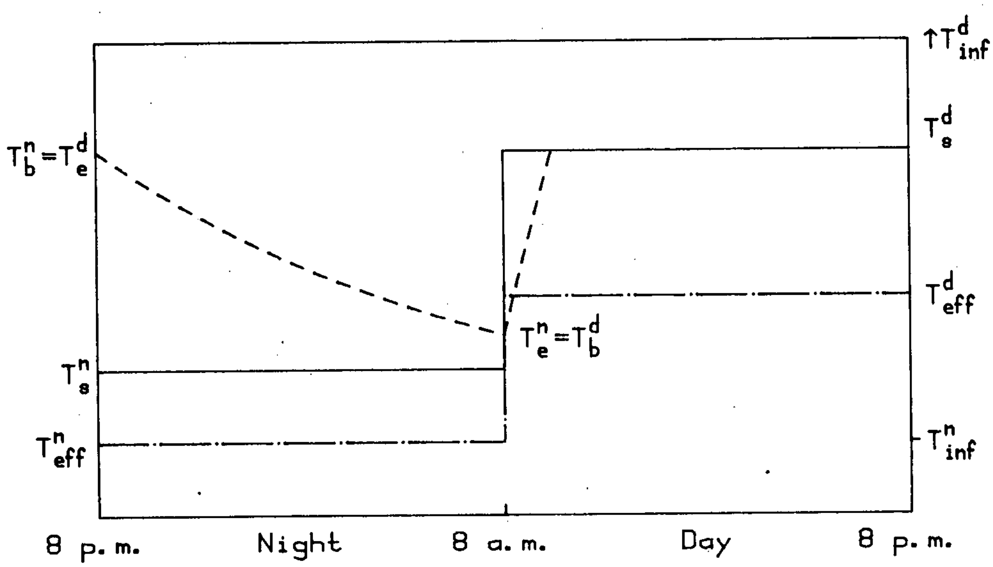


Fig. 3: Schematic Night Thermostat Setback, Heating

For simplicity in the following example we treat only the heating case where the daytime thermostat setting is higher than the nighttime setting. The program permits the three other combinations of heating and cooling, daytime and nighttime setbacks.

We start at 8pm when the thermostat setting is lowered and the house temperature begins to float downwards towards the outside effective temperature, T_{eff}, which is also the infinite temperature, T_{inf}:

$$T_{inf} = T_{eff} \tag{55}$$

The temperature during the float period is given by:

$$T(t) = T_{inf} + (T_b - T_{inf})e^{-t/\tau} \tag{56}$$

where: t is the time since 8pm [h]

τ is the principal time constant of the house [h]

$$= M \div (K + \rho cQ) \tag{57}$$

M is the equivalent thermal capacity of the house [Wh/°C]

K is the building conduction heatloss constant [W/°C]

ρcQ is the building infiltration heatloss constant [W/°C]

Q is the seasonal average infiltration rate [m^3/h]

The equivalent thermal capacity, M, is estimated for three types of houses, "Light", "Medium", and "Heavy". At 8am when the equipment reheats the house, the indoor temperature rises up towards the daytime T_{inf}, defined as:

$$T_{inf} = T_{eff} + \{ IH \div (K + \rho cQ) \} \tag{58}$$

where: I is a seasonal index, 1 for heating, -1 for cooling
H is the heating system capacity, as defined below

There are three cases to consider depending on the comparative magnitudes of the effective outdoor temperature:

a) The outdoor effective temperature is so low compared to the new thermostat setting, that, after some free floating, the indoor temperature reaches the new thermostat setting and heating resumes.

b) The outdoor effective temperature is comparable to the new thermostat setting and the indoor temperature floats throughout the entire period.

c) The outdoor effective temperature is higher than the thermostat setting. In this case we assume that the thermostat setback has no effect and the indoor temperature stays constant.

All three cases can be described by algebraic inequalities. The equations governing thermostat setbacks are:

Case a) -- "Partial float"

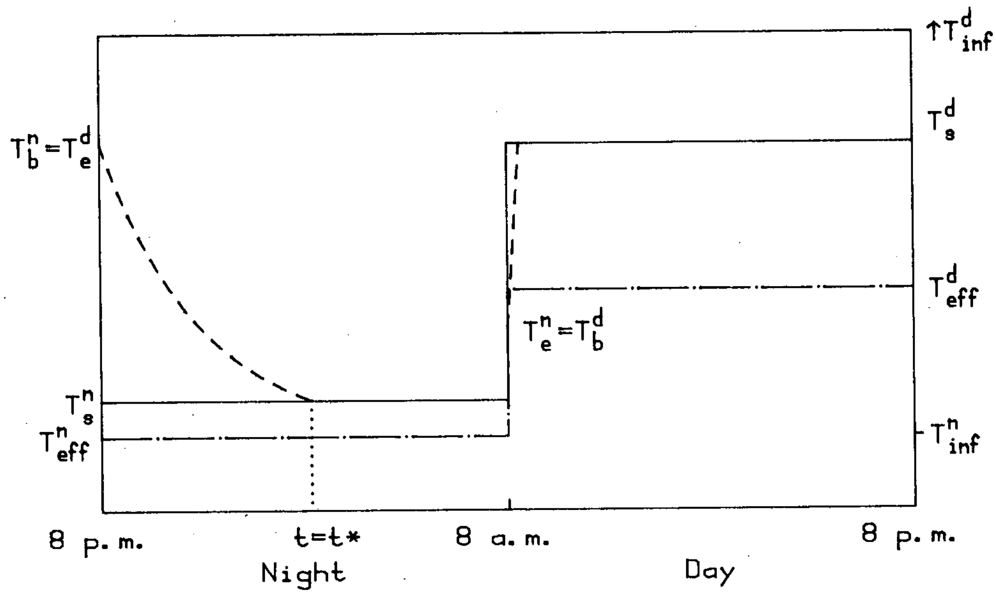


Fig. 4: Schematic Night Thermostat Setback, Heating

We have:

$$T_e = T_s \tag{59}$$

The time t^* at which heating resumes, is the time at which the indoor temperature equals the setpoint temperature, i.e.:

$$T_s - T_{inf} = (T_b - T_{inf})\, e^{-t^*/\tau} \tag{60}$$

$$t^* = \tau \ln (1 + x) \tag{61}$$

Thus partial float occurs if the time at which heating resumes is less than 12 hours. The average temperature, T_a, is given by:

$$T_a = T_s + (T_b - T_s) \frac{\tau}{12} \left\{ 1 - \frac{\ln(1 + x)}{x} \right\} \tag{62}$$

where:

$$x = \frac{T_b - T_s}{T_s - T_{inf}} \tag{63}$$

Case b) -- "All-float"

The temperature floats exponentially for the entire 12 hour period, as illustrated in Figure 3.

$$T_e = T_b - (T_b - T_{inf})\ (1 - e^{-12/\tau}) \tag{64}$$

$$T_a = T_{inf} + (T_b - T_e)/12 \tag{65}$$

The condition for "all-float" is that the final nighttime temperature, T_e, is greater than the nighttime thermostat setpoint, T_s.

Case c) -- "No float"

There are no temperature changes in this condition.

$$T_e = T_b = T_s = T_a \tag{66}$$

VARIABLE-BASE DEGREE-DAYS

Given the indoor average night and day temperatures for each month, CIRA requires weather data on effective outdoor temperature for day and night to find heating and cooling loads. The effective outdoor temperature is that outdoor dry-bulb temperature that would produce the same heat transfer through the envelope by conduction and convection only, under steady-state conditions, as the superposition of conductive, convective and radiative heat transfer (short and long-wave) and internal "free heat" actually occuring. Thus the weather data required is the monthly sum of the hourly difference between average indoor temperature and effective outdoor temperature. This degree-day sum is calculated separately for day and for night.

$$DD_{T_{am}} = \sum_{n=1}^{d} \frac{1}{12} [DH_{T_{am}}] \tag{67}$$

$$DH_{T_{am}} = \sum_{i=i^*}^{i^*+12} [I(T_{am} - T_{o_i})]_+ \tag{68}$$

where:

- T_{am} is the average indoor temperature for mode m [^oC]
- T_{o_i} is the hourly effective outside temperature [^oC]
- i is an hourly index starting at either 8 a.m. or 8 p.m.
- d is the number of days in the month
- m is the degree-day mode [heating day, heating night, cooling day, and cooling night]
- I is a seasonal index (1 for heating, -1 for cooling)
- $[X]_+$ is equal to X when X is greater than zero, else zero
- $DD_{T_{am}}$ is the number of monthly degree-days at average indoor temperature a and mode m [^oF-"day" or ^oF-"night"]
- $DH_{T_{am}}$ is the number of daily (i^* = 8 a.m.) or nightly (i^* = 8 p.m.) degree-hours at average indoor temperature a and mode m [^oC]

In an hour by hour program, this summation would be carried out directly. For CIRA, we developed a function of monthly average indoor temperature and monthly average effective outdoor temperature to predict the monthly values of these summations. We chose to develop our own correlation method rather than use an existing one, e.g. [14], because of our need to differentiate between night and day. The function is:

$$DD = \frac{d}{2}\left\{[I(\Delta T)]_+ + \mu[\lambda - |\Delta T|]_+^v\right\} \quad (69)$$

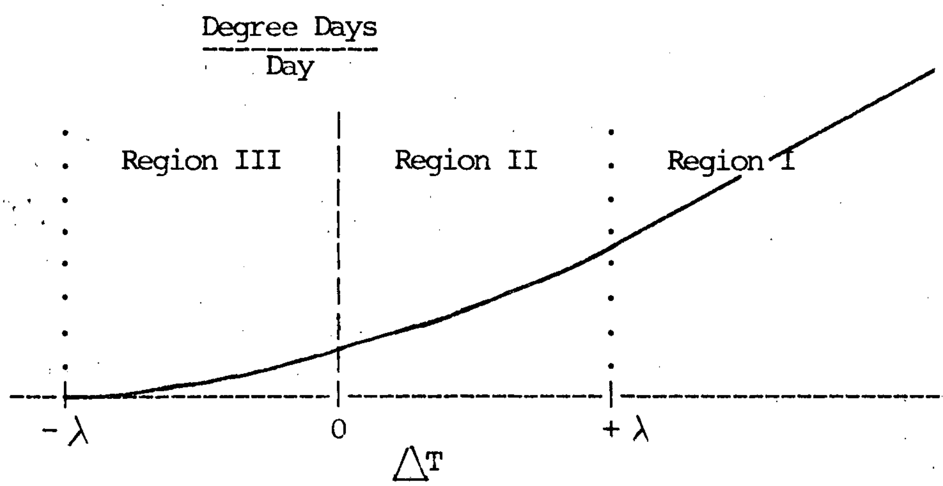


Figure 5: CIRA degree day correlation.

where: $$\Delta T = T_a - T_{eff} \quad (70)$$

DD	are the predicted degree-days or degree nights [°C]
I	is a seasonal index (1 for heating, -1 for cooling)
d	is the number of days in the month
μ, v	are dimensionless empirical degree-day coefficients (one set for each combination of heating/cooling & day/night)
λ	is an empirical degree-day temperature (one for each combination of heating/cooling & day/night [°C]
$[X]_+$	is equal to X when X is greater than zero, else it is zero
T_a	is the average indoor day/night temperature [°C]
T_{eff}	is the effective monthly outdoor day/night temperature [°C].

The equation splits into three regions. For the heating mode, there is a low temperature region (ΔT greater than λ) where the degree days per day are equal to 1/2 ΔT; an intermediate region where 1/2 ΔT plus a power fit is used; and a third, high-temperature region, where the power fit only is used.

In Region I, the second term in the equation is zero, since $[X]_+$ is equal to zero when X is negative. Thus the equation reduces to the simple degree day equation:

$$DD = \frac{d}{2}\left\{[I(T_a - T_{eff})]_+\right\} \tag{71}$$

In Region II, both terms are present in the equation, and the inside temperature $[T_a]$ is greater than the effective outside temperature $[T_{eff}]$. Thus the function is:

$$DD = \frac{d}{2}\left\{[I(T_a - T_{eff})]_+ + \mu[\lambda - (T_a - T_{eff})]^{\nu}{}_+\right\} \tag{72}$$

In Region III, the first term is zero and the inside temperature is less than the effective outdoor temperature. Thus the function is:

$$DD = \frac{d}{2}\left\{\mu[\lambda - (T_a - T_{eff})]^{\nu}{}_+\right\} \tag{73}$$

The values of μ, ν and λ can be found using a curve fit to conventional degree days. This is because our definition is identical to the conventional definition of degree days to base T_b for actual outside temperature T_o. By comparison with equation 54, the base temperature is defined as:

$$T_b = T_a - (T_{eff} - T_o) \tag{74}$$

The Weather Library gives details of the curve fit routine that we use. Figure 6 shows a comparison of actual degree days calculated from hour by hour data, and degree days calculated by this correlation method. (Here, "degree days" is used in the sense of the sum of the CIRA "degree-days" plus CIRA "degree-nights".)

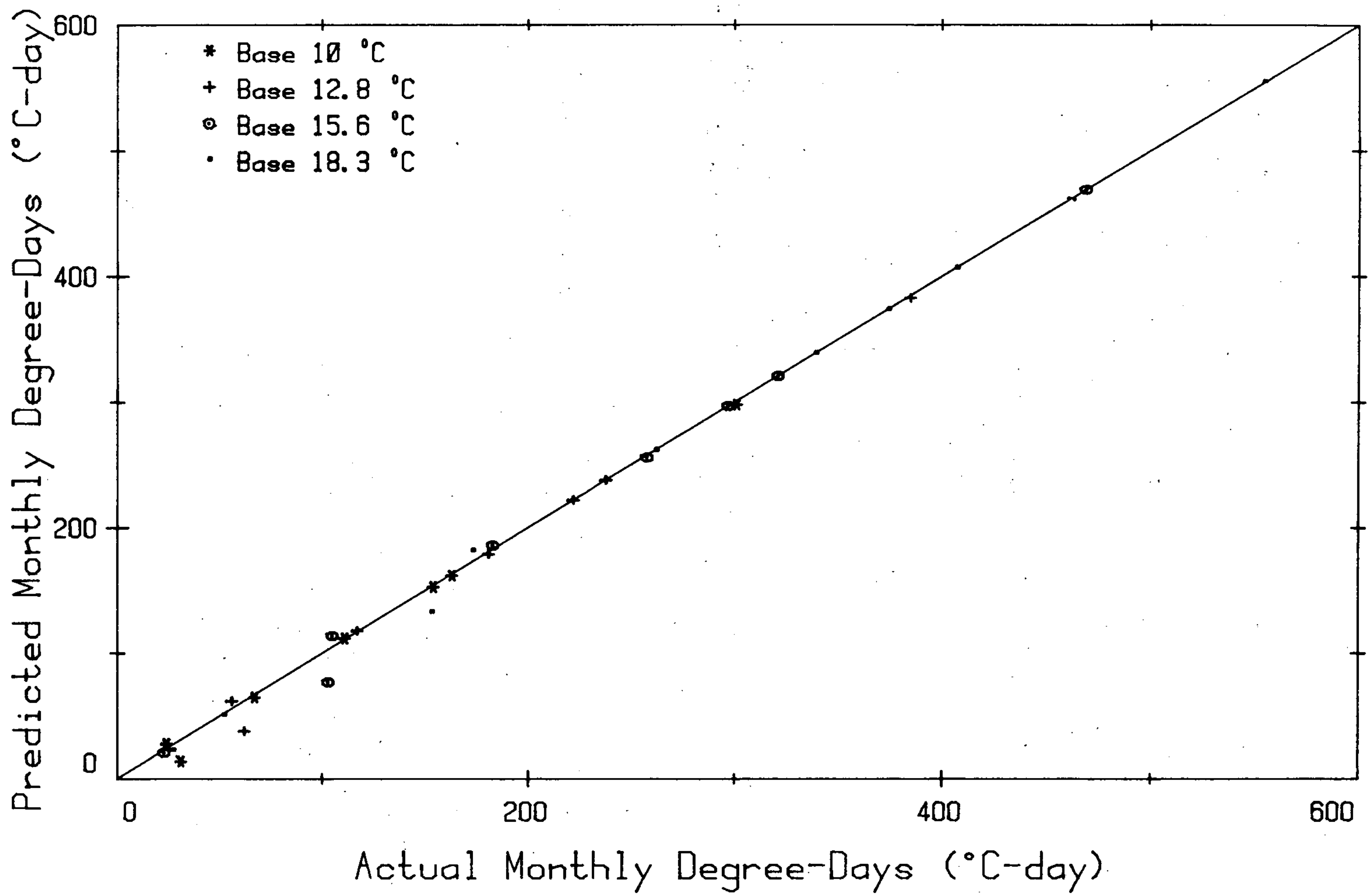


Figure 6. Comparison of CIRA variable-base degree days vs. actual degree days at various bases for Washington, DC. Actual degree days are calculated from a Test Reference Year (TRY) tape.

HEATING AND SENSIBLE COOLING LOADS

If there were no thermostat setback, the heating or sensible cooling load L^* [Wh/day] would be:

$$L^* = 24\ (K + \rho cQ)\ DD \tag{75}$$

where: K is the building conduction heatloss coefficient [W/°C]

ρcQ is the building infiltration heatloss coefficient [W/°C]

DD is the number of degree days per day

Where there is a heating season thermostat setback, the maximum amount of heat H_{max} [Wh/day or Wh/night] released or absorbed during a change in thermostat setting is:

$$Hmax = M \left| T_s^d - T_s^n \right| \tag{76}$$

where: M is the equivalent thermal capacity of the house [Wh/°C]

T_s^d is the daytime thermostat setting [°C]

T_s^n is the nighttime thermostat setting [°C]

The actual amount of stored heat, [Wh/day or night] released or absorbed is the lesser of H_{max} and L* (evaluated for the period during which the temperature floats):

$$H^* = \text{minimum}\ [L^*\ ;\ H_{max}\ ] \tag{77}$$

Thus, the actual heating load is calculated as:

$$L_{float} = I(L^* - H^*) \tag{78}$$

$$L_{recharge} = I(L^* + H^*) \tag{79}$$

Cooling loads are calculated similarly. However, note that cooling loads are negative numbers.

PASSIVE AND ACTIVE SOLAR SYSTEMS

Solar energy systems are incorporated into the calculation by evaluating how much energy they supply to the house, so that the net load supplied by the auxiliary heating equipment can be determined.

Passive solar systems

The passive solar systems addressed, (restricted here to Trombe walls, water walls, and greenhouses) are treated using the correlation method developed by Balcomb et al.[10] to which the interested reader should refer. (Simple direct gain systems are treated as windows, as described above in the "Radiative Heat Exchanges" section.) A quantity called the solar savings fraction SSF, which is the fraction of the load that is supplied by the solar system, is calculated as a function of the solar load ratio SLR and the load collector ratio LCR. These are defined as follows:

$$LCR = \left\{ \frac{K + \rho c Q}{A_s} \right\} \tag{80}$$

$$SLR = \left\{ \frac{S}{L^d + L^n} \right\} \tag{81}$$

where: K is the building conduction heatloss constant [W/°C]

$\rho c Q$ is the building infiltration heatloss constant [W/°C]

A_s is the collector area [m^2]

S is the average absorbed solar energy [Wh/day]

L^d is the daytime heating load [Wh/day]

L^n is the nighttime heating load [Wh/day]

The correlation for the SSF is defined as:

$$SSF = 1 - (1 - F)\, K_s \tag{82}$$

where:

$$K_s = 1 + \frac{G_s}{LCR} \tag{83}$$

$$F = B_s - C_s\, e^{-D_s X} \quad \text{for} \quad X > R_s \tag{84}$$

$$= A_s X \qquad \text{for } X < R_s \tag{85}$$

(if F > 1, use F = 1)

$$X = \frac{1}{K_s}\left\{SLR - \frac{H_s (UA)_p}{K+\rho c Q}\right\} \tag{86}$$

The coefficients A_s, B_s, C_s, D_s, G_s, H_s, and R_s are shown for different types of passive solar systems in Table 4. UA_p is the conduction heatloss constant for the passive solar elements

Table 4. Correlation Coefficients for Solar Savings Fractions

SYSTEM TYPE	H_s	G_s	R_s	A_s	B_s	C_s	D_s
Trombe wall	0.00	0.85	0.6	0.3698	1.0408	1.0797	0.4607
Trombe wall (night insul.)	0.00	0.12	1.0	0.4556	0.9769	1.2159	0.8469
Water wall	0.00	1.20	1.3	0.4025	0.9872	1.5053	0.9054
Water wall (night insul.)	0.00	0.17	1.2	0.4846	0.9799	1.8495	1.2795
Greenhouse	0.92	0.00	0.96	0.5084	0.9436	1.331	1.117

Once the solar savings fraction has been calculated, the daytime heating load, L_d, that had been calculated for the building is reduced:

$$L^d \text{ becomes } L^d\ (1 - SSF) \tag{87}$$

The nighttime heating load is similarly reduced:

$$L^n \text{ becomes } L^n\ (1 - SSF) \tag{88}$$

Finally, the daytime and nighttttime cooling loads calculated in the previous section are corrected to account for the increased conduction through the passive solar elements, i.e. K becomes $(K + UA_p)$.

Active Solar Systems

Active solar systems for space and water heating are are treated using the f-chart method from reference [15], to which the interested reader should refer. f is the fraction of monthly space and water heating loads supplied by solar energy, and is related to two dimensionless quantities X and Y through the correlations expressed in graphical form (the f-chart) or the equivalent equations:

$$X = 24\ A\ F\ U\ B\ (T_r - T_a)/(L_h + L_w) \qquad (89)$$

$$Y = 24\ A\ F\ (\tau\alpha)\ DI/(L_h + L_w) \qquad (90)$$

$$B = \left\{\frac{75A}{C}\right\}^{1/4} \quad \text{for liquid systems} \qquad (91)$$

$$B = \left\{\frac{v}{10.1}\right\}^{0.28} \quad \text{for air systems} \qquad (92)$$

$$D = \left\{1 - \rho_d\ (1 - \alpha)\right\}^{-1} \quad \text{for both systems} \qquad (93)$$

where:
- A is the area of the solar collector [m^2]
- F is the collector-heat exchanger efficiency factor [fraction]
- U is the collector overall energy loss coefficient [W/m^2-°C]
- T_a is the monthly average outdoor temperature [°C]
- L_h is the daily average load for space heating (= 0 for cooling) [Wh/day]
- L_w is the daily average water heating load [Wh/day]
- I is the average radiation incident on the collector surface per unit area [W/m^2]
- $\tau\alpha$ is the monthly average transmittance-absorptance product
- T_r is the reference temperature = 100°C
- C is the water storage capacity [liters]
- V is the collector air flow for an air system [liters/s]
- ρ_d is the average diffuse reflectance
- α is the average collector absorptance

(i) For an air system f is given by:

$$f = 1.04Y - 0.065X - 0.159Y^2 + 0.00187X^2 - 0.0095Y^3 \quad (94)$$

(ii) For a liquid system that does space heating f is given by:

$$f = 1.029Y - 0.065X - 0.245Y^2 + 0.0018X^2 - 0.0215Y^3 \quad (95)$$

(iii) For a liquid system that does water heating the fraction f_w of the water heating load that it provides is given by equation (95) but with X defined as:

$$X = 24\ A\ F\ U\ B\ (149 - 1.29\ T_a)/(L_h + L_w) \quad (96)$$

(iv) For a liquid system that does both space and water-heating f and f_w are calculated as above, then f is modified as follows:

$$f \text{ becomes } \{f\ (L_h + L_w) - f_w L_w\}/L_h \quad (97)$$

Finally, as for passive solar, the daytime and nighttime space heating loads are modified:

$$L^d \text{ becomes } L^d\ (1 - f) \quad (98)$$

$$L^n \text{ becomes } L^n\ (1-f) \quad (99)$$

The water heating load is reduced using f_w:

$$L_w \text{ becomes } L_w\ (1-f_w) \quad (100)$$

ENERGY CONSUMPTION

Heating Capacity

We define output heating capacity as the hourly rate of heat made available by the equipment when operating at full load, not counting distribution losses. For oil and gas burning equipment, and for electric resistance heat, this output capacity C_H is simply:

$$C_H = I_{HR}\, e_R \tag{101}$$

where: I_{HR} is the rated input capacity [W]

e_R is the rated, or steady-state efficiency [fraction]

For heat pumps, the output heating capacity is:

$$C_H = C_{HR}\, \Phi_{1H} \tag{102}$$

where: C_{HR} is the rated total output capacity [W]

Φ_{1H} is an empirical function correlating equipment capacity with outdoor and indoor temperatures.

The function Φ_{1H} can be determined from empirical data or from detailed system simulation. We use a curve fit based on data for a Coleman heat pump [16]. The curve used is shown in Figure 7. CIRA calculates Φ_{1H} separately for day and night.

$$\Phi_{1H} = \{ 0.000254\, T_o^{\,2} + 0.0253\, T_o + 0.7404 \} \times \{ 1 + 0.0057\, (21.11 - T_s)\} \tag{103}$$

where: T_s is the thermostat setting [^oC]

T_o is the outdoor temperature [^oC]

Part Load Ratio

Only a part of the available heat capacity is necessary to meet the sensible heating load, L_H. This fraction, X, is the part load ratio, and is calculated from:

$$X = \frac{L_H}{C_H^* \, (1 - d_H)} \qquad (104)$$

where: L_H is the sensible heat load [W]

C_H^* is the output heating capacity including fan power [W]

$= C_H + P_M$

P_M is the power of the circulating fan or pump, assuming 634 W/m^3-s for fans, 100 W for pumps [W]

d_H is the overall jacket and distribution loss [fraction]

The part load ratio is important in determining the cycling efficiency of the heating equipment.

Heating Efficiency

The overall heating efficiency e_H is the fraction of the energy content of the fuel consumed by the heating equipment that actually goes to meet the heating load. It depends on the rated (or steady-state) efficiency (or the COP for heat pumps), on indoor and outdoor temperatures (especially for heat pumps), and on the part load ratio. It can be expressed as:

$$e_H = \frac{e_R \, X}{\Phi_{2H} \Phi_{3H}} \qquad (105)$$

where: e_H is the overall heating efficiency [fraction]

e_R is the rated (or steady-state) efficiency [fraction]

(For heat pumps it is equal to the rated COP)

Φ_{2H} is an equipment-specific function describing the dependence on indoor and outdoor temperatures

Φ_{3H} is a similar function describing the dependence on part load ratio; it is the fractional on-time

X is the part-load ratio

For all heating equipment except heat pumps we use $\Phi_{2H} = 1$. For heat pumps we use a curve fit to data for a Coleman heat pump [16], as illustrated in Figure 7, which shows $1/\Phi_{2H}$.

$$\Phi_{2H} = \{ -0.0000179\, T_o^3 + 0.00066\, T_o^2 - 0.021\, T_o + 1.144 \} \times \{ 1 - 0.0133 (21.11 - T_s)\} \tag{106}$$

For all heating equipment except heat pumps, oil boilers and gas furnaces we use P_{3H} equal to the part load ratio, X. For heat pumps we use a curve fit to data from tests carried out at the National Bureau of Standards, NBS [17].

$$\Phi_{3H} = 0.3699\, X^3 - 0.8225\, X^2 + 1.4528\, X \tag{107}$$

For oil boilers we use a curve fit to data from tests carried out at Brookhaven National Laboratory, BNL, on 16 oil boilers [18a]. Values for $\{ X / \Phi_{3H} \}$ are shown in Figure 8 below.

$$\Phi_{3H} = 0.025\, X^2 + 0.9495\, X + 0.0259 \tag{108a}$$

Gas furnaces use a curvefit by Alereza and Hovander to NBS data [18b].

$$\Phi_{3H} = -0.0418\, X^2 + 1.0397\, X + 0.0023 \tag{108b}$$

Heating Energy Consumption

Having evaluated the sensible heating load and the heating efficiency, we can calculate the heating energy consumption. This is done separately for day and night.

$$E_H = \frac{N\, L_H}{e_H\, (1 - d_H)} + N\, 24\, P_M \Phi_{3H} \tag{109}$$

where: E_H is the monthly heating energy use for day or night [Wh]

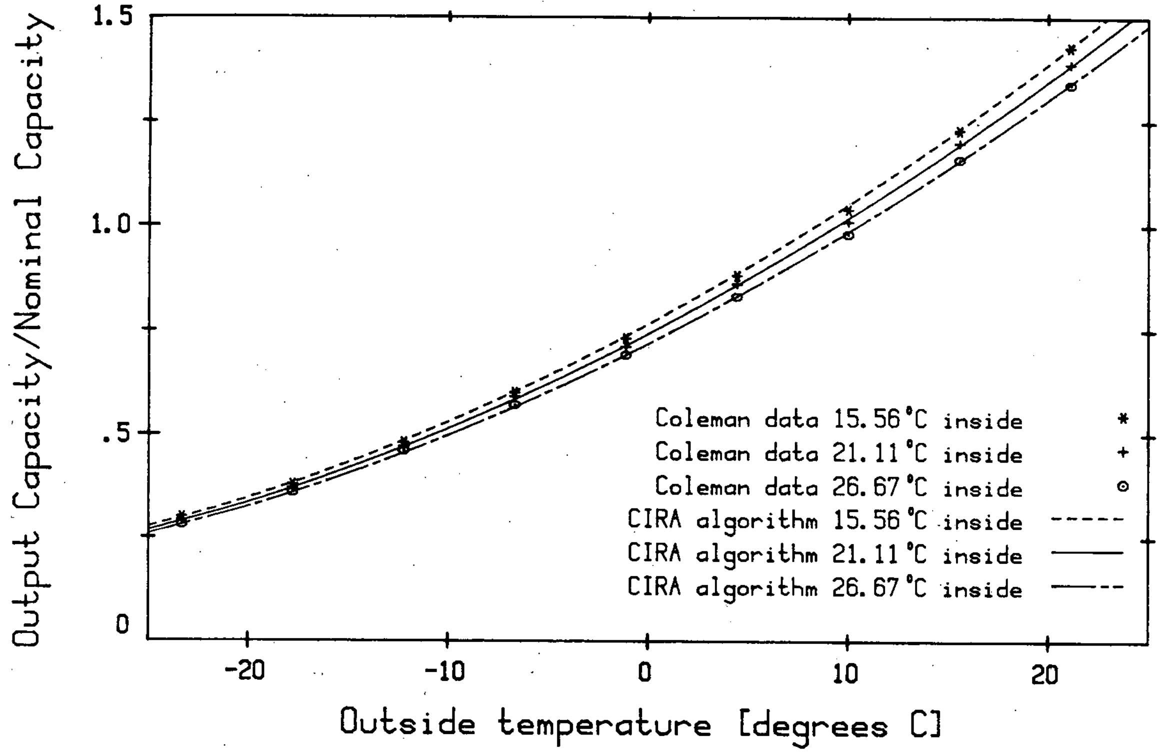
N is the number of days in the month

L_H is the sensible heating load for day or night [Wh]

e_H is the overall heating efficiency [fraction]

d_H is the overall jacket and distribution loss [fraction]

P_M is the power of the circulating fan or pump, assuming 634 W/m^3-s for fans, or 100 W for pumps [W]



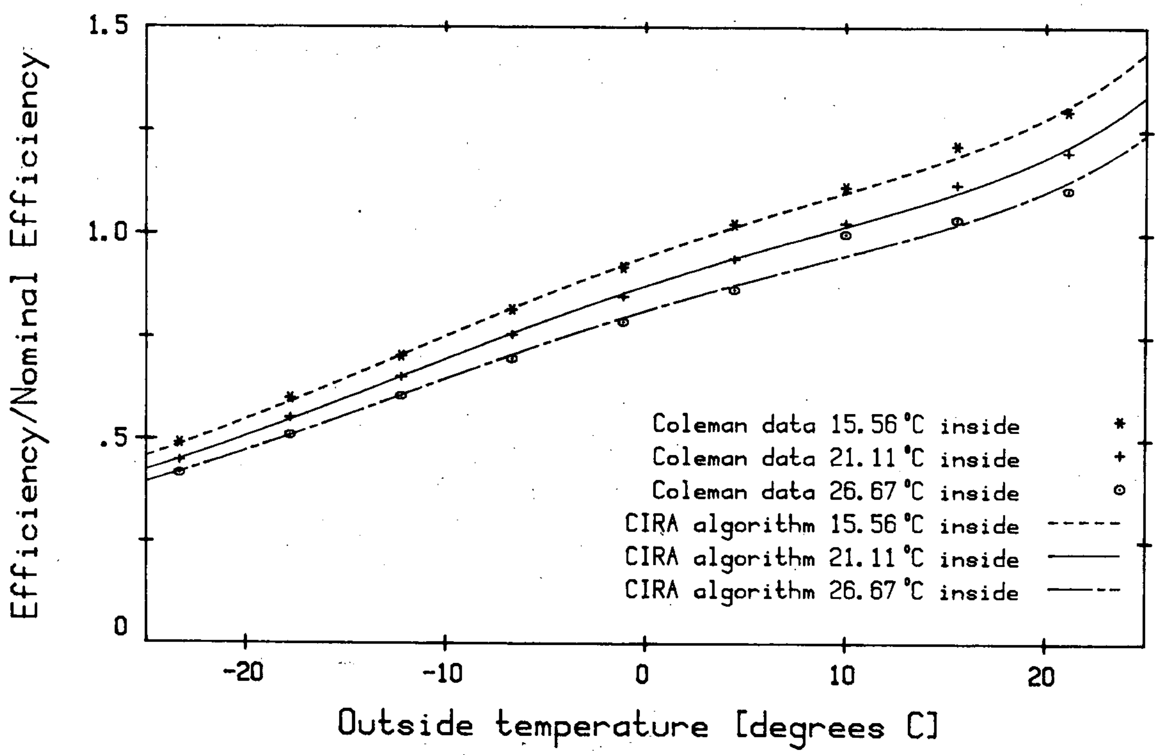
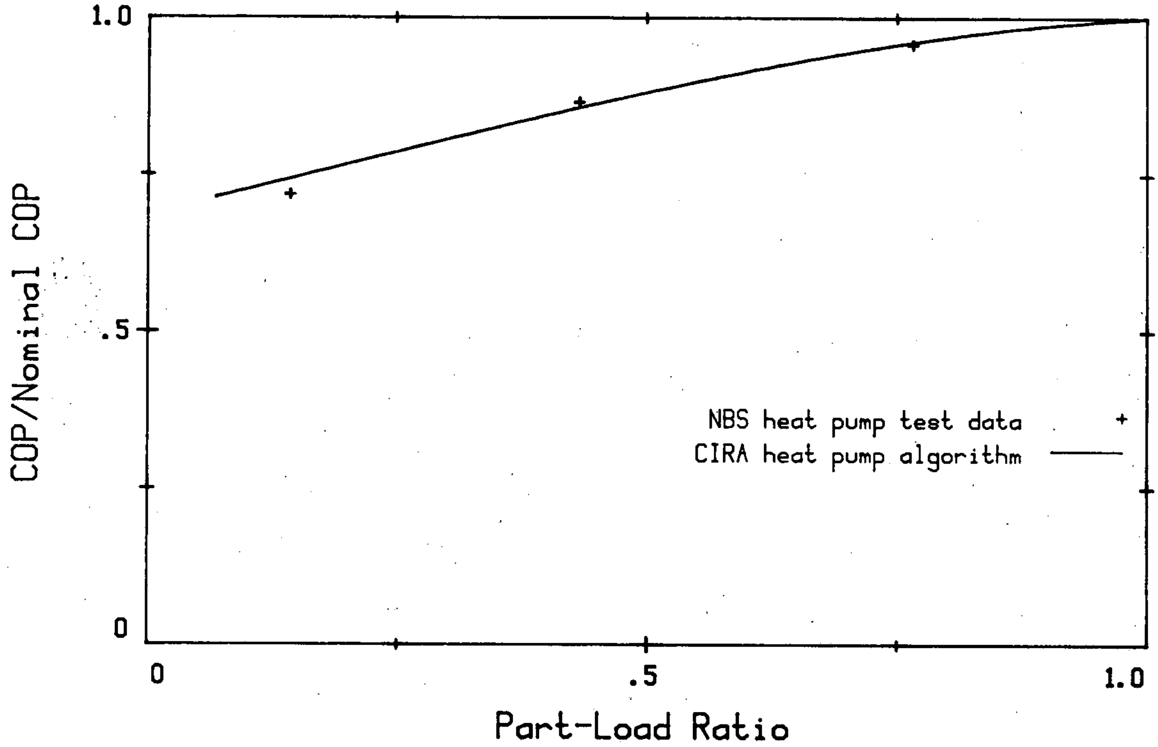


Figure 7. Heat pump heating capacity and heating efficiency as functions of outside temperature.



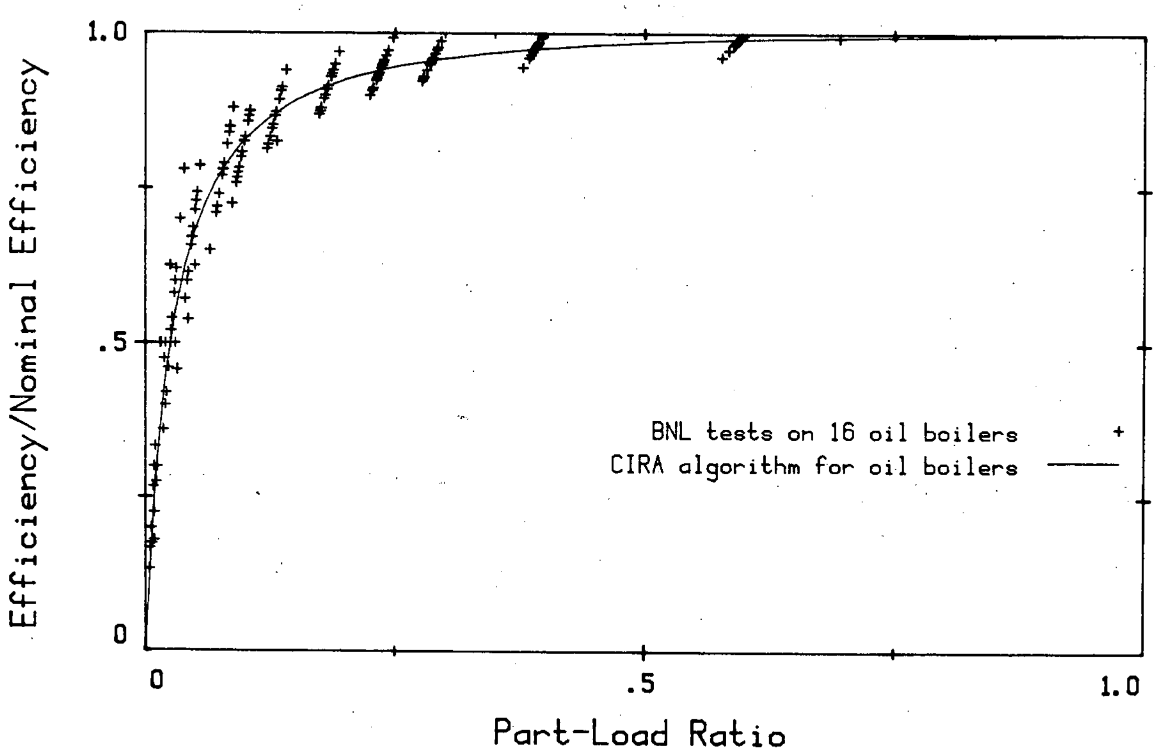


Figure 8. Oil boiler and heat pump efficiencies as functions of part load ratio.

For calculation purposes, it is useful to express the above equation as a function of Φ_{1H}, Φ_{2H} and Φ_{3H}, i.e.:

Oil and gas and resistive heat: $E_H = 24\ N \Phi_{3H} \{ I_{HR} \Phi_{2H} + P_M \}$ (110)

Heat pumps: $E_H = 24\ N \Phi_{3H} \{ C_{HR}/COP_R \Phi_{1H} \Phi_{2H} + P_M \}$ (111)

Cooling Capacity and Efficiency

The cooling capacity and efficiency are calculated by means of a set of correlations developed by Pierfrancesco Brunello. Only the conclusions are presented here; the full derivation may be found in reference [19]. There are two separate conditions to be considered: wet coil operation and dry coil operation. In dry coil operation, the air temperature in the evaporator remains above the dew point, no condensation occurs, and there is no latent load. In wet coil operation, condensation does occur in the evaporator, and there is a latent load.

Entering Wet Bulb Temperature

The first step is to calculate the wet bulb temperature of circulating room air above which the evaporator coil would become wet. This temperature,the apparatus wet bulb temperature $T_{wi}*$, is found from:

$$T_{wi}* = \{ \alpha + \beta \}/\gamma \qquad (112)$$

where: $T_{wi}*$ is the apparatus wet bulb temperature [°C]

T_{dc} is the dry bulb temperature before the coil

$= T_{setpoint} + \{ P_M/sm_e \}$ [°C]

P_M is the power of the circulating fan or pump, assuming 634 W/m^3-s for fans, 100 W for pumps [W]

T_{diR} is the ARI reference inside dry bulb temperature [26.6°C] (ARI is the Air Conditioning and Refrigeration Institute)

$$\alpha = s\ m_e\ (1-B_R)(T_{dc} - T_{diR}) \qquad (113)$$

s is the specific heat of moist air [J/kg-°C]

m_e is mass air flow rate through the evaporator [kg/s]

B_R is the by-pass factor at rated conditions

$$\beta = (0.00927T_{do} - 0.8593)C_{TR} - (0.00399T_{do} - 2.7351)C_{SR} \quad (114)$$

C_{TR} is the total cooling capacity, ARI reference conditions [W]

C_{SR} is the sensible cooling capacity, ARI reference conditions [W]

$$\gamma = 0.0239\,C_{TR} + 0.08204\,C_{SR} \quad (115)$$

T_o is the outside dry bulb temperature[^oC]

The coefficients in equations 114 and 115 are derived from curve fits to manufacturers' data. For conditions with wet bulb temperatures less than or equal to T_{wi}*, the system operates with dry coil. If the system operates with dry coil, there is no latent load. The latent load is given by:

$$L_L = \{ m_i\,(W_o - W_i) + m_g \} \times r \quad (116)$$

where: L_L is the latent load [W]

m_i is the infiltration mass flow rate [kg/s]

W_o is the outside humidity ratio [fraction]

W_i is the inside humidity ratio [fraction]

m_g is the internal moisture generation rate [kg/s]

r is the latent heat of evaporation of water [J/kg]

If this is set to zero, then the inside humidity ratio is given by:

$$W_i = W_o + (m_g/m_i) \quad (117)$$

Given this inside humidity ratio and the inside dry bulb temperature, T_{di}, the inside wet bulb temperature may be calculated by standard psychrometric routines. To simplify the calculation, a linear correlation has been developed which is sufficiently accurate under normal operating conditions ($22<T_{di}<33$; $15<T_{wi}<22$ [^oC]).

$$T_{wi} = \frac{10^6 W_i + (0.0015H + 413.6)T_{di} + 0.3840H + 2124}{1255.1 + 0.1295H} \quad (118)$$

where: T_{wi} is the inside wet bulb temperature [^oC]

H is the altitude [m]

If this temperature is less than the apparatus wet bulb temperature $T_{wi}*$ calculated in Equation 112, the system operates with dry coil. Otherwise, there is moisture removal by the cooling system, and the coil is wet. In that case, there is a latent load, and the inside wet bulb temperature is given by the following set of equations, whose derivation may be found in [19].

$$iT_{wi}^{2} + jT_{wi} + k = 0 \quad (119)$$

where: $i = d \times f$ (120)

$$j = (c \times f) + (d \times c) + (d - b)\ L_s \quad (121)$$

$$k = (c \times e) + (c - a)\ L_s \quad (122)$$

$$a = (0.8593 - 0.00927T_{do})\ C_{TR} \quad (123)$$

$$b = 0.02394\ C_{TR} \quad (124)$$

$$c = (2.7351 - 0.00399\ T_{do})C_{SR} + sm_e(1-B_R)(T_{dc} - T_{diR})-P_M \quad (125)$$

$$d = -0.08204\ C_{SR} \quad (126)$$

$$e = 10^{-6}\{\ 10^{6}W_o + T_{dc}(0.0015H + 413.6) + 0.384H + 2124\ \}\ m_i \times r + (m_g \times r) \quad (127)$$

$$f = -10^{-3}\{\ 0.0001295H + 1.2551\ \}\ m_i \times r \quad (128)$$

Cooling Capacity and Efficiency

Once the equilibrium wet bulb temperature has been calculated, either for wet or dry coil operation, the total capacity can be calculated, including fan power. For wet coil operation it is given by:

$$C_T* = C_{TR}\Phi_{1C} - P_M \quad (129)$$

where: Φ_{1C} is an empirical function correlating equipment capacity with indoor wet bulb and outdoor dry bulb temperatures.

The function Φ_{1C} can be determined from empirical data or from detailed system simulation. We use a curve fit based on manufacturers' data. CIRA calculates Φ_{1C} separately for day and night.

$$\Phi_{1C} = 0.8593 + 0.02394\ T_{wi} - 0.00927\ T_{do} \qquad (130)$$

The sensible capacity is calculated from a similar empirical function:

$$C_S^* = C_{SR}\ \{\ 2.7351 - 0.08204\ T_{wi} - 0.00399\ T_{do}\ \} + \{\ (s \times m_e\ ) \times (1-B_R) \times (T_{dc} - T_{diR})\ \} - P_M \qquad (131)$$

For dry coil operation, the same equations are used, but with T_{wi}* used instead of T_{wi}. For dry coil, C_T will be equal to C_S. Once the sensible and total capacities are known, the part load ratio can be calculated, and from this the efficiency. The part load ratio is:

$$X = \frac{L_S}{C_S^*\ (\ 1 - d_C\ )} \qquad (132)$$

where: X is the part-load ratio

L_S is the sensible cooling load [W]

C_S* is the sensible cooling capacity, less fan power [W]

d_C is the overall jacket and distribution loss [fraction]

Cooling COP

Given the part load ratio and the wet and dry bulb temperatures, the actual coefficient of performance, COP_C, may be calculated:

$$COP_C = \frac{COP_R\ X}{\Phi_{2C}\ \Phi_{3C}} \qquad (133)$$

where: COP_R is the rated COP at ARI reference conditions

Φ_{2C} is an equipment-specific function describing the COP dependence on indoor wet bulb and outdoor dry bulb temperatures

$$= 0.5967 - 0.01378\ T_{wi} + 0.01926\ T_{do} \qquad (134)$$

Φ_{3C} is an equipment-specific function describing the COP dependence on part load ratio

$$= 0.2952\ X^3 - 0.6591\ X^2 + 1.3639\ X \tag{135}$$

Φ_{2C} is derived from a curve fit to manufacturers' data; Φ_{3C} is derived from a curve fit to NBS data [17].

Cooling Energy Consumption

We are now ready to compute the monthly cooling energy consumption for day and night [Wh/month].

$$E_C = \frac{N\ L_C}{COP_C\ (\ 1 - d_C\ )} + 24\ N\ P_M\ \Phi_{3C} \tag{136}$$

where: E_C is the monthly cooling energy use for day or night [Wh]

N is the number of days in the month

L_C is the daytime or nighttime cooling load [Wh]

COP_C is the actual cooling COP

d_C is the overall distribution loss [fraction]

Again, for purposes of calculation it is convenient to re-express this equation as a function of Φ_{1C}, Φ_{2C}, and Φ_{3C}, i.e.:

$$E_C = 24\ N\ \Phi_{3C}\ (\{C_T/COP_R\}\ \Phi_{1C}\ \Phi_{2C} + P_M\ ) \tag{137}$$

where: $C_T = C_T{}^* + P_M$

Evaporative Coolers

Once through evaporative coolers are modelled following Hayashi [20]. The performance of the cooler is described by its saturating efficiency, e [dimensionless]:

$$T_{dL} = T_{dE} - e\ (T_{dE} - T_{wL}) \tag{138}$$

where: T_{dL} is the leaving dry bulb temperature [°C]

T_{dE} is the entering bulb temperature [°C]

T_{wL} is the leaving wet bulb temperature [°C]

= the entering wet bulb temperature,

since the process is adiabatic.

The saturating efficiency is a function of the cooler flow rate, according to the relationship:

$$e = 1 - \exp\ \{\ (\log_e(1-e_r))\,(V_r/V)^{.355}\ \} \tag{139}$$

where: e is the actual saturating efficiency

e_r is the rated saturating efficiency

V is the actual air flow rate [m^3/s]

V_r is the rated air flow rate [m^3/s]

The sensible capacity C_s [W] of the cooler is calculated separately for day and night, and is given by:

$$C_S = s\ V\ e(T_{do} - T_{wo}) \tag{140}$$

where: s is the volumetric specific heat of air [J/m^3-°C]

T_{do} is the outdoor dry bulb temperature [°C]

T_{wo} is the outdoor wet bulb temperature [°C]

The part load ratio, X, is the sensible load divided by the sensible capacity, and is identical to the fractional on-time, Φ_{3C}. The monthly day or night energy use, E [Wh/month], is calculated from:

$$E = 12\ N\ I\ \Phi_{3C} \tag{141}$$

where: I is the rated power input to the cooler [W]

The indoor humidity ratio is calculated from a moisture balance which considers the infiltration rate, indoor moisture generation rate, and moisture added by the evaporative cooler:

$$m_i(W_o - W_i) + m_g + m_e\,\Phi_{3C}\ e\ a\ (T_{dE} - T_{wL}) = 0 \tag{142}$$

where: m_i is the total infiltration mass flow rate [kg/s]

m_g is the internal moisture generation rate [kg/s]

m_e is the air mass flow rate through the cooler [kg/s]

W_o is the outside humidity ratio

W_i is the inside humidity ratio

W_L is the humidity ratio leaving the cooler

Φ_{3C} is the fractional on-time

$a = 10^{-6}\ \{ .0015H + 413.6 \}$

H is the altitude [m]

Other Energy Consumption

The power consumed for non-space-conditioning end-uses is calculated in watts, and to calculate energy use a constant consumption throughout the year is assumed. To convert from continous watts to millions of British Thermal Units per year, multiply by 0.0299.

i) The power, E [W] used for water heating is calculated from the daily hot water use as:

$$E = S + \frac{\{C \times U \times (T - 12.8)\}}{e \times 24 \times 60 \times 60} \tag{143}$$

where: S is the standby loss [W]

C is the specific heat of water [4.184 10^6 J/m^3-^oC]

U is the hot water use [m^3/day]

T is the water thermostat setting [^oC]

(groundwater is assumed to be at 12.8^oC)

e is the water heater efficiency [fraction]

The free heat contributed by the water heater is the standby loss times a location effect, L, where L is 1.0 for the living space, 0.6 for the basement, 0.3 for the crawl space and 0.5 for the garage.

ii) The power used by the range and clothes dryer [W] and their assumed free heat contributions [W] are given in the table below:

Table 5: Power Use and Free Heat from Range and Dryer

	Free Heat [W]	Power Use [W]
Electric range	70	86
Gas Range	123	171
Electric dryer	35	117
Gas dryer	32	161

iii) The electricity used by the refrigerator [kWh/month] is an input. 90% of the energy is assumed to remain in the house as free heat.

iv) Each daytime occupant is assumed to contribute 66 W to the free heat; each nighttime occupant adds 58 W. Latent heat gains of equal magnitude are accounted for when calculating indoor moisture generation.

v) Electricity used for lights is an input to the program, under "Lights and other heat gains". All of the energy is assumed to remain in the house as free heat.

DISCUSSION

This methodology has been applied to the Hastings Ranch house [21] and compared to the predictions obtained with DOE-2.1 for seven U.S. cities representing a wide variety of climatic conditions: Washington (D.C.), Albuquerque (N.M.), Minneapolis, San Francisco, Boise (Idaho), Seattle, and Portland (Oregon). The results of the comparison are shown in Figures 9 through 12 with monthly heating and cooling loads predicted by CIRA plotted on the ordinate, those predicted by DOE-2.1 plotted on the abscissa. Figs. 9&10 are for a constant indoor temperature, Figs. 11&12 for a 2.8 °C (5 °F) thermostat setback. The scales for both y- and x-axes are logarithmic, due to the large range of loads computed for the different cities, over ten-to-one for cooling, and 20-to-one for heating. The solid line indicates the locus of perfect correspondence, the dashed lines indicate ± 20% discrepancy.

The outliers at the low end of the scale are caused by a particularity of CIRA: while DOE-2.1 calculates both heating and cooling loads for every month, CIRA calculates only that load that it estimates is likely to be higher. In a few cases this criterion of advance choice fails. Of course, CIRA could calculate both heating and cooling loads for each month and then, having compared the two, use the one that is higher; however, this would entail an additional approximately six seconds calculation time.

Based on the data in the top figures, the difference between CIRA and DOE-2.1 predictions is 0.9% ± 7.3% for heating and 3.5% ± 10.5% for cooling. For the data in the bottom figures, the differences are 6.5% ± 8.5% and 13.7% ± 10.5%, for heating and cooling, respectively. All percentages are based on the average DOE2.1 predictions. The systematic discrepancies that seem to correlate with the cooling season and thermostat setbacks could be traced to a variety of causes, such as the treatment of thermal mass or solar gains, to name a few. However, rather than refining the model much further using DOE-2.1 as a reference, future research will concentrate on the comparison of CIRA with actual data. Figure 13 shows preliminary data for 22 houses in Midway, WA, Walnut Creek, CA, and Syracuse, NY, suggesting good agreement between CIRA predictions and actual use. Work is continuing on comparison of actual usage data with CIRA predictions for a number of other houses.

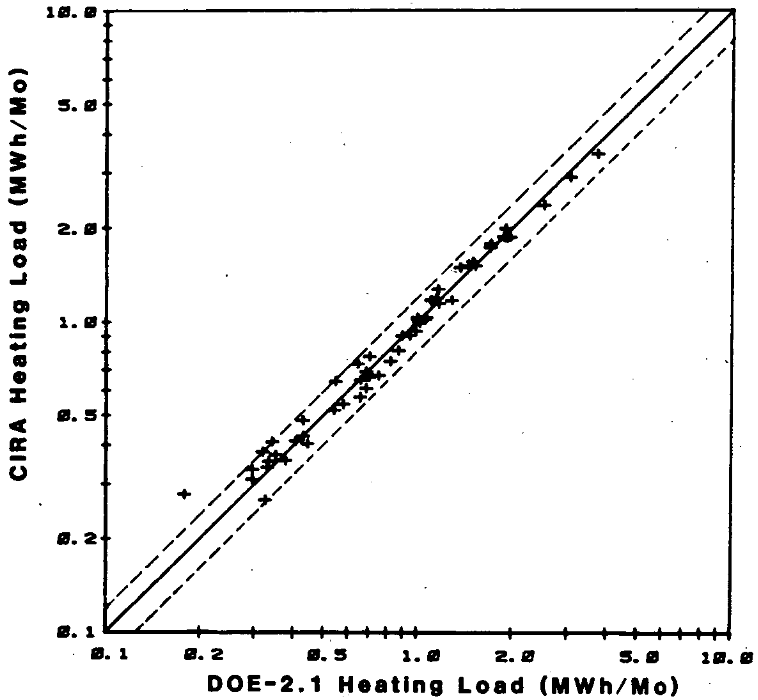


Figure 9. CIRA/DOE 2.1 Comparison: Hastings Ranch House, 7 Cities, Heating Loads.

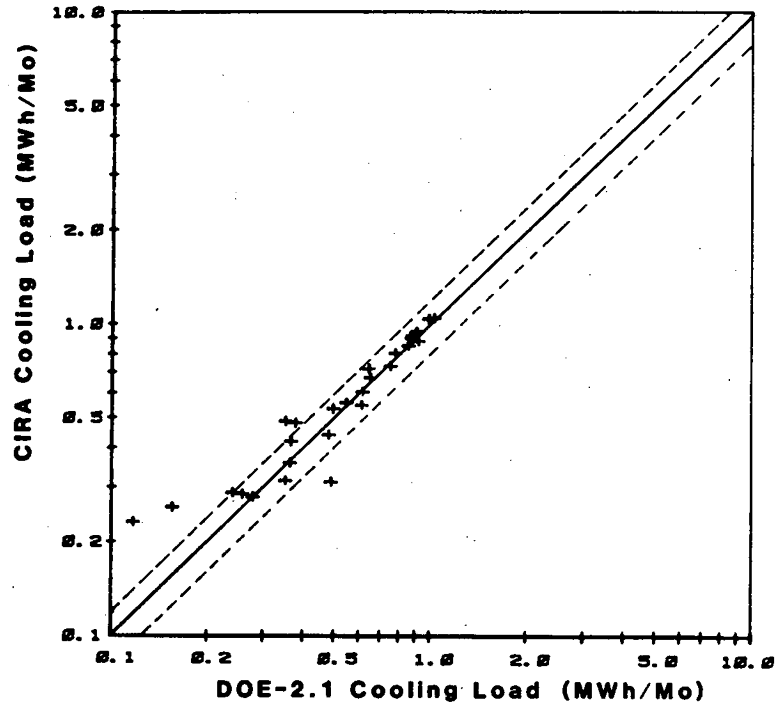


Figure 10. CIRA/DOE 2.1 Comparison: Hastings Ranch House, 7 Cities, Cooling Loads.

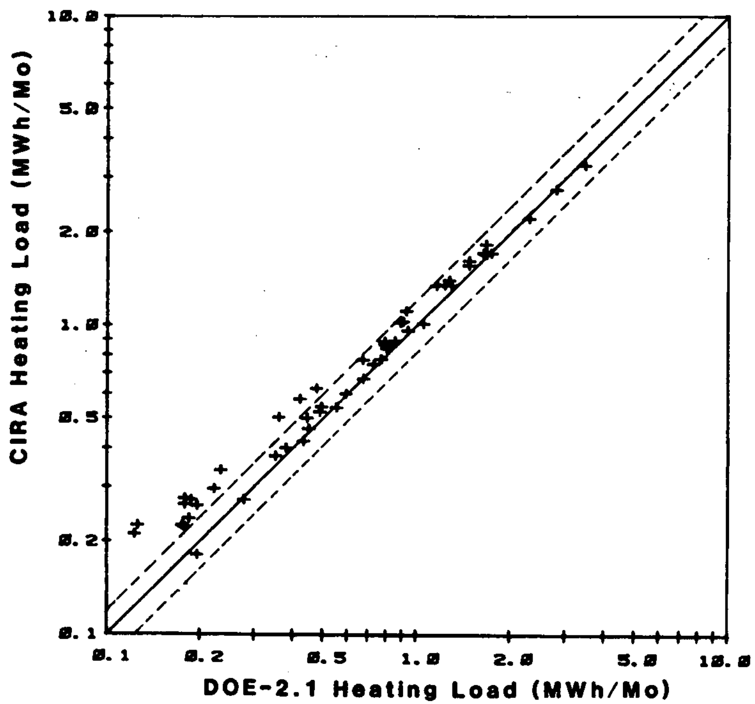


Figure 11. CIRA/DOE 2.1 Comparison: Hastings Ranch House, 7 Cities, 2.8°C Night Thermostat Setback. Heating loads.

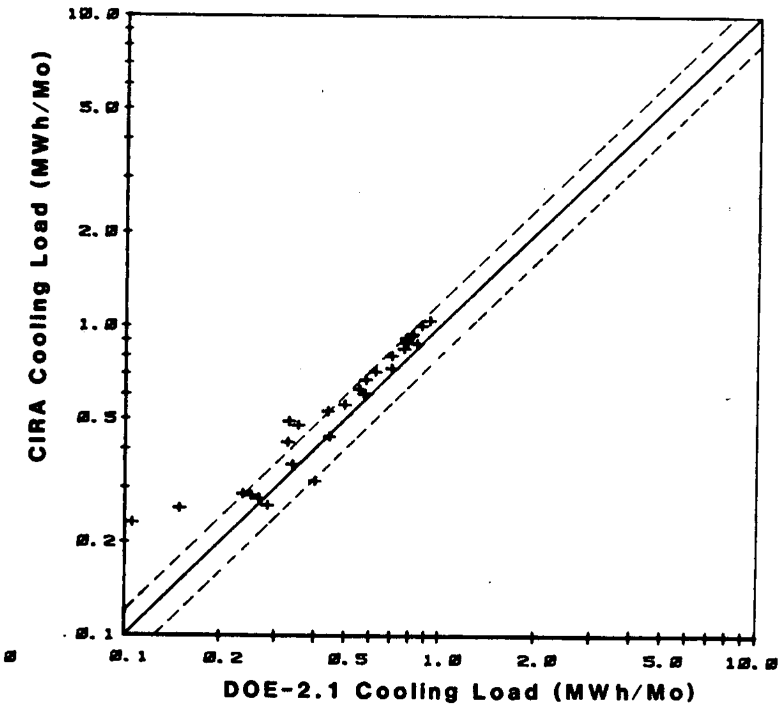


Figure 12. CIRA/DOE 2.1 Comparison: Hastings Ranch House, 7 Cities, 2.8°C Night Thermostat Setback. Cooling loads.

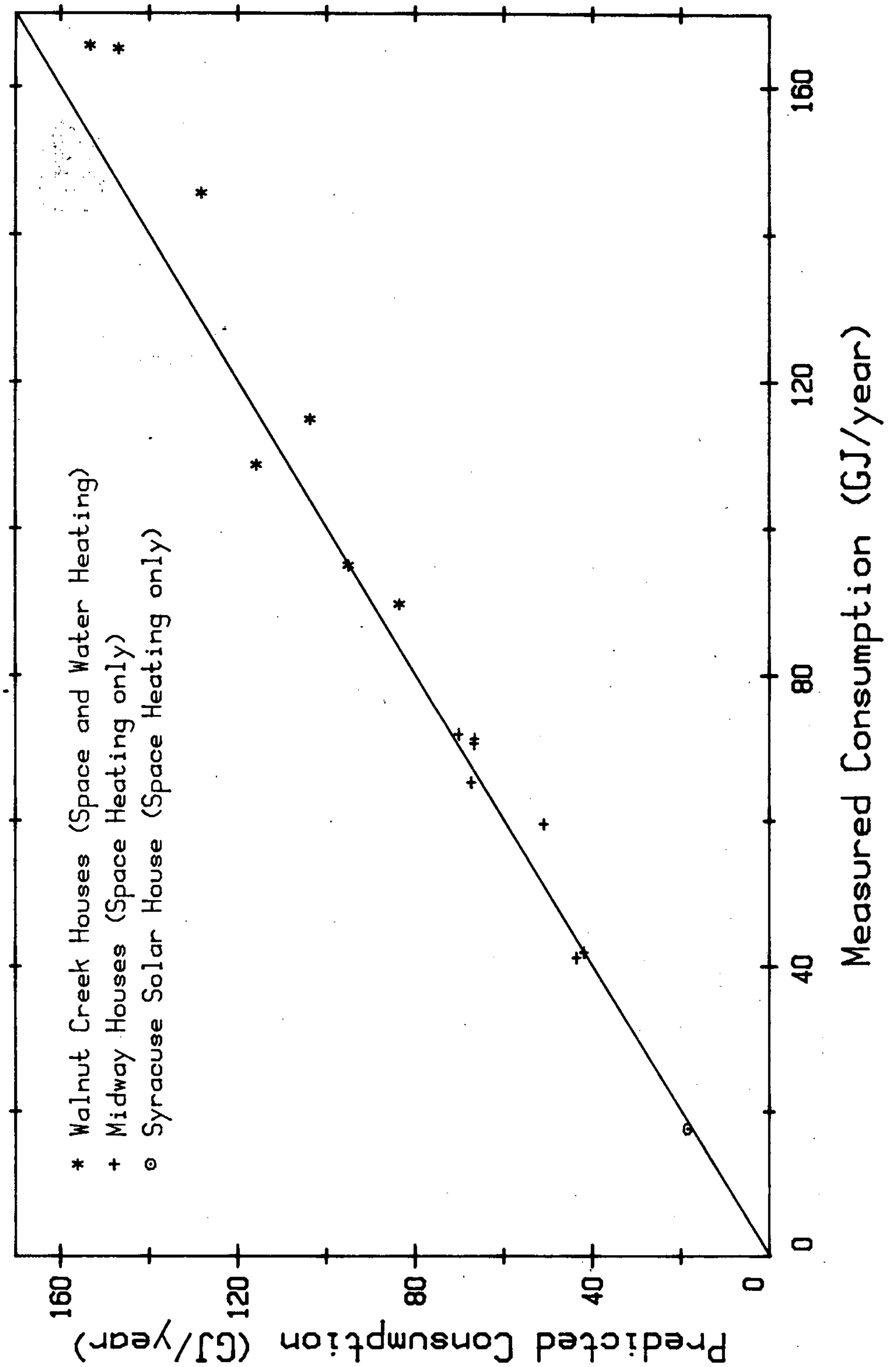


Figure 13. Comparison of CIRA predicted vs. measured annual energy consumption for 22 houses.

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ECONOMIC OPTIMIZATION

Section VI

ECONOMIC OPTIMIZATION

CIRA performs residential building energy analysis and determines economically optimal mixes of discrete energy-saving measures (retrofits) for a given building and for a chosen dollar budget. The catalog of retrofits used by CIRA approaches 100 items; it includes envelope performance retrofits (such as increased insulation and air leakage reduction), HVAC modifications (such as replacement burners and duct sealing), appliance improvements (such as water-heater blankets and efficient refrigerators) and other miscellaneous retrofits (such as clock thermostats). From the catalog the program chooses those retrofits which are applicable to the building under consideration, and ranks them by decreasing savings-to-cost ratio. This ratio is defined for each retrofit as the incremental life-cycle savings (energy savings minus future maintenance and replacement costs) divided by the incremental first cost.

As is well known, space heating or cooling energy savings associated with any given retrofit depend on which other retrofits have already been installed. To reduce the potentially large number of yearly energy consumption calculations to be carried out during optimization, a scheme has been developed based on partial derivatives of yearly energy consumption.

In the energy calculation model used by CIRA, each retrofit is described by a change in one or more of a) the building load coefficient, b) the internal gains, c) the furnace or air conditioner efficiency, or d) the heating or cooling distribution losses. Every time annual heating and cooling energy consumptions are evaluated, CIRA also calculates their partial derivatives with respect to (a) and (b). The energy saving from each retrofit can be estimated for changes in (a) or (b) as the product of the partial derivatives and the change in (a) or (b). For changes in (c) and (d), analytical expressions are used to estimate the energy savings.

During optimization, retrofits are chosen in order of individual savings-to-cost ratio until the annual energy consumption has been reduced by an estimated 25%. At this stage, the chosen retrofits are "installed" in the house by making the cumulative changes in (a), (b), (c) and (d) above permanent; the energy consumptions and derivatives are recalculated; and the estimated savings from the installed retrofits are adjusted so that the sum of the savings is correct. This process of chosing, installing and adjusting is repeated until either the dollar limit is reached, or no more retrofits exist with savings-to-cost ratios greater than one. In this paper, this process is described in detail and illustrated using a sample house.

ENERGY AND COST CALCULATIONS

Calculation of Yearly Energy Calculations

Monthly energy calculations are done for five main uses: Space heating, space cooling, domestic water heating, electricity, and fossil fuel use for other appliances. The last three energy calculations are relatively straightforward and depend on the program users' inputs regarding the stock of appliances, the number of occupants, and so forth.

Space heating and space cooling consumption is calculated using monthly, variable-base degree-days and degree-nights for both heating and cooling seasons. The base temperatures used in calculating the degree-days and degree-nights are derived from thermostat settings, solar and internal gains, infra-red radiation losses to the sky and the thermal performance of the building envelope. Thermostat setbacks are handled by using the concept of effective thermal mass of the house. Performance variations of HVAC equipment with changes of part load and ambient conditions are taken into account. Degree-days and degree-nights for different reference temperatures are evaluated by using a site-specific empirical correlation with monthly average daily and nightly outdoor temperatures. Space heating and cooling predictions using this method have been shown to approximate the results from the DOE-2.1 building simulation program[1] within $\pm 10\%$.[2] Preliminary comparisons with measured energy consumption data from 22 houses have shown a comparable correspondence between measured and predicted yearly heating and appliance energy consumption, with higher discrepancies for month-by-month consumptions.[2]

Calculation of Energy Savings of Individual Retrofits

CIRA calculates the energy consumption of a house as a function of many parameters, such as thermal resistance, leakage area, thermal mass, spatial distribution of thermal resistance and leakage area, furnace efficiency, and distribution losses. For a given house, these parameters may each have up to four different values, for the periods heating day, heating night, cooling day, and cooling night.

The CIRA retrofit database stores information on how each of these parameters is altered by a retrofit. More than one parameter may be changed -- e.g. adding a storm window in winter will decrease the building load coefficient by increasing the thermal resistance of the window and decreasing its air leakage, but will also decreases the internal gains by reducing solar gain. The actual database entry for this retrofit (in Reverse Polish Notation) reads:

```
A12=(D12 I .92+I) : A13=(D13!.6*) : A09=(D09!.88*)          (1)
```

where
I is the symbol for the "invert" operation,
! is the symbol for the "enter" operation,
A12/D12 are the new and old U-values, respectively,
A13/D13 are the new and old specific leakage areas,
A09/D09 are the new and old winter solar gain factors.

The above instruction thus reads: "add R-0.92 (in british units) to the window system being retrofitted; reduce its leakage area by 40%; reduce its winter solar gain factor by 12%." The program then translates these instructions into corresponding changes of the building parameters that determine annual energy consumption and recalculates the latter. This structure allows the addition of almost any retrofit to the database used for the optimization.

It is necessary to retain the specific effect on the building structure, as opposed to global values such as "percent savings," since the energy savings actually achieved by each retrofit will depend on local weather conditions, on the economic assumptions, and on the thermal characteristics of the house -- or on what retrofits have been previously installed. A shortcut to increase the speed of calculation will be presented in a later section.

Dollar Savings and Costs

For each retrofit, the energy saving calculated by CIRA is converted into a gross lifetime dollar saving by multiplying by the price of energy and reducing to present value.

$$S = \sum_{f=1}^{4} (-\Delta E_f) * P_f * \sum_{n=1}^{N} \left(\frac{1+e_f}{1+d}\right)^n \qquad (2)$$

where
ΔE_f are changes in yearly consumption for each fuel caused by the retrofit (GJ/yr or Mbtu/yr),
f is an index denoting fuel type,
P_f are fuel prices ($/GJ or $/MBtu),
e_f are real fuel price escalation rates (fractional),
d is the real discount rate (fractional),
N is the economic horizon (years).

The time horizon, escalation rate, price of energy and discount rate are all input by the user; they are not fixed by the program.

The maintenance costs are given as a percentage replacement after a number of years, e.g. 100% after 3 years for plastic storms. (The costs and the maintenance schedules of all retrofits are stored in an external database, and can easily be changed by the user to suit local conditions.) If the lifetime of a retrofit is short, more than one replacement may be needed. For example, for a ten year horizon and plastic storms, the storms would have to be replaced after three, six, and nine years, so the maintenance cost would be:

$$M = IC * \frac{PR}{100} * \sum_{n=3,6,9} \left(\frac{1+m}{1+d}\right)^n \qquad (3)$$

where
IC is the initial cost for the retrofit ($),
M is the present value of maintenance expenditures over the life of the retrofit being considered ($),
m is the real escalation rate of maintenance costs (fractional),
d is the real discount rate (fractional),
PR is the percent replacement of the retrofit necessary at periodic intervals (%).

Real escalation rates are yearly cost increases corrected for general inflation. For instance, real and nominal maintenance escalation rates are related by the expression:

$$m = \frac{m' - i}{1 + i} \qquad (4)$$

where
m is the real maintenance escalation rate (fractional),
m' is the nominal maintenance escalation rate (fractional),
i is the inflation rate (fractional).

For the purposes of the printout, Fig. 1, the maintenance cost is annualized to:

$$AM = M \Big/ \sum_{n=1}^{n=N} \left(\frac{1+m}{1+d}\right)^n \qquad (5)$$

where
AM is the annualized maintenance cost ($),
N is the economic horizon (years).

AM is therefore the amount in constant dollars that would have to be paid into a fund every year, increasing 100*m % per annum, to pay for all maintenance over the lifetime of the retrofit. The initial cost of a retrofit is calculated from data in the retrofit library as:

CIRA————————COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT————————CIRA

'ASHRAE-TEST' house in WASH-DC at 14 feet.

Spent: $4205.50 Limit: $10000.00

Real DISCOUNT rate (%): 3.00 Real MAINT ESC rate (%): 0.00

	Heating	Cooling	Water	Electric
Type of EQUIPMENT	Gas Furnace	Central AC	Gas	-na-
Fuel PRICES ($/MBtu)	5.30	20.50	5.30	20.50
Real ESCALATION rate (%)	3.00	3.00	3.00	3.00

	Retrofit DESCRIPTION	NAME & LOCATION	Initial COST	1st Year SAVINGS	Annualized MAINTENANCE	Net SAVGS to COST R
1	Set water htr. thermostat to 120 F	Smith APPLIANC	$0.50	$34.41	$0.09	999.9
2	AUTO. 5 F Htg. & Clg. NIGHT SETBACK	ASHRAE-TEST GENERAL	$120.00	$174.68	$4.47	28.6
3	Install 6 inches of loose fiberglass	Insulated ROOF/CEI	$695.00	$648.24	$7.50	18.5
4	Install R-6 water htr. blanket	Smith APPLIANC	$30.00	$13.93	$2.62	8.0
5	DOUBLE glaze	North WINDOWS	$168.00	$34.14	$0.00	4.1
6	DOUBLE glaze	East WINDOWS	$168.00	$34.14	$0.00	4.1
7	DOUBLE glaze	West WINDOWS	$168.00	$34.14	$0.00	4.1
8	*TRIPLE glaze	North WINDOWS	$72.00	$15.41	$0.00	3.7
9	*TRIPLE glaze	East WINDOWS	$72.00	$15.41	$0.00	3.7
10	*TRIPLE glaze	West WINDOWS	$72.00	$15.41	$0.00	3.7
11	DOUBLE glaze	South WINDOWS	$168.00	$29.14	$0.00	3.5
12	Buy new EFFICIENT REFRIGERATOR	Smith APPLIANC	$700.00	$106.92	$0.00	3.1
13	*TRIPLE glaze	South WINDOWS	$72.00	$8.85	$0.00	2.4
14	INSULATE with 3.5" blown-in cellulose	North WALLS	$440.00	$45.76	$0.00	2.1
15	INSULATE with 3.5" blown-in cellulose	South WALLS	$440.00	$38.64	$0.00	1.8
16	INSULATE with 3.5" blown-in cellulose	West WALLS	$260.00	$22.02	$0.00	1.7
17	INSULATE with 3.5" blown-in cellulose	East WALLS	$260.00	$22.02	$0.00	1.7
18	*Install 9 inches of loose fiberglass	Insulated ROOF/CEI	$300.00	$21.73	$3.24	1.2

* - This replaces a previous retrofit on this component. Savings and costs are in addition to those of the replaced retrofit.

CIRA————————COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT————————CIRA

Figure 1: An illustrative retrofit package for a Hastings Ranch House in Washington, DC, weather. These retrofits appear in all the following figures, with the same identifying numbers throughout. A reduced retrofit database was employed; the selection of retrofits is not typical.

$$IC = C_f + (C_m * Q) \quad (6)$$

where

IC is the initial cost ($),
C_f is the fixed cost ($),
C_m is the marginal cost per "quantity" of retrofit ($/Q),
Q is the quantity of retrofit (square foot, linear foot, ea., etc.).

The total lifetime dollar savings (LS) from a retrofit is the sum of the dollar savings minus the sum of the maintenance costs -- i.e. S-M as defined above. The savings-to-cost ratio (SCR) is defined as

$$SCR = \frac{S - M}{IC} \quad (7)$$

As discussed in the next sections, retrofits are ranked in decreasing order of SCR and retrofits with a SCR of less than one are removed from the list. This optimization criterion is somewhat biased in favor of low-cost measures. Another possible optimization criterion could have been net life-cycle savings -- the quantity (S-M-IC), but that, in turn, favors expensive retrofits. A review and discussion of the different economic optimization strategies can be found in an NBS pamphlet.[3]

ECONOMIC OPTIMIZATION

Principle of the Optimization Procedure

After the energy consumption of the original house has been evaluated, the retrofitting process begins. First, CIRA scans a disk library of several hundred retrofit options. The entries contain costs (per square foot, per linear foot, or per unit) and figures of merit (typically: added thermal resistance, decreased solar or internal gains, decreased leakage area, and improved efficiency). Those retrofits which physically cannot apply to the building are not considered -- e.g. cavity insulation for solid masonry walls, or sliding storms for casement widows. For each retrofit, initial and maintenance costs are calculated, the latter including a periodic allowance for partial replacement where appropriate. The next step is to rate each retrofit by the energy savings it would cause if taken alone. These are converted to dollar savings, and reduced to net present value. From these items the savings-to-cost ratios are calculated. The retrofits are sorted by this ratio, and the retrofit with the highest savings-to-cost ratio is chosen, then removed from the list of retrofits and installed in the house. Finally, the new energy consumption of the house is re-calculated.

Now the process starts anew. Each remaining retrofit is re-rated (for the altered house) by calculating a new savings-to-cost ratio. These retrofits are sorted, and the best one chosen and installed. The second installed retrofit naturally has a lower savings-to-cost ratio than the first, and this trend continues as more retrofits are chosen. The loop of rating, sorting, installing, and re-calculating energy consumption continues until there are no more cost-effective retrofits. The list of retrofits is then printed out, together with relevant economic parameters. A sample output for a limited library of retrofits is shown in Fig. 1. At the top is some summary information about the house and the economic assumptions -- prominent by its omission is the economic horizon, in this case 20 years. The fuel costs chosen represent the national averages for residences for April, 1982.[4] The rest of the printout shows the list of retrofits ordered by decreasing SCR. The "Name and Location" column refers to components of the house, such as windows and walls, and to their user-chosen names, such as "West" windows or "North" walls. The remaining four columns are self-explanatory.

Discussion of a Sample Retrofit of the Hastings Ranch House

The sample house used throughout this paper is an uninsulated ranch house in Washington, D.C. weather, built according to the "Hastings Ranch House" specifications.[5]

The optimization begins with a rating of all applicable retrofits in the library. Fig. 2 is an graphical illustration of the results of this initial rating process. Each retrofit is represented by a sloping line. The horizontal coordinate of the end of each line represents the initial cost, the vertical coordinate represents life-cycle savings of a retrofit, taken by itself without considering any interactions yet. In this example, all lines have slopes greater than one, that is, they all would be cost-effective taken by themselves. Not surprisingly, the first retrofit chosen for the sample house in these weather conditions is to reset the water heater thermostat to 120 ^{o}F. This has a nominal cost of 50 cents, and saves $687 over the twenty-year period under consideration, including maintenance costs and after reducing to present value. Its savings-to-cost ratio is 1,373 (the printout in Fig. 1 shows 999.9 for any savings-to-cost ratio greater or equal 1,000). The water heater thermostat reset was chosen because it is steepest, -- a graphical way of stating that its savings-to-cost ratio is greatest. In Fig. 2 this initial retrofit is shown as a small, almost vertical line in the lower left hand corner.

The next most cost-effective retrofit is an automatic night setback thermostat. This retrofit costs $120, and results in a lifetime saving of $3,427, for a savings-to-cost ratio of 28.6. Next is the installation of 6 inches of loose fiberglass in the attic, at a cost of $695 for a savings of $12,853 and a savings-to-cost ratio of 18.5.

The noticeable kink in the curve in Fig. 3 at this point reflects the quantum jump in savings-to-cost ratio going from the initial high-payoff retrofits to the more expensive window retrofits. Normally there would be many intervening retrofits to make a smooth curve; the abrupt change here

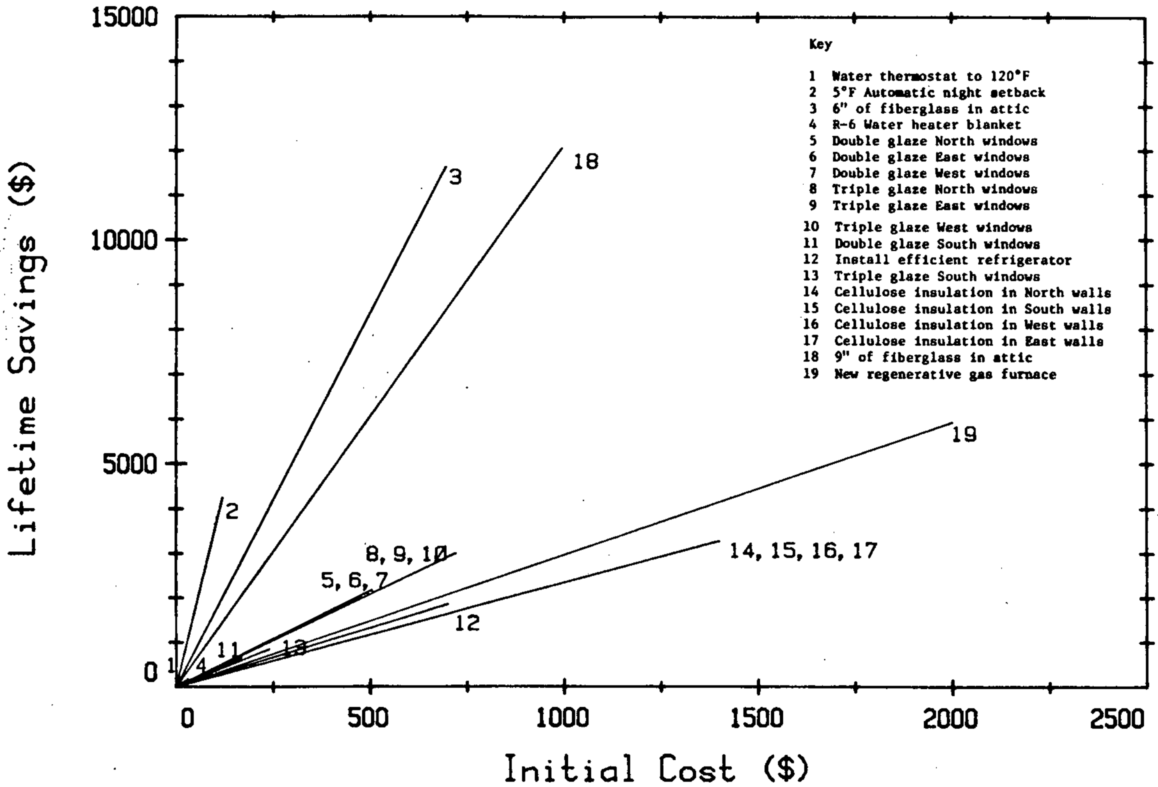

Figure 2: Savings and costs for all the retrofits in the reduced database as if they were to be installed individually in the Hastings Ranch House in Washington, DC, weather. Energy costs and escalation rates assumed for this CIRA run are given in Figure 1.

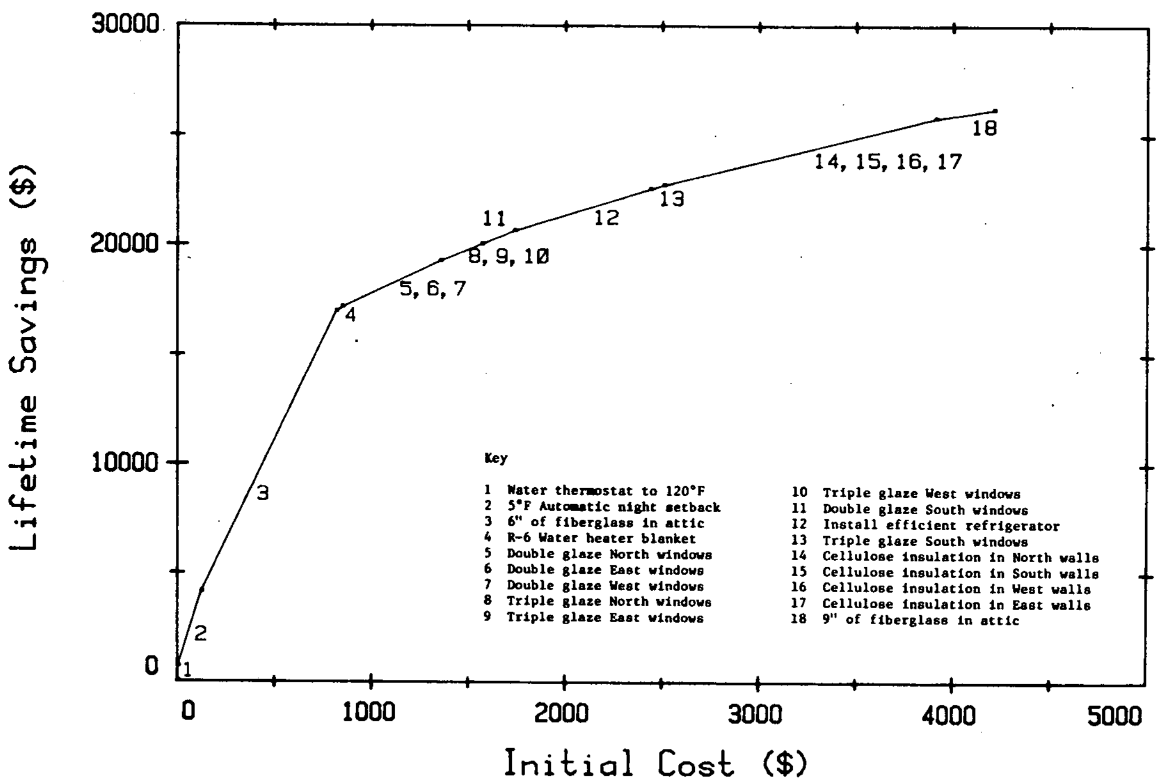

Figure 3: Cumulative lifetime savings from the illustrative retrofit package of retrofits for the Hastings Ranch House in Washington, DC, weather. Energy costs and escalation rates assumed for this CIRA run are given in Figure 1.

is an unintentional consequence of the small size of the sample of retrofits chosen to illustrate the optimization.

Continuing with the retrofits, after an insulating blanket on the water heater comes double glazing for the North, East, and West windows, at a cost of $504 and a saving of $2,048, and savings-to-cost ratio of 4.1. The very next retrofit is to "remove" this double glazing and install triple glazing instead. This retrofit costs an additional $216 (the difference between triple glazing at $936 and double glazing at $720) and saves an additional $786, for an incremental savings-to-cost ratio of 3.7.

The optimal mix of retrofits often depends on the constraint placed on the initial budget, or investment. As the budget increases, it may become cost-effective to upgrade a retrofit on a particular component with a more expensive, but mutually exclusive retrofit with higher savings. In our example, a budget of $1,350 (the sum of all costs thus far) calls for double glazing on all but the South windows. After increasing the budget to $1,566, the most cost-effective retrofit for this house is triple glazing on the same windows. Referring to Fig. 2, the incremental retrofit from double to triple glazing for North windows would be represented by an line (not shown) connecting the tips of lines #5 and #8 which represent double and triple glazing for the North windows, respectively. Here, this incremental retrofit was chosen because its savings-to-cost ratio was higher than any of its competitors at this stage of retrofit.

A similar removal of an earlier retrofit occurs with attic insulation, where it is found that going from 6 inches of fiberglass to 9 inches has a savings-to-cost ratio of 1.2, after installation on other components of several intervening retrofits with higher cost-effectiveness. For each installed retrofit, CIRA remembers how to "undo" its cost to the homeowner and its effect on one or more building parameters, using a string of instructions similar to the one shown in Eq. 1. Instructions on how to undo any retrofit must be retained in case a competing retrofit, presently not chosen because of inferior cost-effectiveness, will be chosen later at a higher level of cumulative investment for lack of better alternatives.

The next most cost-effective retrofit is double glazing of the South windows. Again, this retrofit and all its competitors are magnified in Fig. 4. with the same scale (but not the same origin) as Fig. 2. Notice that many of the retrofits in Fig. 2 are still present but the lines representing them are considerably shallower. The cause is a general decrease in marginal return on conservation investment. The intervening retrofits have made double glazing on the South windows and all other remaining retrofits comparatively less cost-effective. Double glazing, #11, was chosen at this point for lack of better alternatives. The gradual decrease of the savings-to-cost ratio of any <u>individual</u> retrofit as the retrofitting process advances is an expression of the well-known diminishing marginal energy savings of retrofits in buildings: "more insulation saves progressively less." A more extreme example is the 85% efficient gas furnace: throughout the retrofitting process, it was considered cost-effective, but always less so than other retrofits. When its turn finally came after all other retrofits had been installed, its SCR

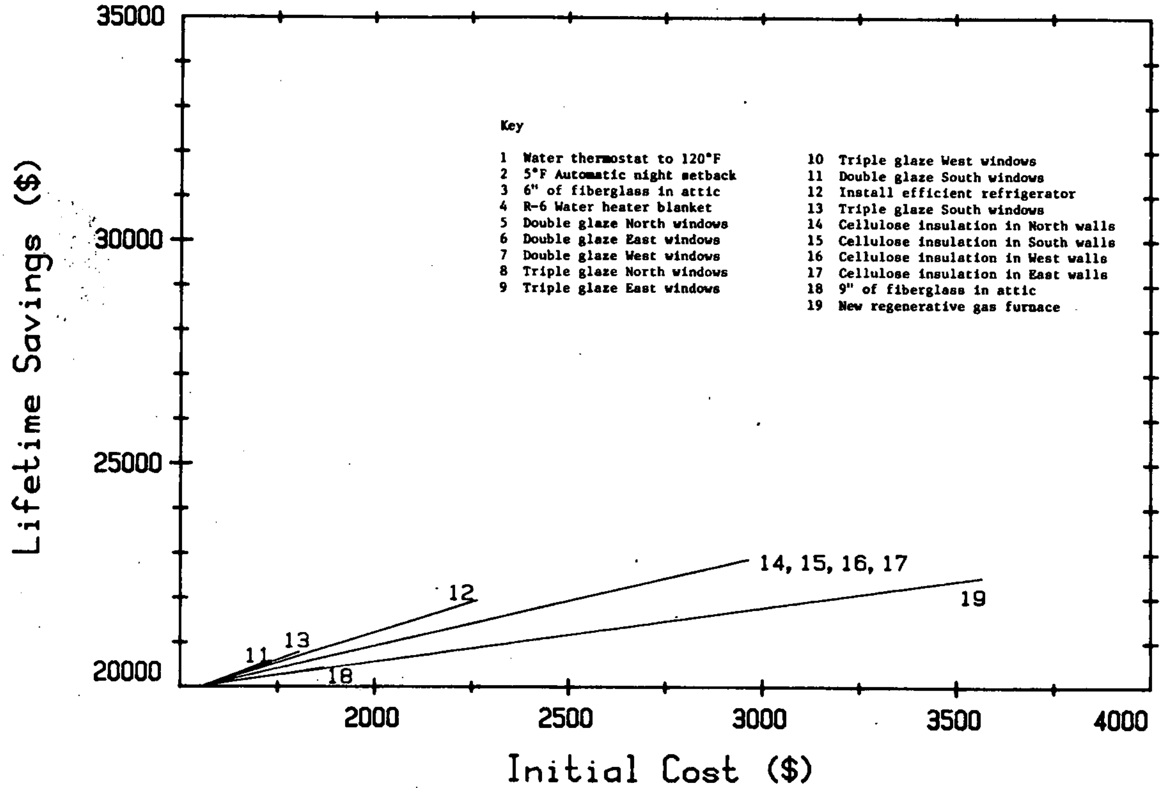

Figure 4: Savings and costs for the retrofits remaining in the database after $1566 has been invested, as if they were individually installed on the Hastings Ranch House with the $1566 worth of retrofits in place.

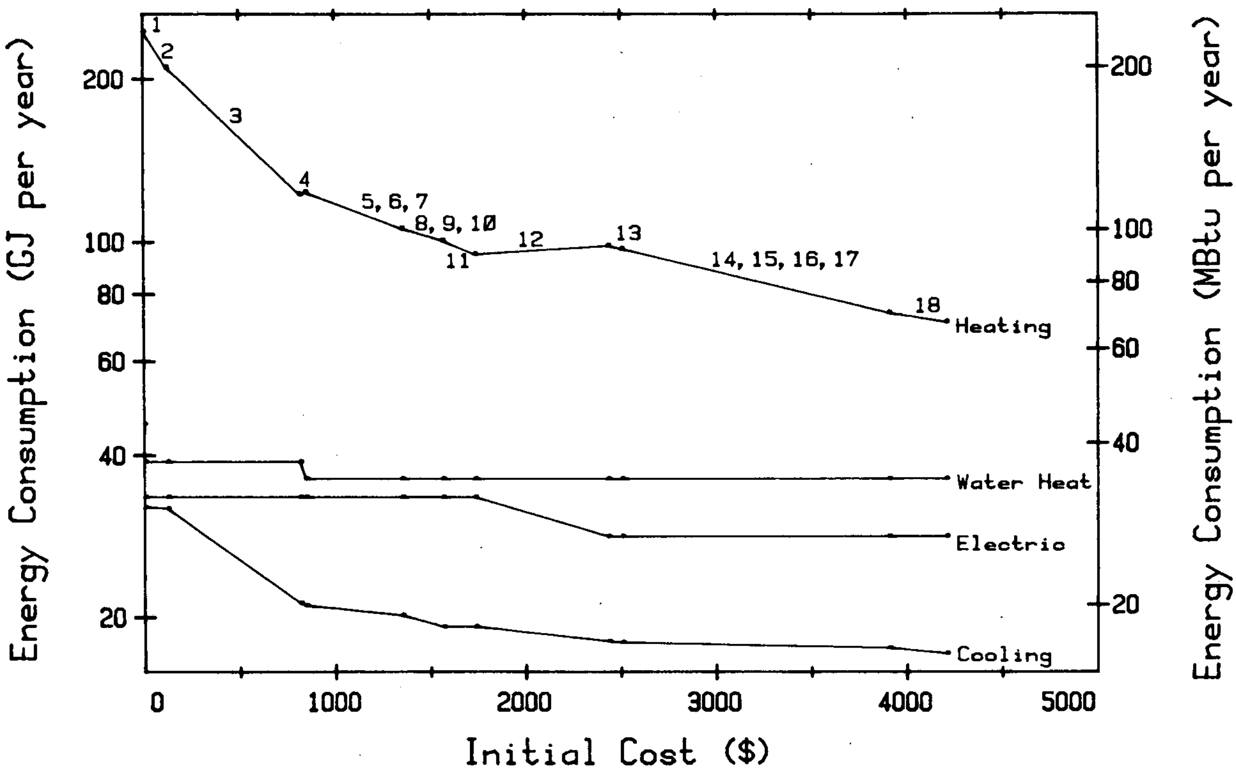

Figure 5: Energy consumptions by end use as functions of initial cost as the installation of retrofits proceeds in optimal order in this CIRA run. Note that the scale is logarithmic. MBtu are millions of British thermal units. For key, see Figure 1.

was found barely shy of one and was thus excluded and not plotted.

Another, related phenomenon, can be observed in Fig. 3: the progressive flattening of the curve represents the diminishing marginal energy savings with increasing total investment in energy conservation, a familiar phenomenon in macroeconomics.[6]

It is interesting to observe how retrofitting the South windows with double glass was not found cost-effective until the windows on all other orientations had already been triple glazed. For this house, the South windows are shaded with overhangs. Thus, the cooling savings realized from reduced summer solar gain due to multiple glazing is scarcely utilized and reduces the cost-effectiveness of double-glazing the South windows. Of course, multiple glazing is not generally used to reduce solar gain. Outdoor or even indoor shading -- not included in the reduced catalog of this sample retrofit optimization -- would likely be more effective.

The retrofitting process is terminated after the regenerative gas furnace. Taken as a whole, the optimal package of retrofits costs $4,206 and saves $25,887 over 20 years, including maintenance and reduced to present value. The cumulative savings-to-cost ratio is therefore 6.2. Expressed another way, this is equivalent to a discounted payback of about 3 years or an internal rate of return of over 20%.

Fig. 5 shows how the consumptions of the different fuels used in this sample house vary through this same retrofitting sequence. As expected, the general trend is downward. Note, however, the slight increases in heating consumption when a more energy-efficient refrigerator (#12) is installed at a $1,734 investment level. This reflects the decrease in "free heat" in the living space following an appliance retrofit. Conversely, cooling consumption benefits from such retrofits.

In Fig. 6 the same sequence of retrofits is represented by the total yearly operating cost to run this sample house, using the different fuel prices input by the CIRA user. The periodic retrofit maintenance costs are not included in this operating cost. Here, the inverse negative of the slope of the curve at any point represents the marginal simple payback of the retrofits. For example, if only retrofits with a simple payback of 3 years or less were to be considered in this sample house, then only retrofits on a section of curve steeper than the slope -1/3 would have to be considered. In this case, this would leave only the two water heater retrofits, the clock thermostat and the 6 inch attic insulation.

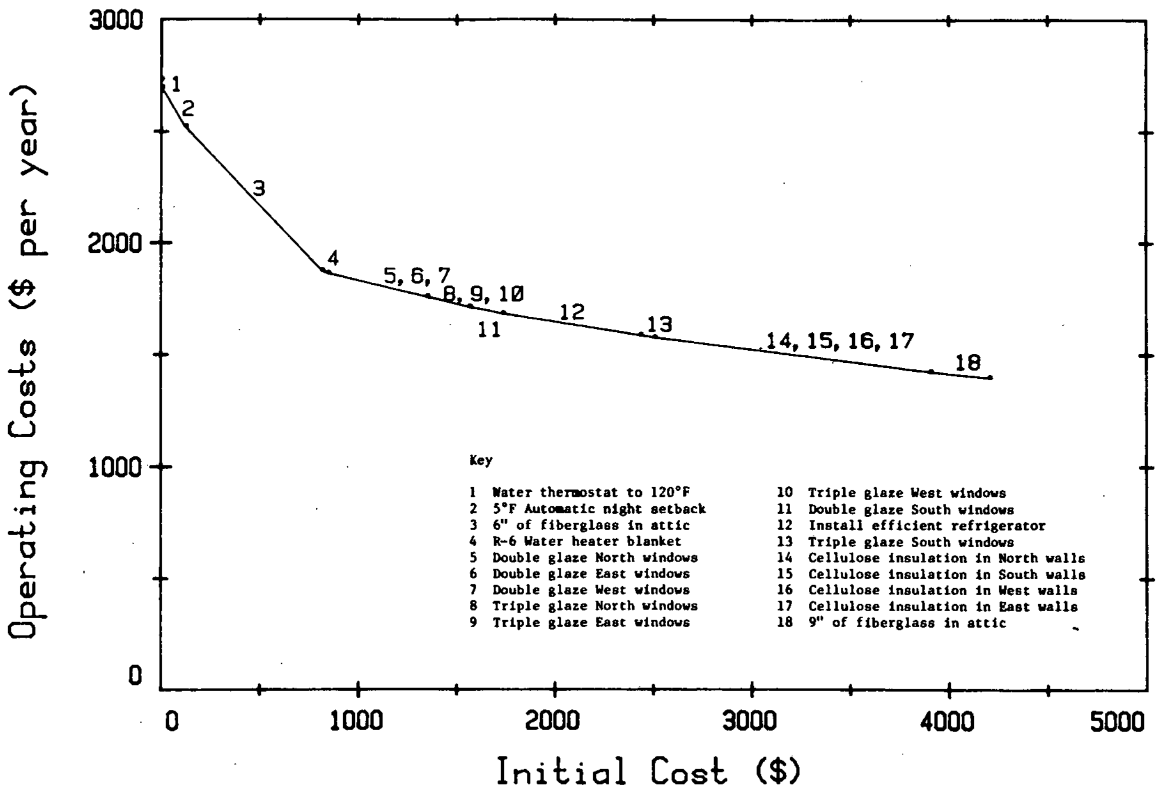

Figure 6: Operating costs for the Hastings Ranch House as function of initial cost as the installation of retrofits proceeds in optimal order in this CIRA run. Energy costs and escalation rates are given in Figure 1.

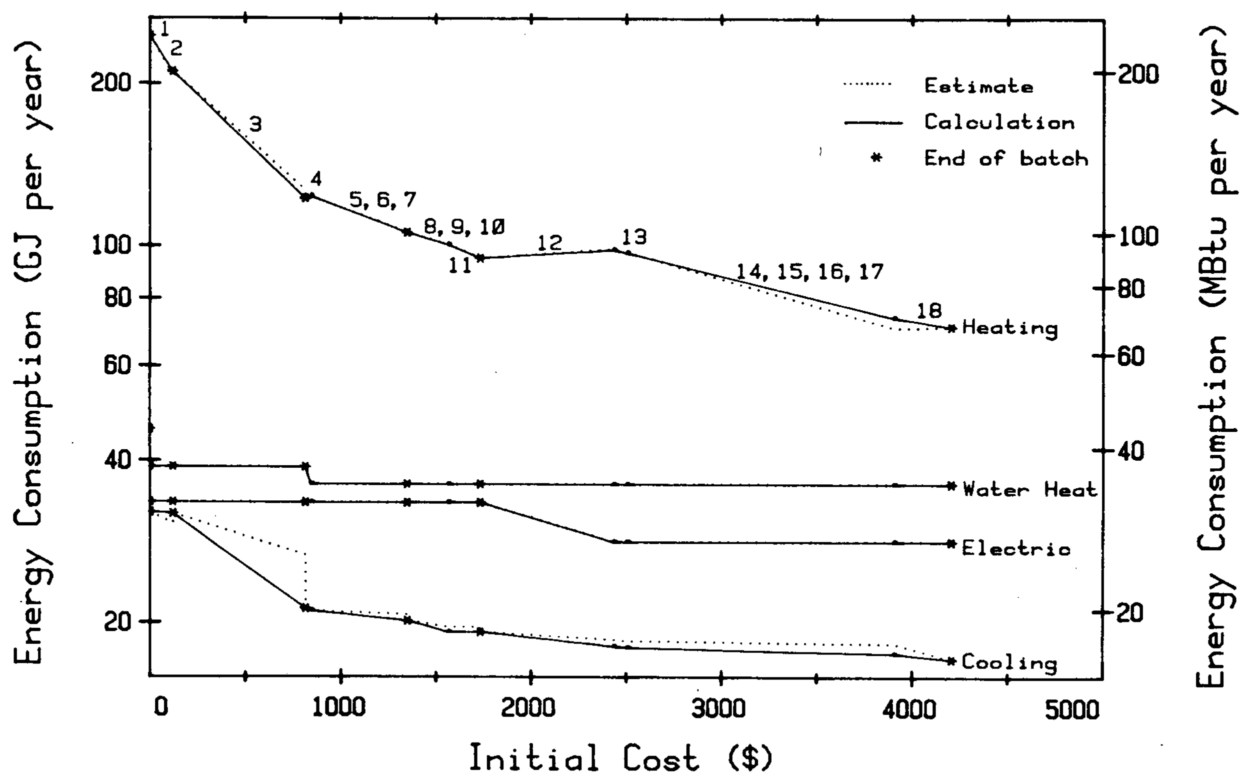

Figure 7: Energy consumptions by end use as functions of initial cost as the installation of retrofits proceeds in optimal order in this CIRA run. Both the estimated energy reductions (calculated with partial derivatives) and the exact calculations are shown. At the end of each batch of retrofits, the estimated savings are corrected. Note that the scale is logarithmic. MBtu are millions of British thermal units. For key, see Figure 1.

Implementation of the Optimization Procedure in CIRA

In principle, the procedure outlined above requires the recalculation of annual energy consumption each time a single retrofit is rated. Under such a procedure, a complete retrofit selection process (in which 200 or more retrofits, including the same retrofit for different components, are considered) could require several thousand calculations of annual energy use. This would take an unacceptable length of time. To speed up the process, CIRA rates the retrofits by an estimate of the savings based on partial derivatives of annual energy consumption and selects retrofits not individually but a batch at a time. After each batch, it recalculates annual energy consumption and corrects the estimates.

Partial Derivatives

As discussed in an earlier section, CIRA calculates the energy consumption of a house as a function of many parameters. However, only four of these are varied by most common retrofits. They are:

1. B ($W/^{o}C$ or Btu/hr-F): Building load coefficient, (including infiltration losses),

2. I (W or Btu/hr): Internal gains, (including solar gain and sky radiation losses),

3. F (fractional): Rated heating or cooling efficiency,

4. D (fractional): Distribution losses.

For a given house, these parameters may each have up to four different values, for the periods heating day, heating night, cooling day, and cooling night. Since the effect of a retrofit on each of these four parameters is known, rather than recalculating the exact change in energy for each retrofit, we can estimate this change from the sensitivity of annual energy use to these four parameters. For B and I, this sensitivity is described by two partial derivatives for heating and two for cooling. To estimate the partial derivatives with respect to building load coefficient, CIRA decreases the latter by 10%, and recalculates the annual heating and cooling energy use. The change in heating energy use divided by the change in building load coefficient approximates the partial derivative of heating energy use with respect to load coefficient, with all other parameters held constant.

$$\left.\frac{d\,E_h}{d\,B_h}\right| \simeq \frac{E_h(B) - E_h(0.9 * B)}{0.1 * B} = X_h \qquad (8)$$

where

E_h = Energy use for heating (GJ/yr or MBtu/yr).
B_h = Building Load Coefficient for heating (W/°C or Btu/hr-F).
B = Value of B_h of house to be retrofit (W/°C or Btu/hr-F).
$E_h(B)$ = Energy use of house with B_h equal to B (GJ/yr or MBtu/yr).
$E_h(0.9*B)$ = Energy use of house with B_h decreased 10% (GJ/yr or MBtu/yr).

For the internal gain derivatives CIRA subtracts 200 Btu/hr (58.6 W) from the internal gain, and recalculates heating and cooling energy use.

$$\left.\frac{d\,E_h}{d\,I_h}\right| \simeq \frac{E_h(I) - E_h(I - 200)}{200^*} = Y_h \qquad (9)$$

where

E_h = Energy use for heating (GJ/yr or MBtu/yr).
I_h = Internal Gains for heating (W or Btu/hr).
I = Value of I_h of house to be retrofit (W or Btu/hr).
$E_h(I)$ = Energy use of house with I_h equal to I (GJ/yr or MBtu/yr).
$E_h(I\text{-}200)$ = Energy use of house with I_h decreased by 200 Btu/hr (58.6W) (GJ/yr or MBtu/yr).
* This becomes 58.6 if metric units are used (W)

For the energy savings from HVAC equipment efficiency increases and HVAC distribution loss reductions, CIRA uses the fact that energy use is inversely proportional to rated efficiency and distribution efficiency (the latter defined as one minus distribution losses):

$$\frac{E_2}{E_1} = \frac{F_1 * (1-D_1)}{F_2 * (1-D_2)} \qquad (10)$$

where

F_1 = HVAC efficiency at condition 1,
F_2 = HVAC efficiency at condition 2,
D_1 = distribution efficiency at conditon 1,
D_2 = distribution efficiency at conditon 2,
E_1 = energy use at F_1 and D_1,
E_2 = energy use at F_2 and D_2.

To rate a retrofit by the total energy use change it causes in heating and cooling, CIRA simply adds the contributions in the four main parameters:

$$\triangle E_h = (X_h * \triangle B_h) + (Y_h * \triangle I_h) - E_h * \left(\frac{\triangle F_h}{F_h} - \frac{\triangle D_h}{1-D_h} \right) \qquad (11)$$

and

$$\triangle E_c = (X_c * \triangle B_c) + (Y_c * \triangle I_c) - E_c * \left(\frac{\triangle F_c}{F_c} - \frac{\triangle D_c}{1-D_c} \right) \qquad (12)$$

The first two terms in equations 11 and 12 are the products of the partial derivatives and changes in B and I, as described above. The last terms are an estimate of the change in annual energy consumption caused by changes in rated efficiency and distribution losses, based on the relation in Eq. 10 above.

Grouping of Retrofits in Batches

The second strategy used by CIRA to speed up the optimization process is to choose retrofits in small batches instead of one by one. There are two main conditions on the composition of a batch of retrofits: a batch may not contain more than one retrofit for each component, and may not reduce the estimated energy consumption of the house by more than 25%. The first condition prevents such events as the simultaneous installation of double glazing and insulating shades on a single window. Clearly, the installation of the first retrofit would greatly diminish the savings from the second. This is called a collision of retrofits. The second condition is required because the derivatives vary as the building load coefficient and the internal gains vary. A 25% change in energy consumption is the range over which the variation in the derivatives has been found to be acceptable.

After a batch of retrofits is installed on the house, a complete re-calculation of annual energy consumption is carried out. The results of this calculation are used to adjust the savings apportioned to each retrofit which affects space heating and cooling. The adjustment factor so calculated has been found to normally lie between 1.05 and 0.95. The saving from each space heating or cooling retrofit is adjusted so that the total saving is correct.

For example, the retrofits chosen could be a a new furnace, a new refrigerator, a water heater blanket for an electric water heater, and an insulating panel for a window. Taken individually, they might be estimated to save exactly 25%. However, when they are installed together, they might save 23%. The fridge and water heater do not interact with each other, so the sum of the electric savings they gave individually is the saving they give when installed together. However, savings from the furnace and the insulating panel are affected by the presence of the fridge and the blanket, so they are adjusted downward to get the correct total. The complete process is illustrated in Fig. 7. It represents the space heating and cooling energy consumptions estimates for each retrofit as a dotted line and the corresponding corrected values as a continuous curve for each fuel type identical to the curves in Fig. 5. An asterisk indicates the exact energy calculated for the house with all the retrofits installed that have been chosen so far. No adjustments of the energy estimates are needed for water heating and electricity, as discussed earlier.

The optimization begins with separately estimating the energy savings for all retrofits and sorting them by decreasing SCR. The winner in the first batch of retrofits is the water heater thermostat setback. The next batch is the automatick clock night setback. It is alone (not included with the previous or following retrofits) because of the strong effect of thermostat setbacks on the partial derivatives. After each of these two batches have been installed, CIRA recalculates the exact yearly energy space heating and cooling energy consumptions and corrects the initial estimates. The result is plotted as the continuous curve for the first two retrofits.

The next batch of retrofits is limited to the 6 inches of attic insulation, as this, alone, decreases the space conditioning consumption by one third. Again, compare the initial estimate, indicated by the third asterisk with the exact recalculation. The process continues with wrapping the water heater and with double glazing the non-South windows as the winners in the next batch, then with recalculating the exact energy consumptions, and so on.

CONCLUSIONS

Optimizing a mix of retrofits on a building is a tedious process. It may be compared to the textbook case of ranking investments by return on investment. Each retrofit, then, is viewed as an investment in energy savings and the monetary savings realized over the years to come constitute the return. However, the analogy is incomplete at best, as the returns on retrofit investments are a moving target. With each retrofit that the "investor" acquires, the returns on all remaining retrofits change, in general downward.

The yearly energy consumption of a building is neither a linear nor a simple function of the building parameters, let alone of the retrofits affecting these parameters. Furthermore, for individual retrofits the parameters affecting energy are rarely monotonic functions of cost. A good example is the multitude of window shades commercially available, some cheap and others expensive, and often with little correlation to R-value or shading coefficient or any reasonable combination thereof. Therefore, unless radical assumptions are made on the cost structure of retrofits and unless the energy calculations are considerably simplified, the elegant analytical techniques of optimization under constraints are difficult to apply.[7]

It is partly because of these difficulties that the numerical, tedious approach to retrofit optimization was taken in CIRA. The program evaluates the actual energy savings of every possible retrofit several times as the house under consideration progresses from the original state to advanced weatherization. The strategy used by CIRA to find the mix of retrofits with the largest net life-cycle savings is essentially that used by a blind person to find the highest point of a hill: follow the line of steepest ascent. That is, keep re-rating retrofits and implement those with the highest savings-to-cost ratio until the available budget is used up or the remaining retrofits point down. This pragmatic method is simple but effective. Rating retrofits by estimated savings, and installing retrofits in batches enables the method to also be efficient for microcomputer applications.

REFERENCES

1. See, for example, DOE-2 Reference Manual (Version 2.1A), Lawrence Berkeley Laboratory LBL-8706 Rev. 2, May 1981.

2. See Engineering Methods (Section V of this manual).

3. H.E. Marshall and R.T. Ruegg, Simplified Energy Design Economics (National Bureau of Standards Special Publication 544, January 1980).

4. Monthly Energy Review (August 1982).

5. S.R. Hastings, "Three Proposed Typical House Designs for Energy Conservation Research," National Bureau of Standards NBSIR 77-1309, Oct. 1977.

6. See, for example, Chapter 11 on Investment Demand in W.H. Branson, Macroeconomic Theory and Policy (New York: Harper & Row, 1972).

7. For an interesting application of analytical optimization techniques to energy saving retrofits, see J.D. Balcomb, "Optimum Mix of Solar and Conservation," presented at the American Section of the Intl. Solar Energy Society, 1980 Annual Meeting, Phoenix, AZ, June 1980.

ORGANIZATION & GLOSSARY

INSERT GOLDENROD DIVIDER

"ORGANIZATION & GLOSSARY"

SECTION VII

PROGRAM ORGANIZATION AND GLOSSARY

The Programs

CIRA is a short overview program which sets up all the files necessary for all its sub-programs.

CIRAINP asks the questions about the house, using the <COMPONENT>.INF and <COMPONENT>.EXP files. It puts this input data into HOUSE.DAT.

CIRASTD reduces the data in HOUSE.DAT into a standard form, for example it combines all walls into four walls, facing North, South, East and West. It calculates the solar fluxes for the actual house orientation, calculates the infra-red radiation loss to the sky, etc. It puts this standardized data into the COMSTD common block.

CIRAEGY is the core of the program. It uses the COMSTD common block to calculate the annual loads and energy consumption of the house. The results are put into HOUSE.LOD. If the retrofit option is used, it also calculates the derivatives of energy use with respect to building load coefficient etc.

CIRAPLT takes the raw data in HOUSE.LOD and converts it into tabular and plot form ready for the video display unit and/or the printer.

CIRAMAT compares the description of the house in HOUSE.DAT with the available retrofits in <COMPONENT>.RET, and matches up the possible retrofits. The complete list of possible retrofits, their actual cost for each component (taking account of size etc.), and the effect each has on internal gain etc. is placed in RETROS.DES.

CIRASRT is the core of the retrofit selection program. It uses the data in RETROS.DES and the derivatives calculated in CIRAEGY to estimate the savings from each retrofit, taken alone. Retrofits which have an estimated lifetime loss are removed from RETROS.DES; the remaining retrofits are sorted in order of lifetime $ savings. Starting at the top, retrofits are taken until the total heating energy reduction is 25% of the energy use of the house currently in COMSTD. These retrofits are taken out of RETROS.DES and put in RETROS.SRT.

CIRAINS "installs" these retrofits in the house by updating COMSTD and COMDAT. COMDAT is an internal copy of HOUSE.DAT, with the latest retrofits added. Energy consumption and derivatives for this retrofitted house are re-calculated by CIRAEGY, the savings from the retrofits in RETROS.SRT are adjusted to fit this new energy consumption, and the program returns to CIRASRT. The savings from the remaining retrofits in RETROS.DES are calculated, then these retrofits are sorted, and put into RETROS.SRT until a further 25% reduction is achieved. This loop (CIRASRT, CIRAINS, CIRAEGY, and back to CIRASRT) continues until there are no more retrofits which give lifetime net $ savings, or until there is no more money.

CIRARPT uses the data in RETROS.INS to prepare an output file of the cost, savings, etc. of the retrofits, in a form ready for the printer.

The Input Files

<COMPONENT>.INF are data files (e.g. WINDOWS.INF) which store all the questions about a component, plus the defaults, the list of possible answers and any equations used for pre-processing the data to ready it for CIRASTD.

<COMPONENT>.EXP are data files (e.g. WINDOWS.EXP) which contain help for users about how to answer any question in COMPONENT.INF.

<COMPONENT>.RET are data files (e.g. WINDOWS.RET) which contain information on the energy savings and the costs of all the retrofits that can be considered for that component.

Files and Common Blocks Created by CIRA

HOUSE.DAT is a file created by CIRAINP which contains all the input data on the physical description of the original house.

COMDAT is a common block with exactly the same structure as HOUSE.DAT, except that the house parameters in it are continuously updated during the retrofitting process.

COMSTD is a common block created by CIRASTD which contains the house data reduced to the essentials necessary for the energy calculation, e.g. only four walls, pointing North, South, East and West; the weather data for the chosen city is included.

HOUSE.LOD is a file created by CIRAEGY which contains the output data of the annual energy calculation, i.e. monthly infiltration rates, monthly electricity use rates, the building load coefficient, etc.

RETROS.DES is a temporary file created by CIRAMAT which stores the descriptions of the retrofits while they are waiting to be sorted by CIRASRT

RETROS.SRT is a temporary file created by CIRA.SRT which stores the retrofits, ordered by cost effectiveness, until they are ready to be output to the printer.

RETROS.INS is a file containing the retrofits in economically optimal order and all the relevant attendant information on location, costs, savings, etc. necessary for printing by CIRARPT.

COMDER is a common block created by CIRAEGY and updated by CIRASRT that contains the current values of partial derivatives and several useful averages to be used during economic optimization.

HOUSE.SUM is a utility file used by CIRASTD and CIRAEGY, to store information for later use by CIRARPT.

CIRA FLOW DIAGRAM

If retrofit optimization is required

CIRA

CIRAINP [Input]

CIRASTD [Standardize]

CIRAMAT [Match retrofits]

CIRAEGY [Calculate energy and derivatives]

CIRASRT [Estimate savings, sort retrofits]

→ CIRAINS [Install batch of retrofits]

CIRAEGY [Re-calculate energy and derivatives]

CIRASRT [Adjust energy, estimate savings, sort remaining retrofits]

CIRARPT [Prepare report]

For design energy calculations

CIRA

CIRAINP [Input]

CIRASTD [Standardize]

CIRAEGY [Calculate energy]

CIRAPLT [Prepare plot]

QUESTION LIBRARY

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"QUESTION LIBRARY"

Section VIII

QUESTION LIBRARY

Introduction

The CIRA Question Library is a complete set of specifications for the input questions used in the CIRA program. Each question has ten fields which describe the input in detail. The user may change <u>some</u> of the field data to suit his or her particular needs. For example, a user might want to change the wording of a question to make it easier to understand. In the following pages we define the field codes, present sample input listings for multiple choice and numerical data questions, define the symbols and operators, and present the detailed input question listings.

Syntax for Questions

Conditional Fields

There are two basic ideas which are fundamental to the operation of these question specifications. The first is that certain fields can be made to depend upon the answers to previous questions. We call these <u>conditional fields.</u> The general syntax for a field of this type is:

$$\text{result}_0\backslash\text{condition}_1>\text{result}_1\backslash\text{condition}_2>\text{result}_2\backslash\ldots\backslash$$

This reads as "use result_0 unless the condition_i is true, in which case use result_i." Result_i can be any legal entry to this field.

Condition_i is of the form:

'Tnnoaa'

where 'T' is the type of question ($ or #) this condition depends upon,
'nn' is the two entry question number [eg. "03"],
'o' is the logical operator
[eg. (, < or > for numerical questions and = and " (equal and not equal) for multiple choice questions]
'aa' is the answer to be compared

These fields are evaluated from left to right and the first condition which is found to be true is used. If none are true, the result_0 is used. <u>Warning</u> : These strings MUST adhere to a strict format. Experimentation with the existing input data is not encouraged unless the user feels comfortable with these rules.

Calculator Usage

The second important point to cover is that of calculator usage. The calculator is used primarily in the default field of numeric questions. This structure allows numeric values to be calculated using the answers to previous questions. The general syntax for this type of entry is:

{any valid RPN string including V,T,I and F variables}

Valid RPN string construction is described at the back of this section as are the V,T,I and F variables. This string MUST be enclosed in curly brackets "{...}".

EXPLANATION OF FIELDS

There are two types of input questions used in the CIRA input program: multiple choice and numerical data questions. Each question has ten fields which contain information about the question. The order of the fields in the input listings must follow the order shown in the sample listings of multiple choice and numerical data questions shown below. A maximum of 255 characters is allowed for any one field, unless noted otherwise.

Multiple Choice Questions

Question Number

The question number is used to identify the question and to determine whether it is is a numerical or multiple choice question. A multiple choice question is identified by a "$" preceding the question number. In addition, a question may be "ghosted," or not asked explicitly, if a "G" is placed immediately after the question number. If a question is ghosted the default is automatically used as the answer. In the sample multiple choice question the question number is $02.

Text of Question

The text of each question, located in the second field position, is limited to 38 characters. Commas and double quotes must not be used within the text of a question.

Code Letters for Answers

The code letters listed in this field are abbreviations for all the possible answers to the question. These are the acceptable answers which appear on the screen when <ctrl-L> is used. The code letters in the sample multiple choice question are SWNEH, (South, West, North, East, and Horizontal). These code letters can be made conditional.

Default Value

The default value represents a good estimate for an answer to the question. The default value is the answer given when either the question is ghosted or the question is answered with a <ctrl-D>. If a question is ghosted, as described above, the answer will automatically be the default value. In the sample multiple choice question, the default is S (South). These can also be made conditional.

MULTIPLE CHOICE QUESTIONS

```
$02,Which window ORIENTATION,\ORIENT,SWNEH,S,$18,,4,\SSouth\WWest\NNorth\EEast\HHorizontal\,\S1.0\W1.0\N1.0\E1.0\H1.12\
```

- $02 — Question number (Question is not ghosted)
- Which window ORIENTATION — Text of question
- \ORIENT — Help file for question
- SWNEH — Code letters for answers
- S — Default value
- $18 — Next question #
- (blank) — No action required
- 4 — Data position for result
- \SSouth\WWest\NNorth\EEast\HHorizontal\ — List of answers, plus code letters
- \S1.0\W1.0\N1.0\E1.0\H1.12\ — Associated values, plus code letters

Next Question Number

The next question number is the number of the question that follows the current question. In the sample multiple choice question, the next question number is $18 (multiple choice question 18). The next question number can be made conditional.

Unaction Required

The unaction required is the set of operations to be performed when mutually exclusive retrofits are installed. For example, if a retrofit specifies triple glazing, the program has to know how to "undo" the existing glazing (single or double). The unaction generally refers to data positions, as defined below. The unactions appear in Reverse Polish Notation (RPN) as described below in the section on operators. If the field is left blank as it is in the sample question, then no unaction is required. For example, existing insulation in a wall is does not have a corresponding "unaction" because we assume that existing insulation is not removable. For more information on the unaction required see the Retrofit Library. The unaction required can be made conditional.

Data Position for Result

The number that appears in this field is the data position in the house description that will receive the result of the question. In the sample multiple choice question, the result of the question would be placed in column 4 of the HOUSE.DAT file and in the row corresponding to the component.

List of Possible Answers

The list of possible answers contains the complete set of code letters and answers for the question. Each different code and answer combination is separated by a backslash (\). The list <u>must</u> be terminated by a backslash.

Associated Values

The associated value is the number associated with the answer to a multiple choice question. These values are generally used in subsequent numeric questions to calculate default values or minimum and maximum values. The associated values appear as a code letter followed by a numeric value. Each code letter and number combination is separated by a backslash (\), and, again, the list <u>must</u> be terminated by a backslash.

Numerical Data Questions

Question Number

The question number is used to identify the question and to determine whether it is a multiple choice or numerical data question. A numerical data question is determined by a "#" symbol placed in front of the question number. In addition, a question may be ghosted by putting a "G" immediately after the question number. If a question is ghosted the default is automatically given as the answer. In the sample numerical data question the question number is #06.

Text of Question

The text of each question, located in the second field position, is limited to 38 characters. In addition, the text must not contain any commas or double quotes.

Unit Conversion

The unit conversion field contains the units for the numeric answer as it appears on the screen and the two conversion operations necessary to convert the answer between units used by the the user and units stored in HOUSE.DAT. The units and conversion operations are each separated by a backslash (\) within the field. English units are currently used in this version of the CIRA input program. In the sample numerical question the user units are in % (percent) while the conversion operation is .01* (multiply the answer by .01 before storing in HOUSE.DAT). The reverse conversion factor, .01/ (divide memory value by .01), converts the answer stored in HOUSE.DAT back to the original user units shown on the screen.

Help File for Question

The help file for the question is identified by the component name (e.g. WALLS or WINDOWS) followed by a backslash (\) and the name of the help section as it appears on the floppy disk. If, as in the example, the component name is the same as the current component (in this example "WINDOWS"), then it can be left out, and only the help section must appear preceded by a "\". The help section in the sample numerical question is SGF (solar gain factor).

Minimum Value

The minimum value for the answer is the lowest acceptable answer. The minimum value is shown when the user presses <ctrl-L>. If the user enters a lower value, an Illegal Entry message appears on the screen, and the original question is re-offered until an acceptable answer is given. In the sample numerical data question the minimum value is 5 (a solar gain factor of 5%). The minimum value field can contain conditional statements and calculator operations.

NUMERICAL DATA QUESTIONS

```
#06,Winter SOLAR GAIN factor,%\.01*\.01/,\SGF,5,100,{I19!I04*100/}\$11=NS>{I19!}\,#07,,9
```

- #06 — Question number
- Winter SOLAR GAIN factor — Text of question
- %\.01*\.01/ — Unit conversion
- \SGF — Help file for question
- 5 — Minimum value
- 100 — Maximum value
- {I19!I04*100/}\$11=NS>{I19!}\ — Default value
- #07 — Next question #
- (empty field) — No calculation required
- 9 — Data position for result

Maximum Value

The maximum value for the answer gives an upper bound for the range of acceptable answers. The maximum value is shown when the user presses <ctrl-L>. If a question is answered with a value higher than the maximum value, an Illegal Entry message appears on the screen, and the user is prompted with the same question until an acceptable answer is given. In the sample numerical data question the maximum value is 100 (a solar gain factor of 100%). The maximum value field can contain conditional statements and calculator operations.

Default Value

The default value represents a good estimate for an answer to the question. In a numerical data question, the default value may be specified as a number or as a set of operations applied to previous answers. The answer to a question will be the default value if the question is ghosted or answered with a <ctrl-D>. In the sample numerical data question the default value is found by entering I19 (the integer portion of the associated value of question 19, "type of glazing"), multiplying by I04 (the integer value of question 4, type of drapes and shutters), and dividing by 100 (100%). However, if the answer to multiple choice question 11 is N (no window covers used during daytime) or S (window covers used in summer only), then the default value is given by the integer value of question 19 only ("type of glazing"). Such mixtures of logical and algebraic operations can be chained at will, restricted only by the total allowable field length of 255 characters. The default value field can contain both conditional and calculator operations.

Next Question Number

The next question number specifies the question to follow the current question. In the sample question the next question number is #07. The next quesion number field can have conditional operations.

Unaction Required

The unaction required is the set of operations to be performed when mutually exclusive retrofits are installed. The unaction generally refers to data positions, as defined below. The unactions appear in Reverse Polish Notation (RPN) as described below in the section on operators. If the field is left blank as it is in the sample question, then no unaction is required. Conditional or calculator operations can be used in this field.

Data Position for Result

The number that appears in this field is the data position or column that will receive the result of the question. In the sample numerical data question, the result of the question would be placed in column 9 of the HOUSE.DAT file and in the row corresponding to the component.

KEY TO SYMBOLS USED IN <COMPONENT>.INF FILES

#02	is the numerical data question 2
#02G	means that numerical data question 2 is "ghosted."
$03	is the multiple choice question 3.
$03G	means that multiple choice question 3 is "ghosted."
V04	is the value given in answer to question 4.
T05	is the total associated value for the answer to $05.
I06	is the integral part of T06.
F07	is one thousand times the fractional part of T07.
D08	is the data stored in the HOUSE.DAT file, in the row corresponding to the component being considered and in column 8.

OPERATORS

(i) Reverse Polish

! enter	* multiply	/ divide	+ plus
- minus	' absolute value	¦ invert	^ is y^x
@ change sign	> is x > y?	< is x < y?	= is x = y?
# is x ≠ y?	) is x >= y?	(is x <= y?	L ln(x)
X exp (x)	~ exchange x and y		

All operators work exactly like those in a Hewlett-Packard calculator (complete with 4 internal registers) except for the logical operations. Rather than branching as in an HP calculator, a "true" result of a logical test places "-1" into the x register, while a "false" result places a "0" there, while all upper registers are "rolled" down one step.

(ii) Other

,	a comma separates each field
:	a colon separates values within a field when two or more are present.

DETAILED LIST OF INPUT QUESTIONS

This section explains in detail the input structure of CIRA. All the questions, including those which are automatically answered by default, are listed. Also given are the range of possible answers, the method by which the default is calculated, the data position in which the answer is stored, the unit conversion operation, the next question, and the explanation associated with each question.

As an example of how to read one page, consider Question #09 on page 7 of the WINDOWS section, the first half of which is reproduced below:

WINDOWS Question #09

U-value?

Minimum = 0.1 Btuh/sqft/F
Maximum = 2 Btuh/sqft/F

Default = (1/[100/rgval($19)+rgval($04)/100]*value($11)*value($02)
Btuh/sqft/F

IF $04: "DRAPES & SHUTTERS" WAS "NONE" THEN:
Default = [rgval($19)/100]*value($02) Btuh/sqft/F

Legend $11: Are window covers USED at DAYtime
$02: Which window ORIENTATION
$19: GLAZING
$04: DRAPES & SHUTTERS

Next question = $05: "Average sash FIT"

IF $18: "Window TYPE" WAS "JALOUSIE" THEN:
Next question = #12: "Specific LEAKAGE AREA"

Data position = 12 Units = Btuh/sqft/^{o}F

This question asks about the U-value of a window. The first two lines give the minimum and maximum values permitted, and the next line gives the default. The default is calculated from the answers to questions 2, 4, 11 and 19; value($02) indicates that question 2 was multiple choice, if it had asked for a number, it would have been labelled "answer(#02)" By looking at the page for question 19, it can be seen that "rgval($19)", e.g. the right hand value associated with the answer to question 19, is 110, 58, and 39, for single, double, and triple pane glass respectively, that is, 100 times the U-value for the glazing; the left hand number is 100 times the transmissivity. Similarly, "rgval($04)" is 100 times the R-value of the drapes and shutters, "value($02)" is a correction factor to account for horizontal windows, and "value-11" is a correction factor for usage of drapes. Thus pressing default instructs the computer to carry out the standard U-value calculation, using stored R-values and U-values. The second default is for when there are no drapes, and the calculation is simplified.

The next question is #05 (the question numbers are a historical accident; the questions are asked in the order of page number). This asks for "Average sash FIT", unless the window type was jalousie, where fit is clearly meaningless. In this case, the next question is #12, "Specific LEAKAGE AREA".

The answer to the U-value question is stored at data position 12. In some cases, the answer is converted into some other units before being stored. For example, the question might ask for a percentage but store the result as a fraction. If there is any such conversion, it is shown on the same line as the data position. The boxed section on each page of the documentation (not reproduced above) is the explanation given when <ctrl-H> is pressed during input.

Component.inf files

The following pages present all the questions CIRA asks in two formats. The first is designed for easy reading, with one question per page. The second format, with one complete file per page, is the way the questions are actually stored in the computer in the <COMPONENT.INF> files. The information given in each format is identical.

as <COMPONENT.INF> files.

Master

'L'ong, 'S'hort or 'N'o INSTRUCTIONS?

Acceptable Answer(s):

L - Long instructions
S - Short instructions
N - No instructions

Default:

L - Long instructions

Next Question = RETURN

Data position = 0

Explanations:

```
+------------------------------------------------------------------------------+
|                                                                              |
|                A SUMMARY OF WAYS TO GET HELP                                 |
|                                                                              |
|           <ctrl H>.......Gives HELPful information                           |
|           <ctrl L>.......LISTs all possible  answers.                        |
|           <ctrl D>.......Gives DEFAULT value for  the  answer.               |
|           <ctrl Q>.......QUITS, and lands you at WHAT NEXT?                  |
|           <ctrl E>.......Lets you EDIT your answers to any question.         |
|           <RETURN>.......(Carriage return key)  Repeats your last answer.    |
|           ?..............(Question mark)  Reprints this summary table.       |
|                                                                              |
+------------------------------------------------------------------------------+
```

Which menu ITEM?

Minimum = 1 item no.

Maximum = 22 item no.

Default = 1 item no.

Next question = $26: "Which menu ITEM(S)"

Data position = 0

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|      The MENU is a list of choices or questions displayed on the screen.|
| To choose an item on the menu, type its number or letter.             |
|                                                                        |
+------------------------------------------------------------------------+
```

Which menu ITEM(S)?

Next Question = $26: "Which menu ITEM(S)"

Data position = 0

Explanations:

```
+----------------------------------------------------------------------+
|                                                                      |
|       The MENU is a list of choices or questions displayed on the screen. |
| To choose an item on the menu, type its number or letter.            |
|                                                                      |
+----------------------------------------------------------------------+
```

WHAT NEXT or Continue?

Acceptable Answer(s):

G - General
E - Economic
W - Windows
D - Doors
O - Walls
R - Roof/Ceiling
S - Subfloor
P - Passive-Solar
N - Greenhouse
X - Active-Solar
H - HVAC-system
I - Infiltration
L - Landscape
A - Appliances
C - Continue

Default:

G - General

Next Question = #25: "Which menu ITEM"

IF $27: "WHAT NEXT or Continue" **WAS** "Continue" **THEN:**
Next Question = RETURN

Data position = 0

Explanations:

WHAT NEXT asks either about house components, such as windows, air infiltration, HVAC-system, passive solar features and appliances, or asks general or economic questions. For a complete LIST, press <ctrl-L> Sections can be entered and recalled later for correction in any order.

When you have completed all inputs, answer with "C" (for C-ontinue), after which the computer will take a short time to process all your entries. For example, it checks for vital missing information (e.g.,the "General" option, which contains the city and azimuth information), and, if necessary, issues a request to enter the missing information. Later you will be asked whether you just want to know about the annual energy consumption of your house, or if you also want to retrofit it. In the latter case, more questions will follow regarding the proper choice of retrofits.

SAVE this information?

Acceptable Answer(s):
Y - Yes - save this info
N - No - don't save

Default:
Y - Yes - save this info

Next Question = #25: "Which menu ITEM"

IF $28: "SAVE this information" **WAS** "Yes - save this info" **THEN:**
Next Question = $29: "OVERWRITE old information"

IF $27: "WHAT NEXT or Continue" **WAS** "General"
OR "Economic"
OR "HVAC-system"
OR "Infiltration"
OR "Landscape"
OR "Appliances"
OR "Active-Solar" **THEN:**
Next Question = $27: "WHAT NEXT or Continue"

Data position = 0

Explanations:

After you have entered information in response to each question, the computer is ready to SAVE the new entries (or the changes to existing entries) on disk. If this step would permanently change pre-existing information, the computer will ask for permission to OVERWRITE it.

OVERWRITE old information?

Acceptable Answer(s):

Y - Yes - write over old info
N - No - not yet

Default:

N - No - not yet

Next Question = #25: "Which menu ITEM"

IF $29: "OVERWRITE old information" **WAS** "No - not yet" **THEN:**
Next Question = $26: "Which menu ITEM(S)"

IF $27: "WHAT NEXT or Continue" **WAS** "General"
OR "Economic"
OR "HVAC-system"
OR "Infiltration"
OR "Landscape"
OR "Appliances"
OR "Active-Solar" **THEN:**
Next Question = $27: "WHAT NEXT or Continue"

Data position = 0

Explanations:

After you have entered information in response to each question, the computer is ready to SAVE the new entries (or the changes to existing entries) on disk. If this step would permanently change pre-existing information, the computer will ask for permission to OVERWRITE it.

ENTER, CALCULATE, RETROFIT or QUIT?

Acceptable Answer(s):
E - Enter components
C - Calculate energy
R - Retrofit house
Q - Quit

Default:
C - Calculate energy

Next Question = RETURN

Data position = 0

Explanations:

If you forgot to ENTER some house components, some general or some economic information, respond with "E" and you will get back to the "WHAT NEXT?" question.
Respond with "C"-alculate if you want the computer to estimate energy consumption. Respond with "R"-etrofit if you want the computer to estimate the optimized package of retrofits for the house.
If, however, you want to call it a day and continue tomorrow, answer with "Q"-uit. To get back where you left off, just restart the program and answer "C"-alculate or "R"-etrofit when the computer asks WHAT NEXT?

```
$02,"'L'ong, 'S'hort or 'N'o INSTRUCTIONS",MASTER\GENERAL,LSN,L,RETURN,[0],0,\L
  Long instructions\SShort instructions\NNo instructions\,\\
#25[16],Which menu ITEM,item no.\,MASTER\MENU,1,22,1,$26,[27],0
$26[26],Which menu ITEM(S),MASTER\MENU,,,$26,[28],0,\AA\BB\CC\DD\EE\FF\GG\HH\II
  \JJ\KK\LL\MM\NN\OO\PP\QQ\RR\SS\TT\UU\VV\WW\XX\YDelete component\ZResume/Compl
  eted\,\\
$27[14],WHAT NEXT or Continue,MASTER\NEXT,GEWDORSPNXHILAC,G,#25\$27=C>RETURN\,[
  2]\,0,\GGeneral\WWindows\DDoors\OWalls\RRoof-Ceiling\SSubfloor\IInfiltration\
  LLandscape\HHVAC-system\PPassive-Solar\NGreenhouse\XActive-Solar\AAppliances\
  EEconomic\CContinue\,\\
$28,SAVE this information,MASTER\SAVE,YN,Y,#25\$28=Y>$29\$27=GEHILAX>$27\,[0]\$
  28=Y>[29]\,0,\YYes - save this info\NNo - don't save\,\\
$29,OVERWRITE old information,MASTER\SAVE,YN,N,#25\$29=N>$26\$27=GEHILAX>$27\,[
  7]\$29=N>[0]\,0,\YYes - write over old info\NNo - not yet\,\\
$30,"ENTER, CALCULATE, RETROFIT or QUIT",MASTER\ENTER,ECRQ,C,RETURN,[0],0,\EEnt
  er components\CCalculate energy\RRetrofit house\QQuit\,\\
```

General

NAME of this house?

Next Question = $02: "What CITY"

Data position = 3

Explanations:

```
+---------------------------------------------------------------------------+
|                                                                           |
|      NAME should be a unique name for the  house  that  is  being  audited, |
| e.g.,  "John Public".  Up to ten letters or symbols may be used.  It is used |
| by the program to identify the house.                                     |
|                                                                           |
+---------------------------------------------------------------------------+
```

What CITY?

Acceptable Answer(s) and Associated [Value(s)]:

A - Albuquerque	[5311]
B - Boise	[2838]
F - Fresno	[328]
L - Los Angeles	[97]
M - Minneapolis	[834]
N - Atlanta	[1010]
P - Portland	[21]
C - Sacramento	[17]
D - San Diego	[13]
S - San Francisco	[8]
T - Seattle	[400]
W - Washington DC	[14]

Default:

A - Albuquerque	[5311]

Next Question = #04: "LATITUDE"

Data position = 4

Explanations:

CITY is the name of the nearest available city. Weather data from this city is used in the calculations. Pressing <ctrl-L> will give a list of available cities.

AZIMUTH of north face?

Minimum = -45 degrees

Maximum = 45 degrees

Default = 0 degrees

Next question = $05: "What type of THERMOSTAT"

Data position = 6

Explanations:

```
+-------------------------------------------------------------------------+
|                                                                         |
|      AZIMUTH is the compass direction the  house  faces.   It  is  used to |
| calculate  the  solar energy which falls on each window and wall.  Depending |
| on the house orientation, enter:                                        |
|                                                                         |
|          0     if the north wall of the house faces exactly north;     |
|         10     if it faces 10 degrees east of north;                   |
|        -20     if it faces 20 degrees west of north;                   |
|                                                                         |
| and so on, up to 45 or down to -45.                                     |
|                                                                         |
+-------------------------------------------------------------------------+
```

LATITUDE?

(Not asked explicitely)

Minimum = 0 degrees

Maximum = 90 degrees

Default = 37.0 degrees

IF $02: "What CITY" **WAS** "Albuquerque" **THEN:**
Default = 35.1 degrees

IF $02: "What CITY" **WAS** "Atlanta" **THEN:**
Default = 33.7 degrees

IF $02: "What CITY" **WAS** "Boise" **THEN:**
Default = 43.5 degrees

IF $02: "What CITY" **WAS** "Fresno" **THEN:**
Default = 36.8 degrees

IF $02: "What CITY" **WAS** "Los Angeles" **THEN:**
Default = 33.9 degrees

IF $02: "What CITY" **WAS** "Minneapolis" **THEN:**
Default = 44.9 degrees

IF $02: "What CITY" **WAS** "Portland" **THEN:**
Default = 45.6 degrees

IF $02: "What CITY" **WAS** "Sacramento" **THEN:**
Default = 38.5 degrees

IF $02: "What CITY" **WAS** "San Diego" **THEN:**
Default = 32.4 degrees

IF $02: "What CITY" **WAS** "San Francisco" **THEN:**
Default = 37.6 degrees

IF $02: "What CITY" **WAS** "Seattle" **THEN:**
Default = 47.5 degrees

IF $02: "What CITY" **WAS** "Washington DC" **THEN:**
Default = 38.9 degrees

Next question = #08: "ALTITUDE"

Data position = 5

Explanations:

LATITUDE is the latitude of the house being audited. It is used to calculate horizontal and vertical solar insolation. Pressing <ctrl-D> will

```
| give the latitude of the city you chose.                                |
|                                                                         |
+-------------------------------------------------------------------------+
```

What type of THERMOSTAT?

Acceptable Answer(s):

N - None
H - Heating only
C - Cooling only
D - Dual heating & cooling

Default:

D - Dual heating & cooling

Next Question = #11: "Heating THERMOSTAT setting"

IF $05: "What type of THERMOSTAT" **WAS** "None"
OR "Cooling only" **THEN:**
Next Question = #06: "Avg Indoor WINTER temperature"

Data position = 17

Explanations:

The TYPE of thermostat shows if your thermostat controls heating, or cooling, or both, or neither. This information should be visible on the thermostat itself. For example, it might have two pointers on the same scale, one marked "heating" and the other "cooling".

NOTE: The thermostat must be connected. A heating and cooling thermostat connected only to the furnace counts as "Heating only".

Avg Indoor WINTER temperature?

Minimum = 50 degF

Maximum = 80 degF

Default = 68 degF

Next question = #21: "Heating NIGHT setting"

Data position = 8

Explanations:

```
+--------------------------------------------------------------------------+
|                                                                          |
|      If you don't have or don't use a thermostat, enter your estimate of |
| the average TEMPERATURE in your house in winter or in summer.            |
|                                                                          |
+--------------------------------------------------------------------------+
```

Avg Indoor SUMMER temperature?

Minimum = 60 degF

Maximum = 90 degF

Default = 78 degF

Next question = #20: "Cooling NIGHT setting"

Data position = 10

Explanations:

```
+----------------------------------------------------------------------+
|                                                                      |
|      If you don't have or don't use a thermostat, enter your estimate of |
| the average TEMPERATURE in your house in winter or in summer.        |
|                                                                      |
+----------------------------------------------------------------------+
```

ALTITUDE?

(Not asked explicitely)

Minimum = -100 feet

Maximum = 7000 feet

Default = value($02) feet

Legend: $02: What CITY

Next question = #03: "AZIMUTH of north face"

Data position = 7

Explanations:

Enter the altitude, or elevation, of the house, in feet above sea level. It is used to correct the density of air for the infiltration calculations and for the calculations which involve air humidity. Pressing <ctrl-D> gives the altitude of the weather station of the city you chose.

Heating THERMOSTAT setting?

Minimum = 50 degF

Maximum = 90 degF

Default = 68 degF

Next question = #12: "Heating NIGHT setting"

Data position = 8

Explanations:

The thermostat SETTING is the temperature you set on the dial. Day and night settings can be different, and so can heating and cooling settings. If you turn the heat off at night, enter the lowest permitted temperature as the night setting. Pressing <ctrl-L> gives the permitted range.

Heating NIGHT setting?

Minimum = 50 degF

Maximum = 90 degF

Default = 63 degF

Next question = #13: "Cooling THERMOSTAT setting"

IF $05: "What type of THERMOSTAT" **WAS** "Heating only" **THEN:**
Next question = #07: "Avg Indoor SUMMER temperature"

Data position = 9

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|     The thermostat SETTING is the temperature you set on the dial. Day |
| and night settings can be different, and so can heating and cooling    |
| settings. If you turn the heat off at night, enter the lowest permitted|
| temperature as the night setting. Pressing <ctrl-L> gives the permitted|
| range.                                                                 |
|                                                                        |
+------------------------------------------------------------------------+
```

Cooling THERMOSTAT setting?

Minimum = 65 degF

Maximum = 95 degF

Default = 78 degF

Next question = #14: "Cooling NIGHT setting"

Data position = 10

Explanations:

The thermostat SETTING is the temperature you set on the dial. Day and night settings can be different, and so can heating and cooling settings. If you turn the heat off at night, enter the lowest permitted temperature as the night setting. Pressing <ctrl-L> gives the permitted range.

Cooling NIGHT setting?

Minimum = 65 degF

Maximum = 95 degF

Default = 83 degF

Next question = #16: "Total house FLOOR AREA"

Data position = 11

Explanations:

The thermostat SETTING is the temperature you set on the dial. Day and night settings can be different, and so can heating and cooling settings. If you turn the heat off at night, enter the lowest permitted temperature as the night setting. Pressing <ctrl-L> gives the permitted range.

Total house FLOOR AREA?

Minimum = 100 sqft

Maximum = 10000 sqft

Default = 1000 sqft

Next question = $17: "House MASS"

Data position = 13

Explanations:

```
+----------------------------------------------------------------------+
|                                                                      |
|      FLOOR AREA is the heated (or cooled) living space.  A two-story house |
| with 2 floors of 750 sqft each would therefore have a FLOOR AREA of 1,500 |
| sqft.  Include the basement area if it is heated.                   |
|                                                                      |
+----------------------------------------------------------------------+
```

House MASS?

Acceptable Answer(s) and Associated [Value(s)]:

H - Heavy	[.44]
M - Medium	[.33]
L - Light	[.22]

Default:

M - Medium [.33]

Next Question = #18: "Solar STORAGE factor"

Data position = 14

Explanations:

House MASS is related to the weight of the house that can store heat. The greater the MASS, the more sluggishly the house behaves, i.e. the longer it takes for the house to heat up or cool down. The three options available are:

Heavy	Concrete structures with massive walls
Medium	Light concrete structures, or concrete structures where masonry is shielded by paneling or rugs.
Light	Wood-frame construction.

Solar STORAGE factor?

Minimum = 0 unitless

Maximum = 1 unitless

Default = value($17) unitless

Legend: $17: House MASS

Next question = #19: "SPECIFIC THERMAL MASS"

Data position = 15

Explanations:

The SOLAR STORAGE factor is the ability of the house to store daytime solar heat for use during the night. It is calculated per unit FLOOR AREA. Concrete or brick floors without carpets (at least where the sun hits) have the highest solar storage factor.

If you press <ctrl-D> the computer will give you a default value based on the HOUSE MASS you chose earlier.

SPECIFIC THERMAL MASS?

Minimum = 0 Btu/Fsqft

Maximum = 10 Btu/Fsqft

Default = 3.8 Btu/Fsqft

IF $17: "House MASS" **WAS** "Heavy" **THEN:**
Default = 5.7 Btu/Fsqft

IF $17: "House MASS" **WAS** "Light" **THEN:**
Default = 1.9 Btu/Fsqft

Next question = $26: "Which menu ITEM(S)"

Data position = 16

Explanations:

The SPECIFIC THERMAL MASS is the ability of your house to absorb or release heat (or "coolth") during a thermostat setback. It is calculated per unit FLOOR AREA. The value is highest for masonry construction, especially indoor surfaces not shielded by carpets or wood paneling.

If you press <ctrl-D> the computer will give you an estimate of this parameter, based on your earlier choice of HOUSE MASS.

Cooling NIGHT setting?

(Not asked explicitely)

Minimum = 65 degF

Maximum = 95 degF

Default = answr(#07) degF

Legend: #07: Avg Indoor SUMMER temperature

Next question = #16: "Total house FLOOR AREA"

Data position = 11

Explanations:

The thermostat SETTING is the temperature you set on the dial. Day and night settings can be different, and so can heating and cooling settings. If you turn the heat off at night, enter the lowest permitted temperature as the night setting. Pressing <ctrl-L> gives the permitted range.

Heating NIGHT setting?

(Not asked explicitely)

Minimum = 50 degF

Maximum = 90 degF

Default = answr(#06) degF

Legend: #06: Avg Indoor WINTER temperature

Next question = #13: "Cooling THERMOSTAT setting"

IF $05: "What type of THERMOSTAT" **WAS** "Heating only"
OR "None" **THEN:**
Next question = #07: "Avg Indoor SUMMER temperature"

Data position = 9

Explanations:

```
+--------------------------------------------------------------------------+
|                                                                          |
|      The thermostat SETTING is the temperature you set on  the  dial.  Day |
| and  night  settings  can  be  different,  and  so  can  heating and cooling |
| settings.  If you turn the heat off at night,  enter  the  lowest  permitted |
| temperature  as  the  night  setting.  Pressing <ctrl-L> gives the permitted |
| range.                                                                   |
|                                                                          |
+--------------------------------------------------------------------------+
```

```
$01,NAME of this house,\NAME,,,$02,,3,\\,\\
$02,What CITY,\CITY,ABFLMNPCDSTW,A,#04,,4,\AAlbuquerque\NAtlanta\BBoise\FFresno
  \LLos Angeles\MMinneapolis\PPortland\CSacramento\DSan Diego\SSan Francisco\TS
  eattle\WWashington DC\\A5311\N1010\B2838\F328\L97\M834\P21\C17\D13\S8\T400\W1
  4\
#03,AZIMUTH of north face,degrees\,\AZIM,-45,45,0,$05,,6
#04G,LATITUDE,degrees\,\LAT,0,90,37.0\$02=A>35.1\$02=N>33.7\$02=B>43.5\$02=F>36
  .8\$02=L>33.9\$02=M>44.9\$02=P>45.6\$02=C>38.5\$02=D>32.4\$02=S>37.6\$02=T>47
  .5\$02=W>38.9\,#08,,5
$05,What type of THERMOSTAT,\THERMOSTAT,NHCD,D,#11\$05=NC>#06\,,17,\NNone\HHeat
  ing only\CCooling only\DDual heating & cooling\,\\
#06,Avg Indoor WINTER temperature,degF\,\TEMPERATURE,50,80,68,#21,,8
#07,Avg Indoor SUMMER temperature,degF\,\TEMPERATURE,60,90,78,#20,,10
#08G,ALTITUDE,feet\,\ALTITUDE,-100,7000,{T02!},#03,,7
#11,Heating THERMOSTAT setting,degF\,\SETTING,50,90,68,#12,,8
#12,Heating NIGHT setting,degF\,\SETTING,50,90,63,#13\$05=H>#07\,,9
#13,Cooling THERMOSTAT setting,degF\,\SETTING,65,95,78,#14,,10
#14,Cooling NIGHT setting,degF\,\SETTING,65,95,83,#16,,11
#16,Total house FLOOR AREA,sqft\,\FLOOR AREA,100,10000,1000,$17,,13
$17,House MASS,\MASS,HML,M,#18,,14,\HHeavy\MMedium\LLight\,\H.44\M.33\L.22\
#18,Solar STORAGE factor,unitless\,\SUN STORE,0,1,{T17!},#19,,15
#19,SPECIFIC THERMAL MASS,Btu/Fsqft\,\TMASS,0,10,3.8\$17=H>5.7\$17=L>1.9\,$26,,
  16
#20G,Cooling NIGHT setting,degF\,\SETTING,65,95,{V07!},#16,,11
#21G,Heating NIGHT setting,degF\,\SETTING,50,90,{V06!},#13\$05=HN>#07\,,9
```

Economics

NAME of the following scenario?

(Not asked explicitely)

Default:

Price & Use

Next Question = #02: "Economic HORIZON"

Data position = 3

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|      The name is now given by default.                                 |
|                                                                        |
+------------------------------------------------------------------------+
```

Economic HORIZON?

Minimum = 1 years

Maximum = 30 years

Default = 20 years

Next question = #03: "REAL DISCOUNT rate"

Data position = 4

Explanations:

The economic HORIZON is the time for which cost and savings from energy-saving measures are to be considered. Savings which take place after the horizon are neglected.

Retrofits which are expensive but have low maintenance costs (e.g. attic insulation or double glazing) look better over long horizons. Retrofits which look better over a short horizon are those with short lifetimes and low costs, such as energy saving lightbulbs or plastic storm windows. These might be attractive to a homeowner expecting to move within the next five years.

The computer assumes that carrying out a retrofit, e.g. putting in attic insulation, DOES NOT affect the house resale value.

REAL DISCOUNT rate?

Minimum = -20 %

Maximum = 20 %

Default = 3 %

Next question = #14: "REPLACEMENT-RETROFIT esc. rate"

Data position = 5 **—> contains** Entry*.01

Explanations:

The real DISCOUNT RATE if the cost of money to the homeowner, adjusted for inflation. In other words, it is the after-tax interest rate the homeowner has to pay to borrow money (e.g. home improvement loan), after correcting for inflation. [Another way of looking at it is as the after-tax return, corrected for inflation, of the next best safe investment available to the homeowner, e.g. treasury bills.]

Making a house energy-efficient usually means paying a lot now and letting savings accrue over time. A low real DISCOUNT RATE means that you are willing to accept a steady stream of savings for a number of years, or that you think the investment is a safe one. A high real DISCOUNT RATE means you want your savings very soon, or that you think the investment is a risky one.

$$\text{REAL DISCOUNT RATE} = \frac{\text{After tax interest rate} - \text{Inflation rate}}{1 + \text{Inflation rate}}$$

e.g.	INFLATION RATE	AFTER TAX INTEREST RATE	REAL DISCOUNT RATE
	10%	15%	4.5%
	12%	15%	2.7%

REPLACEMENT-RETROFIT esc. rate?

Minimum = -20 %

Maximum = 20 %

Default = 4 %

Next question = #11: "Maximum INVESTMENT"

Data position = 6 —> **contains** Entry*.01

Explanations:

Most retrofits will require a certain amount of maintenance over the time span of the ECONOMIC HORIZON. For example, if the economic horizon is twenty years, and the item which is being retrofit has a lifetime of ten years, then one complete new unit will have to be installed after ten years.

The REPLACEMENT-RETROFIT escalation rate is the rate at which the price of retrofit equipment is increasing, excluding inflation. If it is increasing at 3% in dollars corrected for inflation, then the replacement equipment in the above example will cost 35% more than the original equipment, since it will be bought ten years later.

Maximum INVESTMENT?

Minimum = 1 $

Maximum = 50000 $

Default = 2000 $

Next question = $06: "NON-ELECTRIC fuel"

Data position = 7

Explanations:

The Maximum INVESTMENT is the maximum amount of money you want to spend on energy retrofits. It will form the upper limit that the computer will consider in all its economic optimizations. No further retrofits are considered when the cumulative cost exceeds the Maximum INVESTMENT.

The economically optimum investment is the investment for which one additional dollar of investment would yield exactly one additional dollar of energy savings, including maintenance, over the projected ECONOMIC HORIZON.

NON-ELECTRIC fuel?

Acceptable Answer(s):
G - Gas
O - Oil
W - Wood
N - None

Default:
G - Gas

Next Question = #04: "ELECTRICITY price"

IF $06: "NON-ELECTRIC fuel" **WAS** "Gas" **THEN:**
Next Question = #15: "GAS price"

IF $06: "NON-ELECTRIC fuel" **WAS** "Oil" **THEN:**
Next Question = #09: "OIL price"

IF $06: "NON-ELECTRIC fuel" **WAS** "Wood" **THEN:**
Next Question = #10: "WOOD price"

Data position = 8

Explanations:

The NON-ELECTRIC FUEL is whatever energy source you use as well as electricity. CIRA assumes that everone has electricity. One other source of energy can be used, usually for space heat (or water heat). Choose any one from the list obtained by pressing <ctrl-L>

GAS price?

Minimum = 0 $/Therm

Maximum = 10 $/Therm

Default = .4711 $/Therm

Next question = #16: "GAS escalation rate"

Data position = 10 —> **contains** Entry/100000

Explanations:

Give energy PRICES and ESCALATION RATES in dollars per unit fuel (e.g. $/Therm for natural gas). ESCALATION RATES are expected future increases in fuel prices adjusted for inflation, as below:

$$\text{REAL ESCALATION RATE} = \frac{\text{PRICE INCREASE - INFLATION RATE}}{\text{1 + INFLATION RATE}}$$

e.g.	INFLATION RATE	PRICE INCREASE	REAL ESCALATION RATE
	10%	15%	4.5%
	12%	15%	2.7%

GAS escalation rate?

Minimum = -20 %

Maximum = 20 %

Default = 2.8 %

Next question = #18: "YEARLY Gas use"

Data position = 11 —> **contains** Entry*.01

Explanations:

Give energy PRICES and ESCALATION RATES in dollars per unit fuel (e.g. $/Therm for natural gas). ESCALATION RATES are expected future increases in fuel prices adjusted for inflation, as below:

$$\text{REAL ESCALATION RATE} = \frac{\text{PRICE INCREASE} - \text{INFLATION RATE}}{1 + \text{INFLATION RATE}}$$

e.g.	INFLATION RATE	PRICE INCREASE	REAL ESCALATION RATE
	10%	15%	4.5%
	12%	15%	2.7%

YEARLY Gas use?

Minimum = 120 Therms

Maximum = 4000 Therms

Default = 960 Therms

Next question = #19: "Gas BASE use"

Data position = 12 —> **contains** Entry*100000

Explanations:

The YEARLY gas use is the total amount of gas you use in a year.

The gas BASE use is the gas use, EXCLUDING space heat and cooling. It is usually the minimum on the curve of gas use per month, if vacations and other anomalies are excluded.

```
therms/month
  |+
  |  +                            +
  |    +                       +
  |       +                 +
  |          +           +
  |............+..+..+....BASE USE...
  |
  |
  +-----------------------------------
January                          December
```

Gas BASE use?

Minimum = 6 Therms/Mo

Maximum = 200 Therms/Mo

Default = {[answr(#18)/12]*58}/96 Therms/Mo

Legend: #18: YEARLY Gas use

Next question = #04: "ELECTRICITY price"

Data position = 13 —> **contains** Entry*100000

Explanations:

The YEARLY gas use is the total amount of gas you use in a year.

The gas BASE use is the gas use, EXCLUDING space heat and cooling. It is usually the minimum on the curve of gas use per month, if vacations and other anomalies are excluded.

```
therms/month
  |+
  |  +                             +
  |    +                        +
  |       +                  +
  |          +            +
  |.............+..+..+....BASE USE...
  |
  |
  +-----------------------------------
January                          December
```

OIL price?

Minimum = 0 $/gal

Maximum = 10 $/gal

Default = .8981 $/gal

Next question = #12: "OIL escalation rate"

Data position = 10 —> **contains** Entry/140000

Explanations:

Give energy PRICES and ESCALATION RATES in dollars per unit fuel (e.g. $/Therm for natural gas). ESCALATION RATES are expected future increases in fuel prices adjusted for inflation, as below:

$$\text{REAL ESCALATION RATE} = \frac{\text{PRICE INCREASE} - \text{INFLATION RATE}}{1 + \text{INFLATION RATE}}$$

e.g.	INFLATION RATE	PRICE INCREASE	REAL ESCALATION RATE
	10%	15%	4.5%
	12%	15%	2.7%

OIL escalation rate?

Minimum = -20 %

Maximum = 20 %

Default = 3.3 %

Next question = #20: "YEARLY Oil use"

Data position = 11 —> **contains** Entry*.01

Explanations:

Give energy PRICES and ESCALATION RATES in dollars per unit fuel (e.g. $/Therm for natural gas). ESCALATION RATES are expected future increases in fuel prices adjusted for inflation, as below:

$$\text{REAL ESCALATION RATE} = \frac{\text{PRICE INCREASE} - \text{INFLATION RATE}}{1 + \text{INFLATION RATE}}$$

e.g. INFLATION RATE	PRICE INCREASE	REAL ESCALATION RATE
10%	15%	4.5%
12%	15%	2.7%

YEARLY Oil use?

Minimum = 100 gal

Maximum = 3000 gal

Default = 750 gal

Next question = #21: "Oil BASE use"

Data position = 12 —> **contains** Entry*140000

Explanations:

```
+-----------------------------------------------------------------------------+
|                                                                             |
|      The YEARLY oil use is the total amount of oil you use in a year.        |
|                                                                             |
|      The oil BASE use is the oil use, EXCLUDING space heat and cooling.  It |
| is  usually  the minimum on the curve of oil use per month, if vacations and |
| other anomalies are excluded.                                               |
|                                                                             |
|       gals/month                                                            |
|          |+                                                                 |
|          |  +                        +                                      |
|          |    +                   +                                        |
|          |       +              +                                          |
|          |          +         +                                            |
|          |............+..+..+....BASE USE...                               |
|          |                                                                  |
|          |                                                                  |
|          +------------------------------------                              |
|       January                        December                               |
|                                                                             |
|                                                                             |
+-----------------------------------------------------------------------------+
```

Oil BASE use?

Minimum = 10 gal/Mo

Maximum = 250 gal/Mo

Default = answr(#20)/24 gal/Mo

Legend: #20: YEARLY Oil use

Next question = #04: "ELECTRICITY price"

Data position = 13 —> **contains** Entry*140000

Explanations:

```
+--------------------------------------------------------------------------+
|                                                                          |
|      The YEARLY oil use is the total amount of oil you use in a year.    |
|                                                                          |
|      The oil BASE use is the oil use, EXCLUDING space heat and cooling.  It |
| is  usually  the minimum on the curve of oil use per month, if vacations and |
| other anomalies are excluded.                                            |
|                                                                          |
|       gals/month                                                         |
|         |+                                                               |
|         |  +                           +                                 |
|         |    +                       +                                   |
|         |       +                  +                                     |
|         |          +            +                                        |
|         |............+..+..+....BASE USE...                              |
|         |                                                                |
|         |                                                                |
|         +-----------------------------------                             |
|       January                         December                           |
|                                                                          |
|                                                                          |
+--------------------------------------------------------------------------+
```

WOOD price?

Minimum = 0 $/Cord

Maximum = 1000 $/Cord

Default = 100 $/Cord

Next question = #13: "WOOD escalation rate"

Data position = 10 —> **contains** Entry/19200000

Explanations:

Give energy PRICES and ESCALATION RATES in dollars per unit fuel (e.g. $/Therm for natural gas). ESCALATION RATES are expected future increases in fuel prices adjusted for inflation, as below:

$$\text{REAL ESCALATION RATE} = \frac{\text{PRICE INCREASE} - \text{INFLATION RATE}}{1 + \text{INFLATION RATE}}$$

e.g.	INFLATION RATE	PRICE INCREASE	REAL ESCALATION RATE
	10%	15%	4.5%
	12%	15%	2.7%

WOOD escalation rate?

Minimum = -20 %

Maximum = 20 %

Default = 1 %

Next question = #22: "YEARLY Wood use"

Data position = 11 —> **contains** Entry*.01

Explanations:

Give energy PRICES and ESCALATION RATES in dollars per unit fuel (e.g. $/Therm for natural gas). ESCALATION RATES are expected future increases in fuel prices adjusted for inflation, as below:

$$\text{REAL ESCALATION RATE} = \frac{\text{PRICE INCREASE} - \text{INFLATION RATE}}{1 + \text{INFLATION RATE}}$$

e.g.	INFLATION RATE	PRICE INCREASE	REAL ESCALATION RATE
	10%	15%	4.5%
	12%	15%	2.7%

YEARLY Wood use?

Minimum = 0.1 Cords

Maximum = 50 Cords

Default = 3 Cords

Next question = #23: "Wood BASE use"

Data position = 12 —> **contains** Entry*19200000

Explanations:

The YEARLY wood use is the total amount of wood you use in a year.

The wood BASE use is the wood use, EXCLUDING space heat and cooling. It is usually the minimum on the curve of wood use per month, if vacations and other anomalies are excluded.

```
 cords/month
   |+
   | +                              +
   |   +                         +
   |      +                   +
   |         +              +
   |............+..+..+....BASE USE...
   |
   |
   +------------------------------------
 January                          December
```

Wood BASE use?

Minimum = 0.01 Cords/Mo

Maximum = 4 Cords/Mo

Default = answr(#22)/24 Cords/Mo

Legend: #22: YEARLY Wood use

Next question = #04: "ELECTRICITY price"

Data position = 13 —> **contains** Entry*19200000

Explanations:

```
+--------------------------------------------------------------------------+
|                                                                          |
|      The YEARLY wood use is the total amount of wood you use in a year.  |
|                                                                          |
|      The wood BASE use is the wood use, EXCLUDING space heat and cooling.|
| It is usually the minimum on the curve of wood use per month, if vacations|
| and other anomalies are excluded.                                        |
|                                                                          |
|       cords/month                                                        |
|         |+                                                               |
|         | +                        +                                     |
|         |   +                    +                                       |
|         |     +                +                                         |
|         |       +            +                                          |
|         |............+..+..+....BASE USE...                              |
|         |                                                                |
|         |                                                                |
|         +-----------------------------------                             |
|       January                       December                             |
|                                                                          |
|                                                                          |
|                                                                          |
+--------------------------------------------------------------------------+
```

ELECTRICITY price?

Minimum = 0 $/kwh

Maximum = 10 $/kwh

Default = .0598 $/kwh

Next question = #05: "ELECTRICITY escalation rate"

Data position = 14 —> **contains** Entry/3414

Explanations:

Give energy PRICES and ESCALATION RATES in dollars per unit fuel (e.g. $/Therm for natural gas). ESCALATION RATES are expected future increases in fuel prices adjusted for inflation, as below:

$$\text{REAL ESCALATION RATE} = \frac{\text{PRICE INCREASE} - \text{INFLATION RATE}}{1 + \text{INFLATION RATE}}$$

e.g.	INFLATION RATE	PRICE INCREASE	REAL ESCALATION RATE
	10%	15%	4.5%
	12%	15%	2.7%

ELECTRICITY escalation rate?

Minimum = -20 %

Maximum = 20 %

Default = 1.5 %

Next question = #08: "YEARLY Electricity use"

Data position = 15 —> **contains** Entry*.01

Explanations:

Give energy PRICES and ESCALATION RATES in dollars per unit fuel (e.g. $/Therm for natural gas). ESCALATION RATES are expected future increases in fuel prices adjusted for inflation, as below:

$$\text{REAL ESCALATION RATE} = \frac{\text{PRICE INCREASE} - \text{INFLATION RATE}}{1 + \text{INFLATION RATE}}$$

e.g.	INFLATION RATE	PRICE INCREASE	REAL ESCALATION RATE
	10%	15%	4.5%
	12%	15%	2.7%

YEARLY Electricity use?

Minimum = 1500 kWh

Maximum = 54000 kWh

> **IF** $06: "NON-ELECTRIC fuel" **WAS** "None" **THEN:**
> **Maximum** = 164000 kWh

Default = 13500 kWh

> **IF** $06: "NON-ELECTRIC fuel" **WAS** "None" **THEN:**
> **Default** = 41000 kWh

Next question = #17: "Electricity BASE use"

Data position = 16 —> **contains** Entry*3414

Explanations:

The YEARLY electricity use is the total amount of electricity you use in a year.

The electricity BASE use is the electricity use, EXCLUDING space heat and cooling. It is usually the minimum on the curve of electricity use per month, if vacations and other anomalies are excluded.

```
kWh/month
   |+
   |  +                              +
   |    +                         +
   |       +                   +
   |          +             +
   |.............+..+..+....BASE USE...
   |
   |
   +-----------------------------------
January                          December
```

Electricity BASE use?

Minimum = 120 kWh/Mo

Maximum = 4500 kWh/Mo

Default = {[answr(#08)/12]*6.37}/22 kWh/Mo

Legend: #08: YEARLY Electricity use

Next question = $07: "ADJUST results to ACTUAL use"

Data position = 17 **—> contains** Entry*3414

Explanations:

```
+---------------------------------------------------------------------------+
|                                                                           |
|     The YEARLY electricity use is the total amount of electricity you use |
| in a year.                                                                |
|                                                                           |
|     The electricity BASE use is the electricity use, EXCLUDING space heat |
| and cooling. It is usually the minimum on the curve of electricity use per|
| month, if vacations and other anomalies are excluded.                     |
|                                                                           |
|       kWh/month                                                           |
|         |+                                                                |
|         | +                        +                                      |
|         |   +                    +                                        |
|         |     +                +                                          |
|         |       +            +                                           |
|         |.............+..+..+....BASE USE...                              |
|         |                                                                 |
|         |                                                                 |
|         +----------------------------------                               |
|       January                        December                             |
|                                                                           |
|                                                                           |
+---------------------------------------------------------------------------+
```

ADJUST results to ACTUAL use?

Acceptable Answer(s):
Y - Yes
N - No

Default:
N - No

Next Question = $26: "Which menu ITEM(S)"

Data position = 9

Explanations:

The computer can ADJUST its results to give the same figure as your bills from last year. If it does this, it will ADJUST the savings from retrofits in the same way.

In its calculations, the computer assumes that the weather is "average" and that you live in your house all year round, and that your behavior is average. So the estimate the computer produces may not be the same as your last year's bill. Take two examples. If you have long vacations your bill is probably less than the computer estimate. If last year was much colder than average, or if your kids always leave the front door open so you are always losing heat, your bill is probably more than the computer estimate.

If you expect this disturbance (vacations, kids, or the weather) to continue the same as last year, then it is a good idea to ADJUST the result. If last year was an unusual year, then it is best to stick with the "average" computer calculations.

```
$01G,NAME of the following scenario,\NAME,,Price & Use,#02,,3,\\,\\
#02,Economic HORIZON,years\,\HORIZON,1,30,20,#03,,4
#03,REAL DISCOUNT rate,%\.01*\.01/,\DISC,-20,20,3,#14,,5
#14,REPLACEMENT-RETROFIT esc. rate,%\.01*\.01/,\RETRO RATE,-20,20,4,#11,,6
#11,Maximum INVESTMENT,$\,\INVEST,1,50000,2000,$06,,7
$06,NON-ELECTRIC fuel,\FUEL,GOWN,G,#04\$06=G>#15\$06=O>#09\$06=W>#10\,,8,\GGas\
  OOil\WWood\NNone\,\\
#15,GAS price,$/Therm\100000/\100000*,\PRICE & RATE,0,10,.4711,#16,,10
#16,GAS escalation rate,%\.01*\.01/,\PRICE & RATE,-20,20,2.8,#18,,11
#18,YEARLY Gas use,Therms\100000*\100000/,\GAS USE,120,4000,960,#19,,12
#19,Gas BASE use,Therms/Mo\100000*\100000/,\GAS USE,6,200,{V18!12/58*96/},#04,,
  13
#09,OIL price,$/gal\140000/\140000*,\PRICE & RATE,0,10,.8981,#12,,10
#12,OIL escalation rate,%\.01*\.01/,\PRICE & RATE,-20,20,3.3,#20,,11
#20,YEARLY Oil use,gal\140000*\140000/,\OIL USE,100,3000,750,#21,,12
#21,Oil BASE use,gal/Mo\140000*\140000/,\OIL USE,10,250,{V20!24/},#04,,13
#10,WOOD price,$/Cord\19200000/\19200000*,\PRICE & RATE,0,1000,100,#13,,10
#13,WOOD escalation rate,%\.01*\.01/,\PRICE & RATE,-20,20,1,#22,,11
#22,YEARLY Wood use,Cords\19200000*\19200000/,\WOOD USE,0.1,50,3,#23,,12
#23,Wood BASE use,Cords/Mo\19200000*\19200000/,\WOOD USE,0.01,4,{V22!24/},#04,,
  13
#04,ELECTRICITY price,$/kwh\3414/\3414*,\PRICE & RATE,0,10,.0598,#05,,14
#05,ELECTRICITY escalation rate,%\.01*\.01/,\PRICE & RATE,-20,20,1.5,#08,,15
#08,YEARLY Electricity use,kWh\3414*\3414/,\ELEC USE,1500\$06=N>5000,54000\$06=
  N>164000\,13500\$06=N>41000\,#17,,16
#17,Electricity BASE use,kWh/Mo\3414*\3414/,\ELEC USE,120,4500,{V08!12/6.37*22/
  },$07,,17
$07,ADJUST results to ACTUAL use,\ADJUST,YN,N,$26,,9,\YYes\NNo\,\\
```

Windows

NAME of the following windows?

Next Question = $02: "Which window ORIENTATION"

Data position = 3

Explanations:

A NAME is given to each window or group of windows. If two or more windows have the same characteristics (i.e. orientation, type, glazing etc.) they can be entered together under the same name. The area then will be the sum of the areas of the individual windows.

Retrofits chosen by the computer for each window or group of windows will use this name to identify which window they apply to.

NOTE: Sliding glass doors are to be entered as windows. If more than 50% of the door area is glass, treat the glass part as a window; the rest of the door area is small enough to be neglected.

Which window ORIENTATION?

Acceptable Answer(s) and Associated [Value(s)]:

S - South	[1.0]
W - West	[1.0]
N - North	[1.0]
E - East	[1.0]
H - Horizontal	[1.12]

Default:

S - South	[1.0]

Next Question = $18: "Window TYPE"

Data position = 4

Explanations:

WINDOW ORIENTATION is the compass direction nearest to the direction the window faces: South, West, East, North or Horizontal. A window may face up to 45 degrees east or west of south, and still be called "South". The computer corrects for this by using the AZIMUTH you gave in the GENERAL option.

Window TYPE?

Acceptable Answer(s) and Associated [Value(s)]:

```
D → Double hung              [0.51]
H → Horizontal Sliding       [0.3]
C → Casement                 [0.19]
T → Tilting                  [0.19]
J → Jalousie                 [1.50]
F → Fixed                    [0.05]
G → Greenhouse               [0.59]
S → Skylight                 [0.05]
O → Dome                     [0.05]
```

IF $02: "Which window ORIENTATION" **WAS** "Horizontal" **THEN:**

```
T → Tilting                  [0.19]
F → Fixed                    [0.05]
S → Skylight                 [0.05]
O → Dome                     [0.05]
```

Default:

```
D → Double hung              [0.51]
```

IF $02: "Which window ORIENTATION" **WAS** "Horizontal" **THEN:**

```
S → Skylight                 [0.05]
```

Next Question = $19: "GLAZING"

Data position = 5

Explanations:

Window TYPE is the kind of window you have, e.g. double-hung, casement, horizontal sliding etc. To obtain a list of the available types of windows, press <ctrl-L>

GLAZING?

Acceptable Answer(s) and Associated [LfVal] [RgVal]:

```
S - Single pane                    [87]   [110]
D - Double pane                    [77]   [58]
T - Triple pane                    [67]   [39]
I - Single pane w/ INSIDE storm    [77]   [58]
O - Single pane w/ OUTSIDE stor    [77]   [58]
P - Double pane w/ INSIDE storm    [67]   [39]
Q - Double pane w/ OUTSIDE stor    [67]   [39]
```

IF $18: "Window TYPE" **WAS** "Jalousie" **THEN:**

```
S - Single pane                    [87]   [110]
```

IF $18: "Window TYPE" **WAS** "Skylight"
OR "Greenhouse" **THEN:**

```
S - Single pane                    [87]   [110]
D - Double pane                    [77]   [58]
```

Default:

```
S - Single pane                    [87]   [110]
```

Next Question = $04: "DRAPES & SHUTTERS"

Data position = 6

Explanations:

> Glazing is the kind of glass in your windows: plain old-fashioned single pane, double-pane (sometimes called thermopane), or perhaps triple pane. Storm windows should be entered here. To obtain a list of the available glazing types, press <ctrl-L>

DRAPES & SHUTTERS?

Acceptable Answer(s) and Associated [LfVal] [RgVal]:

N - None	[100]	[0]
D - Drapes	[62]	[30]
S - Shades or Blinds	[56]	[30]
C - Drapes & Shades	[56]	[60]
O - Outside Shutters	[20]	[30]
H - Shades & Shutters	[20]	[60]
R - Drapes & Shades & Shutters	[20]	[90]

Default:

S - Shades or Blinds	[56]	[30]

Next Question = $11: "Are window covers USED at DAYtime"

IF $04: "DRAPES & SHUTTERS" **WAS** "None" **THEN:**
Next Question = #09: "U-value"

Data position = 8

Explanations:

DRAPES & SHUTTERS are any kind of window cover, including shades and blinds, but not including storm windows; they are treated in GLAZING. Together with glazing, this information is used to calculate window U-VALUE and the SOLAR GAIN factor.

To obtain a list of available window coverings, press <ctrl-L>

Are window covers USED at DAYtime?

Acceptable Answer(s) and Associated [Value(s)]:

Y - Yes	[1]
N - No	[.67]
W - Winter only	[.9]
S - Summer only	[.8]

Default:

N - No	[.67]

Next Question = #09: "U-value"

Data position = 17

Explanations:

> The U-VALUE and SOLAR GAIN factor are affected by the way in which you use your window covers. Press <ctrl-L> to obtain a list of the available options, and select the one that is closest to your situation.

U-value?

Minimum = 0.1 Btuh/sqft/F

Maximum = 2 Btuh/sqft/F

Default = (1/{100/rgval($19)+[rgval($04)/100]*value($11)})*value($02) Btuh/sqft/F

IF $04: "DRAPES & SHUTTERS" **WAS** "None" **THEN:**
Default = [rgval($19)/100]*value($02) Btuh/sqft/F

Legend: $11: Are window covers USED at DAYtime
$02: Which window ORIENTATION
$19: GLAZING
$04: DRAPES & SHUTTERS

Next question = $05: "Average sash FIT"

IF $18: "Window TYPE" **WAS** "Jalousie" **THEN:**
Next question = #12: "Specific LEAKAGE AREA"

Data position = 12

Explanations:

> The U-VALUE is the heat conductance of the window, i.e. the inverse of the R-value. The default value you get by pressing <ctrl-D> is calculated using the information you gave in response to the earlier questions.

Average sash FIT?

Acceptable Answer(s) and Associated [Value(s)]:

L - Loose		[1.5]
A - Average		[1.0]
T - Tight		[0.5]

Default:

A - Average [1.0]

Next Question = #12: "Specific LEAKAGE AREA"

Data position = 7

Explanations:

The average SASH FIT is how tightly the window sash fits in its frame. Do not confuse this sash fit with the size of cracks, if any, between the window frame and the wall! The options are:

Loose	if the sash rattles in the frame and/or if you can see light through or around the sash;
Tight	if outdoor noise decreases substantially when you close the window, and if it "feels" snug;
Average	for cases in between.

Specific LEAKAGE AREA?

Minimum = 0.001 sqin/sqft

Maximum = 0.5 sqin/sqft

Default = [value($18)*value($05)]/6.4516 sqin/sqft

IF $18: "Window TYPE" **WAS** "Jalousie" **THEN:**
Default = .023 sqin/sqft

Legend: $18: Window TYPE
$05: Average sash FIT

Next question = #13: "Summer SOLAR GAIN factor"

Data position = 13 **—> contains** Entry*6.4516

Explanations:

The leakage area of a window is roughly the area of a single hole which would leak in the same way as all the cracks around the sash. The SPECIFIC LEAKAGE AREA of a window is the leakage area divided by the area of the window. If you press <ctrl-D>, the computer will give you a default value based on the answers you gave earlier to questions about window AREA, FIT, COVERS, and TYPE.

Summer SOLAR GAIN factor?

Minimum = 5 %

Maximum = 100 %

Default = [lfval($19)*lfval($04)]/100 %

IF $11: "Are window covers USED at DAYtime" **WAS** "No" **OR** "Winter only" **THEN:**

Default = lfval($19) %

Legend: $19: GLAZING
$04: DRAPES & SHUTTERS

Next question = #06: "Winter SOLAR GAIN factor"

Data position = 14 —> **contains** Entry*.01

Explanations:

The SOLAR GAIN factor is the percentage of solar radiation which would get into the room if the sunlight struck the glass at right angles. The default values are based on your previous answers about GLAZING, window COVERS and window cover USAGE. This factor will change from summer to winter if you use the window covers differently in the different seasons.

The default value you get by pressing <ctrl-D> is based on your answers to previous questions about GLAZING, COVERS, and USAGE.

Winter SOLAR GAIN factor?

Minimum = 5 %

Maximum = 100 %

Default = [lfval($19)*lfval($04)]/100 %

IF $11: "Are window covers USED at DAYtime" **WAS** "No" **OR** "Summer only" **THEN:**

Default = lfval($19) %

Legend: $19: GLAZING
$04: DRAPES & SHUTTERS

Next question = #07: "Window AREA"

Data position = 9 **—> contains** Entry*.01

Explanations:

The SOLAR GAIN factor is the percentage of solar radiation which would get into the room if the sunlight struck the glass at right angles. The default values are based on your previous answers about GLAZING, window COVERS and window cover USAGE. This factor will change from summer to winter if you use the window covers differently in the different seasons.

The default value you get by pressing <ctrl-D> is based on your answers to previous questions about GLAZING, COVERS, and USAGE.

Window AREA?

Minimum = 2 sqft

Maximum = 200 sqft

Default = 15 sqft

Next question = $26: "Which menu ITEM(S)"

> **IF** $02: "Which window ORIENTATION" **WAS** "South" **THEN:**
> **Next question** = #15: "Overhang PROTRUSION"

Data position = 10

Explanations:

> The WINDOW AREA refers to glass and sash ONLY. Do not include the frame or molding. If more than 50% of a door area is glass, treat the glass part as a window; the rest of the door area is small enough to be neglected.
>
> The average WINDOW HEIGHT is the average distance from sill (bottom) to header (top) for all south windows with the same NAME. The average height is used with the OVERHANG HEIGHT to compute shading from the sun.

Overhang PROTRUSION?

Minimum = 0 inches

Maximum = 100 inches

Default = 24 inches

Next question = #14: "HEIGHT above top of window"

IF #15: "Overhang PROTRUSION" **WAS** "0 inches" **THEN:**
Next question = $26: "Which menu ITEM(S)"

Data position = 16 —> **contains** Entry/12

Explanations:

An OVERHANG is any overhang above a window or solar wall, e.g. awnings, horizontal shades, balconies or the roof itself.

The OVERHANG HEIGHT is measured from the top of the sash to the height of the outer tip of the overhang.

The OVERHANG PROTRUSION is measured horizontally out from the plane of the window.

The OVERHANG PROTRUSION, the HEIGHT of the overhang above the window, and the AZIMUTH, all determine the shading effect of an overhang.

HEIGHT above top of window?

Minimum = 0 inches

Maximum = 60 inches

Default = 12 inches

Next question = #08: "Average window HEIGHT"

Data position = 15 —> **contains** Entry/12

Explanations:

An OVERHANG is any overhang above a window or solar wall, e.g. awnings, horizontal shades, balconies or the roof itself.

The OVERHANG HEIGHT is measured from the top of the sash to the height of the outer tip of the overhang.

The OVERHANG PROTRUSION is measured horizontally out from the plane of the window.

The OVERHANG PROTRUSION, the HEIGHT of the overhang above the window, and the AZIMUTH, all determine the shading effect of an overhang.

Average window HEIGHT?

Minimum = 1 feet

Maximum = 10 feet

Default = 4 feet

> **IF** $18: "Window TYPE" **WAS** "Horizontal Sliding" **THEN:**
> **Default** = 3 feet
>
> **IF** $18: "Window TYPE" **WAS** "Casement" **THEN:**
> **Default** = 4.5 feet
>
> **IF** $18: "Window TYPE" **WAS** "Jalousie" **THEN:**
> **Default** = 3 feet

Next question = $26: "Which menu ITEM(S)"

Data position = 11

Explanations:

The WINDOW AREA refers to glass and sash ONLY. Do not include the frame or molding. If more than 50% of a door area is glass, treat the glass part as a window; the rest of the door area is small enough to be neglected.

The average WINDOW HEIGHT is the average distance from sill (bottom) to header (top) for all south windows with the same NAME. The average height is used with the OVERHANG HEIGHT to compute shading from the sun.

```
$01,NAME of the following windows,\NAME,,,$02,,3,\\,\\
$02,Which window ORIENTATION,\ORIENT,SWNEH,S,$18,,4,\SSouth\WWest\NNorth\EEast\
  HHorizontal\,\S1.0\W1.0\N1.0\E1.0\H1.12\
$18,Window TYPE,\TYPE,DHCTJFGSO\$02=H>TFSO\,D\$02=H>S\,$19,,5,\DDouble hung\HHo
  rizontal Sliding\CCasement\TTilting\JJalousie\FFixed\GGreenhouse\SSkylight\OD
  ome\,\D0.51\H0.3\C0.19\T0.19\J1.50\F0.05\G0.59\S0.05\O0.05\
$19,GLAZING,\GLAZING,SDTIOPQ\$18=J>S\$18=SG>SD\,S,$04,\$19=SDT>g=U12={D12|100!F
  19/-|}U14={D14!I19!100//}U09={D09!I19!100//}:\$19=IO>g=U12={D12|.909!.9*-|}U1
  4={D14!.87/}U09={D09!.87/}:\$19=PQ>g=U12={D12|1.724!.9*-|}U14={D14!.77/}U09={
  D09!.77/}:\,6,\SSingle pane\DDouble pane\TTriple pane\ISingle pane w/ INSIDE
  storm\OSingle pane w/ OUTSIDE storm\PDouble pane w/ INSIDE storm\QDouble pane
  w/ OUTSIDE storm\,\S87.110\D77.058\T67.039\I77.058\O77.058\P67.039\Q67.039\
$04,DRAPES & SHUTTERS,\DRAPES,NDSCOHR,S,$11\$04=N>#09\,\$19=IP>i=U12={D12|.909!
  .9*-|}U09={D09!.87/}:\$19=OQ>s=U12={D12|.909!.9*-|}U09={D09!.87/}:\,8,\NNone\
  DDrapes\SShades or Blinds\CDrapes & Shades\OOutside Shutters\HShades & Shutte
  rs\RDrapes & Shades & Shutters\,\N100.0\D62.03\S56.03\C56.06\O20.03\H20.06\R2
  0.09\
$11,Are window covers USED at DAYtime,\USAGE,YNWS,N,#09,,17,\YYes\NNo\WWinter o
  nly\SSummer only\,\Y1\N.67\W.9\S.8\
#09,U-value,Btuh/sqft/F\,\UVAL,0.1,2,{100!F19/F04!100/T11*+|T02*}\$04=N>{F19!10
  0/T02*}\,$05\$18=J>#12\,\$04"OHR>\$11=Y>o=U12={D12|.3!T11*-|}U14={D14!.87/}U0
  9={D09!.87/}:\$11=S>o=U12={D12|.3!T11*-|}U14={D14!.87/}:\$11=W>o=U12={D12|.3!
  T11*-|}U09={D09!.87/}:\$11=N>o=U12={D12|.3!T11*-|}:\,12
$05,Average sash FIT,\FIT,LAT,A,#12,\$04"SC>\$11=Y>r=U12={D12|F04!100/T11*-|}U1
  4={D14!I19!100//}U09={D09!I19!100//}:\$11=S>r=U12={D12|F04!100/T11*-|}U14={D1
  4!I19!100//}:\$11=W>r=U12={D12|F04!100/T11*-|}U09={D09!I19!100//}:\$11=N>r=U1
  2={D12|F04!100/T11*-|}:\,7,\LLoose\AAverage\TTight\,\L1.5\A1.0\T0.5\
#12,Specific LEAKAGE AREA,sqin/sqft\6.4516*\6.4516/,\LEAKG,0.001,0.5,{T18!T05*6
  .4516/}\$18=J>.023\,#13,,13
#13,Summer SOLAR GAIN factor,%\.01*\.01/,\SGF,5,100,{I19!I04*100/}\$11=NW>{I19!
  }\,#06,\$04"D>\$11=Y>d=U12={D12|.3!T11*-|}U14={D14!I04!100//}U09={D09!I04!100
  //}:\$11=S>d=U12={D12|.3!T11*-|}U14={D14!I04!100//}:\$11=W>d=U12={D12|.3!T11*
  -|}U09={D09!I04!100//}:\$11=N>d=U12={D12|.3!T11*-|}:\,14
#06,Winter SOLAR GAIN factor,%\.01*\.01/,\SGF,5,100,{I19!I04*100/}\$11=NS>{I19!
  }\,#07,,9
#07,Window AREA,sqft\,\DIMENS,2,200,15,$26\$02=S>#15\,,10
#15,Overhang PROTRUSION,inches\12/\12*,\OVERHANG,0,100,24,#14\#15=0>$26\,,16
#14,HEIGHT above top of window,inches\12/\12*,\OVERHANG,0,60,12,#08,,15
#08,Average window HEIGHT,feet\,\DIMENS,1,10,4\$18=H>3\$18=C>4.5\$18=J>3\,$26,,
  11
```

Doors

NAME of following doors?

Next Question = $18: "Door TYPE"

Data position = 3

Explanations:

A NAME is given to each door or group of doors. If two or more doors have the same characteristics (i.e. type, fit etc.) they can be entered together under one name. The area of the door then will be the sum of the areas of the individual doors.

Retrofits chosen by the computer for each door or group of doors will use this name to identify which door they apply to.

NOTE: "Sliding glass doors" (and any door with more than 50% of its area glass) are to be entered as windows.

Door TYPE?

Acceptable Answer(s) and Associated [Value(s)]:

P - Plain (Hinged)	[0.19]
S - Sliding	[0.3]
F - French	[0.19]
H - Hatched	[0.19]
X - Fixed	[0.1]

Default:

P - Plain (Hinged) [0.19]

Next Question = $03: "Door MATERIAL"

Data position = 5

Explanations:

The door type is the kind of door, e.g. sliding, fixed or French. The TYPE, together with the door MATERIAL, STORM DOORS, and GLASS AREA, is used to estimate the U-VALUE of the door.

For a list of available door types, press <ctrl-L>

Door MATERIAL?

Acceptable Answer(s) and Associated [Value(s)]:

```
W - Wood Solid Core               [.33]
H - Wood Hollow Core              [.46]
F - Steel w/ mineral fiber core   [.24]
U - Steel w/ solid urethane foa   [.14]
P - Steel w/ solid polystyrene    [.16]
```

Default:

```
W - Wood Solid Core               [.33]
```

Next Question = #09: "Approximate Glass AREA"

Data position = 6

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|     The door MATERIAL is the substance of which the door is made. e.g. |
| solid wood or steel filled with fiberglass. The door MATERIAL, together|
| with the TYPE, STORM DOORS, and GLASS AREA, is used to estimate the U-VALUE |
| of the door.                                                           |
|                                                                        |
|     To obtain a list of available door types, press <ctrl-L>           |
|                                                                        |
+------------------------------------------------------------------------+
```

Approximate Glass AREA?

Minimum = 0. %

Maximum = 50. %

Default = 10. %

Next question = $04: "Any STORM doors"

Data position = 15 —> **contains** Entry*.01

Explanations:

The area of GLASS as a percentage of the total door area should be entered here. Any door with a glass area greater than 50% e.g. a sliding glass door, should be entered as a window.

Any STORM doors?

Acceptable Answer(s) and Associated [Value(s)]:

N - None	[0.0]
I - Inside storm	[1.0]
O - Outside storm	[1.0]

Default:

N - None	[0.0]

Next Question = #10: "U-value"

Data position = 7

Explanations:

STORM DOORS are aluminum (or wood) frame doors, generally with a large glazed area, that are installed next to a main door.

U-value?

Minimum = .05 Btuh/sqft/F

Maximum = 2. Btuh/sqft/F

Default = 1/{1/[{-[answr(#09)/100-1]}*value($03)+(answr(#09)/100)*1.1]+value($04)}
Btuh/sqft/F

Legend: $03: Door MATERIAL
$04: Any STORM doors
#09: Approximate Glass AREA

Next question = $05: "Door FIT"

Data position = 12

Explanations:

The U-VALUE is the heat conductance of the door, i.e. the inverse of R-value. The default given by pressing <ctrl-D> is based on your previous answers.

Door FIT?

Acceptable Answer(s) and Associated [Value(s)]:

L - Loose	[1.5]
A - Average	[1.0]
T - Tight	[0.5]

Default:

A - Average [1.0]

Next Question = #11: "Specific leakage AREA"

Data position = 9

Explanations:

Door FIT is how tightly the door fits in its frame when closed. Do not confuse this door fit with the size of cracks around the frame. The options available are:

Loose	if the door rattles in the frame and/or if you can see light at the bottom of the door;
Tight	if outdoor noise decreases substantially upon closing the door and it "feels" snug;
Average	cases in between.

Specific leakage AREA?

Minimum = .01 sqin/sqft

Maximum = .1 sqin/sqft

Default = [value($05)*value($18)]/6.4516 sqin/sqft

Legend: $05: Door FIT
$18: Door TYPE

Next question = #07: "Door AREA"

Data position = 13 **—> contains** Entry*6.4516

Explanations:

The leakage area is roughly the area of the single hole which would leak in the same way as the sum of all the leaks from the cracks around the edge of the door.

The SPECIFIC LEAKAGE AREA is the leakage area divided by the area of the door.

If you press <ctrl-D> the computer will give you a default value based on the answers you gave earlier.

Door AREA?

Minimum = 10. sqft

Maximum = 40. sqft

Default = 18. sqft

Next question = $26: "Which menu ITEM(S)"

Data position = 10

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|      The area is the height of the door times its width.  Include any glass |
| in  this  area.  Do  NOT include the door frame or moldings; these should be |
| included in the WALL area.                                             |
|                                                                        |
+------------------------------------------------------------------------+
```

```
$01,NAME of following doors,\NAME,,,$18,,3,\\,\\
$18,Door TYPE,\TYPE,PSFHX,P,$03,,5,\PPlain (Hinged)\SSliding\FFrench\HHatched\X
 Fixed\,\P0.19\S0.3\F0.19\H0.19\X0.1\
$03,Door MATERIAL,\MATERIAL,WHFUP,W,#09,,6,\WWood Solid Core\HWood Hollow Core\
 FSteel w/ mineral fiber core\USteel w/ solid urethane foam core\PSteel w/ sol
 id polystyrene core\,\W.33\H.46\F.24\U.14\P.16\
#09,Approximate Glass AREA,%\.01*\.01/,\GLASS,0.,50.,10.,$04,,15
$04,Any STORM doors,\STORM,NIO,N,#10,,7,\NNone\IInside storm\OOutside storm\,\N
 0.0\I1.0\O1.0\
#10,U-value,Btuh/sqft/F\,\U-VAL,.05,2.,{V09!100/!!1-@T03*~1.1*+|T04+|},$05,,12
$05,Door FIT,\FIT,LAT,A,#11,,9,\LLoose\AAverage\TTight\,\L1.5\A1.0\T0.5\
#11,Specific leakage AREA,sqin/sqft\6.4516*\6.4516/,\LEAKAGE AREA,.01,.1,{T05!T
 18*6.4516/},#07,,13
#07,Door AREA,sqft\,\AREA,10.,40.,18.,$26,d=U12={D12|T03|-|}U13={D13|2^V11|2^-.
 5^|},10
```

Walls

NAME for the following walls?

Next Question = $02: "Which wall ORIENTATION"

Data position = 3

Explanations:

A NAME is given to each wall or group of walls. If two or more walls have the same characteristics (i.e. orientation, type etc.) they can be entered under one name. The area will then be the sum of the areas of the individual walls.

Retrofits chosen by the computer for each wall or group of walls will use this name to identify which wall they apply to.

NOTE: If a wall is shared with a GARAGE or a GREENHOUSE, information about it should NOT be entered in this section. These walls are treated in the GARAGE and GREENHOUSE sections.

Which wall ORIENTATION?

Acceptable Answer(s):

S - South walls
W - West walls
N - North walls
E - East walls

Default:

S - South walls

Next Question = $03: "Wall TYPE"

Data position = 4

Explanations:

WALL ORIENTATION is the compass point closest to the direction the wall faces: South, West, East, or North. A wall may point up to 45 degrees east or west of south, and still be called "South". The computer corrects for the exact wall orientation through the "AZIMUTH" you gave in the GENERAL option.

Wall TYPE?

Acceptable Answer(s) and Associated [LfVal] [RgVal]:

F - Two by Four Frame	[464]	[350]
T - Two by Six Frame	[461]	[550]
S - Solid brick	[390]	[0]
B - Block & Brick	[593]	[0]
C - Block;Cavity & Brick	[491]	[350]
G - Shared w/ Garage	[464]	[350]

Default:

F - Two by Four Frame	[464]	[350]

Next Question = $04: "Wall INSULATION"

Data position = 5

Explanations:

WALL TYPE is what type of wall you have, e.g. two-by-four wood frame, or solid brick. Walls shared with GREENHOUSES or GARAGES should be entered in those sections only, not here.

To obtain a list of available wall types, press <ctrl-L>

Wall INSULATION?

Acceptable Answer(s) and Associated [Value(s)]:

N - None	[0.0]
F - Fiberglass batts	[3.3]
L - Fiberglass loose	[3.0]
B - Fiberglass boards	[4.0]
C - Celluose fill	[3.4]
U - UF-foam	[4.0]
P - Polyurethane boards	[6.0]
S - Polystyrene boards	[5.0]
V - Vermiculite fill	[2.2]

IF $03: "Wall TYPE" **WAS** "Solid brick" **THEN:**

N - None	[0.0]
F - Fiberglass batts	[3.3]
B - Fiberglass boards	[4.0]
U - UF-foam	[4.0]
P - Polyurethane boards	[6.0]
S - Polystyrene boards	[5.0]

Default:

F - Fiberglass batts [3.3]

IF $03: "Wall TYPE" **WAS** "Solid brick" **THEN:**

N - None [0.0]

Next Question = #09: "Insulation THICKNESS"

IF $04: "Wall INSULATION" **WAS** "None" **THEN:**

Next Question = #12: "INSULATABLE wall THICKNESS"

Data position = 6

Explanations:

```
+--------------------------------------------------------------------------+
|                                                                          |
|      Wall INSULATION is the kind of insulation inside this  wall.  If you |
| have any doubts, look inside the wall to make sure.  Good places to look are |
| behind electrical wall fixtures or under loose window or door moldings.  |
|                                                                          |
|      To obtain a list of available insulation types, press <ctrl-L>      |
|                                                                          |
+--------------------------------------------------------------------------+
```

Insulation THICKNESS?

Minimum = 0 inches

Maximum = 20 inches

Default = rgval($03)/100 inches

Legend: $03: Wall TYPE

Next question = #12: "INSULATABLE wall THICKNESS"

Data position = 11

Explanations:

Insulation THICKNESS is the thickness of the insulation in the wall cavity. If you press <ctrl-D> the computer will give you a default value which is the maximum width of the wall cavity for the type of wall you chose.

INSULATABLE wall THICKNESS?

Minimum = 0 inches

Maximum = 20 inches

Default = -{[rgval($03)/100-answr(#09)]*[?0<rgval($03)/100-answr(#09)?]} inches

IF $04: "Wall INSULATION" **WAS** "None" **THEN:**
Default = rgval($03)/100 inches

Legend: #09: Insulation THICKNESS
$03: Wall TYPE
?xx? = -1 (if xx is true) = 0 (if xx is false)

Next question = $05: "Exterior INSULATING SHEATHING"

IF $03: "Wall TYPE" **WAS** "Shared w/ Garage" **THEN:**
Next question = #14: "INNER Garage envelope AREA"

Data position = 8

Explanations:

The INSULATABLE wall thickness is the width left in the wall cavity that can be insulated. If you press <ctrl-D> the computer will give you a value which is the width of the uninsulated wall cavity for the wall TYPE you chose, minus the current insulation THICKNESS.

Exterior INSULATING SHEATHING?

Acceptable Answer(s) and Associated [Value(s)]:

N - None	[0.0]
O - One inch	[5.0]
T - Two inches	[10.]
R - Three inches	[15.]

Default:

N - None	[0.0]

Next Question = #10: "Wall R-VALUE"

Data position = 7

Explanations:

Exterior insulating SHEATHING is insulation on the ouside of the walls. It is usually only found on large masonry buildings. Houses which have been re-sided may have had insulation installed underneath the new sheathing. Each inch of exterior insulation is assumed to add R-5 to the wall.

Wall R-VALUE?

Minimum = 1 F-sqft/Btuh

Maximum = 50 F-sqft/Btuh

Default = lfval($03)/100 F-sqft/Btuh

```
IF $03: "Wall TYPE" WAS "Solid brick"
                        OR "Block & Brick"
                        OR "Block;Cavity & Brick" THEN:
        Default = value($04)*answr(#09)+?5<value($04)*answr(#09)?
                   +value($05)+lfval($03)/100 F-sqft/Btuh

IF $03: "Wall TYPE" WAS "Two by Four Frame"
                        OR "Two by Six Frame" THEN:
        Default = [lfval($03)/100]/[.955/({value($04)*answr(#09)
                   +?5<value($04)*answr(#09)?}/{[.96*lfval($03)]/100}
                   +1)+.045]+value($05) F-sqft/Btuh

Legend: $03: Wall TYPE
        $04: Wall INSULATION
        #09: Insulation THICKNESS
        ?xx? = -1 (if xx is true)   = 0 (if xx is false)
        $05: Exterior INSULATING SHEATHING
```

Next question = #08: "Wall AREA wo/ windows & doors"

Data position = 16 —> **contains** 1/[Entry]

Explanations:

The R-VALUE is the thermal resistance of the wall. The default values you will get by pressing <ctrl-D> are based on your previous answers to wall TYPE, INSULATION, INSULATION THICKNESS and EXTERIOR INSULATING SHEATHING. (A correction is made for the effect on framing on R-value.)

Wall AREA wo/ windows & doors?

Minimum = 10 sqft

Maximum = 2000 sqft

Default = 200 sqft

Next question = #13: "No. of WINDOWS"

Data position = 10

Explanations:

```
+---------------------------------------------------------------------------+
|                                                                           |
|      The wall AREA does NOT! include the windows or doors, i.e. it is:    |
|                                                                           |
|       { Wall height times wall length } - { Door area } - { Window area }  |
|                                                                           |
|                                                                           |
+---------------------------------------------------------------------------+
```

No. of WINDOWS?

Minimum = 0 No.

Maximum = 20 No.

Default = 3 No.

Next question = #06: "No. of VENTS in wall"

Data position = 14

Explanations:

A VENT is a kitchen vent or any similar WALL opening.

A PENETRATION is a hole where a wire or small pipe goes through the WALL.

A WINDOW is any window in the WALL.

Do not enter any information about CEILING vents, penetrations, or windows at this point. They are asked for under ROOF/CEILING.

Each vent, penetration and window adds a small leakage area to the wall. If you want to know more about leakage area, press <ctrl-H> when you are asked about SPECIFIC LEAKAGE AREA in the INFILTRATION section.

No. of VENTS in wall?

Minimum = 0 No.

Maximum = 10 No.

Default = 1 No.

Next question = #07: "No. of other PENETRATIONS"

Data position = 12

Explanations:

A VENT is a kitchen vent or any similar WALL opening.

A PENETRATION is a hole where a wire or small pipe goes through the WALL.

A WINDOW is any window in the WALL.

Do not enter any information about CEILING vents, penetrations, or windows at this point. They are asked for under ROOF/CEILING.

Each vent, penetration and window adds a small leakage area to the wall. If you want to know more about leakage area, press <ctrl-H> when you are asked about SPECIFIC LEAKAGE AREA in the INFILTRATION section.

No. of other PENETRATIONS?

Minimum = 0 No.

Maximum = 10 No.

Default = 1 No.

Next question = #11: "Specific LEAKAGE AREA"

Data position = 13

Explanations:

A VENT is a kitchen vent or any similar WALL opening.

A PENETRATION is a hole where a wire or small pipe goes through the WALL.

A WINDOW is any window in the WALL.

Do not enter any information about CEILING vents, penetrations, or windows at this point. They are asked for under ROOF/CEILING.

Each vent, penetration and window adds a small leakage area to the wall. If you want to know more about leakage area, press <ctrl-H> when you are asked about SPECIFIC LEAKAGE AREA in the INFILTRATION section.

INNER Garage envelope AREA?

Minimum = 10 sqft

Maximum = 1000 sqft

Default = 150 sqft

Next question = #15: "Average HEIGHT of the garage"

Data position = 10

Explanations:

The GARAGE envelope area is the area of wall which the garage shares with the house (including the area of any windows and doors in this wall.) plus the ceiling area if the garage shares its ceiling with the house. If the garage does not cover the complete surface of one wall of the house, the rest of the wall area should be entered as another named wall.

For example, if a one story garage is attached to a two story house, the upper story of the house wall is to be entered as a separate wall.

Average HEIGHT of the garage?

Minimum = 0 feet

Maximum = 30 feet

Default = 8 feet

Next question = #16: "Garage Exterior wall PERIMETER"

Data position = 15

Explanations:

```
+-------------------------------------------------------------------------+
|                                                                         |
|     The average HEIGHT of the garage is just that: the average height from |
| external grade to the top of the garage roof.                           |
|                                                                         |
+-------------------------------------------------------------------------+
```

Garage Exterior wall PERIMETER?

Minimum = 0 feet

Maximum = 100 feet

Default = 50 feet

Next question = $17: "Garage Exterior Envelope TYPE"

Data position = 9

Explanations:

The garage PERIMETER is the distance around the garage where the walls are not shared with the house.

Garage Exterior Envelope TYPE?

Acceptable Answer(s) and Associated [LfVal] [RgVal]:

		[LfVal]	[RgVal]
U	Uninsulated walls & roof	[4]	[2]
W	Uninsulated walls only	[4]	[999]
I	Insulated walls & roof	[12]	[20]
N	Insulated walls only	[12]	[999]

Default:

U - Uninsulated walls & roof [4] [2]

Next Question = #18: "Garage DOOR & WINDOW Area"

Data position = 12

Explanations:

The garage ENVELOPE TYPE concerns only those surfaces of the garage that are not shared with the house. To obtain a list of the available types, press <ctrl-L>, and choose the code letter closest to your situation. For example, if your garage shares one wall and its roof with the house, and the garage walls are insulated, choose "Insulated walls only".

Garage DOOR & WINDOW Area?

Minimum = 0 sqft

Maximum = 1000 sqft

Default = 400 sqft

Next question = #19: "Garage FLOOR Area"

Data position = 13

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|      The DOOR area for the garage is  the  total  area  of  any  doors  and |
| windows, except those leading to the house.                            |
|                                                                        |
+------------------------------------------------------------------------+
```

Garage FLOOR Area?

Minimum = 0 sqft

Maximum = 600 sqft

Default = 200 sqft

Next question = #20: "Overall Garage R-VALUE"

Data position = 14

Explanations:

```
+----------------------------------------------------------------------+
|                                                                      |
|      The FLOOR area is the area of the garage floor.                 |
|                                                                      |
+----------------------------------------------------------------------+
```

Overall Garage R-VALUE?

Minimum = 1 F-sqft/Btuh

Maximum = 50 F-sqft/Btuh

Default = ([value($04)*answr(#09)+?5<value($04)*answr(#09)?+lfval($03)/100]
/answr(#14)+1/{{answr(#16)*answr(#15)-answr(#18)}/lfval($17)+[1
/(rgval($17))+0.25]*answr(#19)+answr(#18)/2})*answr(#14) F-sqft/Btuh

Legend: $04: Wall INSULATION
#09: Insulation THICKNESS
$03: Wall TYPE
?xx? = -1 (if xx is true) = 0 (if xx is false)
#14: INNER Garage envelope AREA
#16: Garage Exterior wall PERIMETER
#15: Average HEIGHT of the garage
#18: Garage DOOR & WINDOW Area
$17: Garage Exterior Envelope TYPE
#19: Garage FLOOR Area

Next question = #11: "Specific LEAKAGE AREA"

Data position = 16 —> **contains** 1/[Entry]

Explanations:

Specific LEAKAGE AREA?

Minimum = 0 sqin/sqft

Maximum = 0.3 sqin/sqft

Default = {[6*answr(#06)+4.5*answr(#07)+5*answr(#13)]/answr(#08)+.05}/6.4516 sqin/sqft

IF $03: "Wall TYPE" **WAS** "Shared w/ Garage" **THEN:**
Default = 0.3 sqin/sqft

Legend: #06: No. of VENTS in wall
#07: No. of other PENETRATIONS
#13: No. of WINDOWS
#08: Wall AREA wo/ windows & doors

Next question = $26: "Which menu ITEM(S)"

Data position = 17 —> **contains** Entry*6.4516

Explanations:

The leakage area of a wall is the area of a single hole in the wall which would leak in the same way as all the leaks from cracks around the edge of the wall and around vents, penetrations, and window frames.

The SPECIFIC LEAKAGE AREA is the leakage area divided by the area of the wall.

If you press <ctrl-D> the computer will give you a default value based on the answers you gave earlier.

WALLS.INF

```
$01,NAME for the following walls,\NAME,,,$02,,3,\\,\\
$02,Which wall ORIENTATION,\ORIENT,SWNE,S,$03,,4,\SSouth walls\WWest walls\NNor
  th walls\EEast walls\,\\
$03,Wall TYPE,\TYPE,FTSBCG,F,$04,,5,\FTwo by Four Frame\TTwo by Six Frame\SSoli
  d brick\BBlock & Brick\CBlock;Cavity & Brick\GShared w/ Garage\,\F464.35\T461
  .55\S390.00\B593.00\C491.35\G464.35\
$04,Wall INSULATION,\INSULATION,NFLBCUPSV\$03=S>NFBUPS\,F\$03=S>N\,#09\$04=N>#1
2\,,6,\NNone\FFiberglass batts\LFiberglass loose\BFiberglass boards\CCelluose f
  ill\UUF-foam\PPolyurethane boards\SPolystyrene boards\VVermiculite fill\,\N0.
  0\F3.3\L3.0\B4.0\C3.4\U4.0\P6.0\S5.0\V2.2\
#09,Insulation THICKNESS,inches\,\THICKNESS,0,20,{F03!100/},#12,,11
#12,INSULATABLE wall THICKNESS,inches\,\INSULATABLE,0,20,{F03!100/V09-!!0<*@}\$
  04=N>{F03!100/}\,$05\$03=G>#14\,,8
$05,Exterior INSULATING SHEATHING,\SHEATHING,NOTR,N,#10,,7,\NNone\OOne inch\TTw
  o inches\RThree inches\,\N0.0\O5.0\T10.\R15.\
#10,Wall R-VALUE,F-sqft/Btuh\|\|,\R-VALUE,1,50,{I03!100/}\$03=SBC>{T04!V09*!!5<
  +T05+I03!100/+}\$03=FT>{.955!T04!V09*!!5<+.96!I03*100//1+/.045+I03!100/~/T05+
  }\,#08,,16
#08,Wall AREA wo/ windows & doors,sqft\,\AREA,10,2000,200,#13,,10
#13,No. of WINDOWS,No.\,\HOLES,0,20,3,#06,,14
#06,No. of VENTS in wall,No.\,\HOLES,0,10,1,#07,,12
#07,No. of other PENETRATIONS,No.\,\HOLES,0,10,1,#11,,13
#14,INNER Garage envelope AREA,sqft\,\GARAGE,10,1000,150,#15,,10
#15,Average HEIGHT of the garage,feet\,\HEIGHT,0,30,8,#16,,15
#16,Garage Exterior wall PERIMETER,feet\,\PERIMETER,0,100,50,$17,,9
$17,Garage Exterior Envelope TYPE,\ENVELOP,UWIN,U,#18,,12,\UUninsulated walls &
  roof\WUninsulated walls only\IInsulated walls & roof\NInsulated walls only\,\
  U4.002\W4.999\I12.020\N12.999\
#18,Garage DOOR & WINDOW Area,sqft\,\DOOR,0,1000,400,#19,,13
#19,Garage FLOOR Area,sqft\,\FLOOR,0,600,200,#20,,14
#20,Overall Garage R-VALUE,F-sqft/Btuh\|\|,\GARAGE R-VALUE,1,50,{T04!V09*!!5<+I
  03!100/+V14/V16!V15*V18-I17/F17|0.25+V19*+V18!2/+|+V14*},#11,,16
#11,Specific LEAKAGE AREA,sqin/sqft\6.4516*\6.4516/,\LEAKG,0,0.3,{6!V06*4.5!V07
  *5!V13*++V08/.05+6.4516/}\$03=G>0.03\,$26,,17
```

Roof / Ceiling

NAME for attic/roof or ceiling?

Next Question = $02: "Roof-Ceiling TYPE"

Data position = 3

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|      A NAME is given to each roof/ceiling or group of  roofs/ceilings.   If |
| two   or   more   roofs/ceilings   have the same characteristics, (i.e. type, R- |
| value etc.) they can be entered together under one name.  The  area  of  the |
| roof/ceiling then is the combined area of the individual roofs/ceilings.    |
|                                                                        |
+------------------------------------------------------------------------+
```

Roof-Ceiling TYPE?

Acceptable Answer(s) and Associated [Value(s)]:

U - Unfinished attic [20.]
L - Low pitch roof [12.]
C - Cathedral ceiling [4.]

Default:

U - Unfinished attic [20.]

Next Question = $04: "Insulation TYPE"

Data position = 5

Explanations:

```
+----------------------------------------------------------------------+
|                                                                      |
|     We distinguish among three TYPES of Roof/Ceilings:               |
|                                                                      |
|      - UNFINISHED ATTIC: Unheated, "A-frame"-like space between roof and |
|                 living space; insulation, if any, is assumed to be on |
|                 top of the living space ceiling (or attic floor).    |
|                                                                      |
|      - LOW PITCH ROOF: Very similar to unfinished attic, except that the |
|                 space available for insulation may be limited (zero if |
|                 the "attic" is inaccessible).                        |
|                                                                      |
|      - CATHEDRAL CEILING: The ceiling parallels the roof at a distance |
|                 given by the roof rafters; the resulting cavity may be |
|                 retrofitted with insulation, as long as a 2" air space |
|                 above the insulation is left for ventilation through |
|                 the eave vents.                                      |
|                                                                      |
+----------------------------------------------------------------------+
```

Insulation TYPE?

Acceptable Answer(s) and Associated [Value(s)]:

N - No insulation	[0.0]
F - Fiberglass batts	[3.3]
L - Fiberglass loose	[3.0]
B - Fiberglass boards	[4.0]
C - Cellulose fill	[3.4]
U - UF-foam	[4.0]
P - Polyurethane boards	[6.0]
S - Polystyrene boards	[5.0]
V - Vermiculite fill	[2.2]

Default:

N - No insulation [0.0]

Next Question = #05: "Insulation THICKNESS"

IF $04: "Insulation TYPE" **WAS** "No insulation" **THEN:**
Next Question = #06: "Insulatable AIR SPACE"

Data position = 7

Explanations:

Insulation TYPE is the kind of insulation present. For a list of options, press <ctrl-L> when you are asked about INSULATION TYPE.

Insulation THICKNESS?

Minimum = 0 inches

Maximum = 30 inches

Default = value($02)/2 inches

Legend: $02: Roof-Ceiling TYPE

Next question = #06: "Insulatable AIR SPACE"

Data position = 11

Explanations:

> Insulation TYPE is the kind of insulation present. For a list of options, press <ctrl-L> when you are asked about INSULATION TYPE.

Insulatable AIR SPACE?

Minimum = 0 inches

Maximum = 30 inches

Default = -{[value($02)-answr(#05)]*[?0<value($02)-answr(#05)?]} inches

Legend: $02: Roof-Ceiling TYPE
#05: Insulation THICKNESS
?xx? = -1 (if xx is true) = 0 (if xx is false)

Next question = #07: "Ceiling R-value"

Data position = 8

Explanations:

The INSULATABLE AIR SPACE is the height, in inches, available for retrofit insulation. For example, if floor boards cover the 2 by 6 ceiling joists in an attic with 2" of existing insulation, the INSULATABLE AIR SPACE is 3.5". If the attic is inaccessible, enter zero.

Ceiling R-value?

Minimum = 1 F-sqft/Btuh

Maximum = 50 F-sqft/Btuh

Default = 2.0 F-sqft/Btuh

IF $04: "Insulation TYPE" **WAS NOT** "No insulation" **THEN:**
Default = value($04)*answr(#05)+[?5<value($04)*answr(#05)?]*.84+2 F-sqft/Btuh

Legend: $04: Insulation TYPE
#05: Insulation THICKNESS
?xx? = -1 (if xx is true) = 0 (if xx is false)

Next question = #08: "Ceiling AREA"

Data position = 12 —> **contains** 1/[Entry]

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|      The R-VALUE is the thermal resistance of the ceiling.  Press  <ctrl-D> |
| for a default value based on your previous answers; it includes a correction |
| for the joists.                                                        |
|                                                                        |
+------------------------------------------------------------------------+
```

Ceiling AREA?

Minimum = 10 sqft

Maximum = 3000 sqft

Default = 1000 sqft

Next question = #14: "No. of ceiling VENTS"

Data position = 10

Explanations:

Enter the total FLOOR AREA of the attic or low-pitch roof. For cathedral ceilings, enter the horizontal projection, i.e., the floor area of the rooms covered by the cathedral ceiling.

No. of ceiling VENTS?

Minimum = 0 count

Maximum = 20 count

Default = 5 count

Next question = #09: "No. of ceiling PENETRATIONS"

Data position = 16

Explanations:

VENTS are bathroom vents, kitchen exhausts, air shafts from the living space and from the basement. Count large air shafts as double or triple, according to size.

PENETRATIONS are holes caused by wiring, plumbing and lighting fixtures. Count large penetrations as double or triple.

If you want to know more about leakage area, press <ctrl-H> when you are asked HOW LEAKAGE AREA WAS MEASURED in the INFILTRATION section.

No. of ceiling PENETRATIONS?

Minimum = 0 count

Maximum = 100 count

Default = 10 count

Next question = #10: "Ceiling sp. LEAKAGE area"

Data position = 17

Explanations:

VENTS are bathroom vents, kitchen exhausts, air shafts from the living space and from the basement. Count large air shafts as double or triple, according to size.

PENETRATIONS are holes caused by wiring, plumbing and lighting fixtures. Count large penetrations as double or triple.

If you want to know more about leakage area, press <ctrl-H> when you are asked HOW LEAKAGE AREA WAS MEASURED in the INFILTRATION section.

Ceiling sp. LEAKAGE area?

Minimum = 0 sqin/sqft

Maximum = 0.3 sqin/sqft

Default = {[6*answr(#14)+4.5*answr(#09)]/answr(#08)+.2}/6.4516 sqin/sqft

Legend: #14: No. of ceiling VENTS
#09: No. of ceiling PENETRATIONS
#08: Ceiling AREA

Next question = #11: "Roof PITCH"

Data position = 6 **—> contains** Entry*6.4516

Explanations:

The LEAKAGE AREA of a ceiling is roughly the area of a single hole which would leak air at the same rate as all the VENTS, PENETRATIONS, and other leaks in the ceiling put together.

The ceiling SPECIFIC LEAKAGE AREA is the leakage area divided by the area of ceiling. Press <ctrl-D> for a default value based on the number of VENTS and PENETRATIONS you provided, together with the ceiling AREA.

Roof PITCH?

Minimum = 0 %

Maximum = 200 %

IF $02: "Roof-Ceiling TYPE" **WAS** "Low pitch roof" **THEN:**
Maximum = 30 %

Default = 50 %

IF $02: "Roof-Ceiling TYPE" **WAS** "Low pitch roof" **THEN:**
Default = 20 %

IF $02: "Roof-Ceiling TYPE" **WAS** "Cathedral ceiling" **THEN:**
Default = 70 %

Next question = $15: "Roof top MATERIAL"

Data position = 15 —> **contains** Entry*.01

Explanations:

Roof PITCH and ABSORPTIVITY play an important role in determining heat conduction and solar heat gain through the roof.

A PITCH of 30% means that the roof line goes up 3 ft for every 10 ft horizontal travel. The roof area is computed automatically from the ceiling area and the roof pitch.

The darker the color and the duller the MATERIAL of the roof, the higher the ABSORPTIVITY. For a list of materials, press <ctrl-L>

Press <crtl-D> in response to the question about ABSORPTIVITY, for a default value based on the answer you gave for roof material.

Roof top MATERIAL?

Acceptable Answer(s) and Associated [Value(s)]:

A - Asphalt Shingles	[95]
T - Tar & Gravel	[85]
W - Wood Shingles	[85]
S - Spanish Tiles	[80]

Default:

A - Asphalt Shingles	[95]

Next Question = #12: "Roof ABSORPTIVITY"

Data position = 9

Explanations:

Roof PITCH and ABSORPTIVITY play an important role in determining heat conduction and solar heat gain through the roof.

A PITCH of 30% means that the roof line goes up 3 ft for every 10 ft horizontal travel. The roof area is computed automatically from the ceiling area and the roof pitch.

The darker the color and the duller the MATERIAL of the roof, the higher the ABSORPTIVITY. For a list of materials, press <ctrl-L>

Press <crtl-D> in response to the question about ABSORPTIVITY, for a default value based on the answer you gave for roof material.

Roof ABSORPTIVITY?

Minimum = 0 %

Maximum = 100 %

Default = value($15) %

Legend: $15: Roof top MATERIAL

Next question = #13: "Attic VENTILATION"

Data position = 14 —> **contains** Entry*.01

Explanations:

Roof PITCH and ABSORPTIVITY play an important role in determining heat conduction and solar heat gain through the roof.

A PITCH of 30% means that the roof line goes up 3 ft for every 10 ft horizontal travel. The roof area is computed automatically from the ceiling area and the roof pitch.

The darker the color and the duller the MATERIAL of the roof, the higher the ABSORPTIVITY. For a list of materials, press <ctrl-L>

Press <crtl-D> in response to the question about ABSORPTIVITY, for a default value based on the answer you gave for roof material.

Attic VENTILATION?

Minimum = 0 cfm/sqft

Maximum = 2.0 cfm/sqft

Default = 0.5 cfm/sqft

> **IF** $02: "Roof-Ceiling TYPE" **WAS** "Low pitch roof" **THEN:**
> **Default** = 0.2 cfm/sqft

> **IF** $02: "Roof-Ceiling TYPE" **WAS** "Cathedral ceiling" **THEN:**
> **Default** = 0.1 cfm/sqft

Next question = $26: "Which menu ITEM(S)"

Data position = 13

Explanations:

Roof VENTILATION is usually hard to determine; fortunately, it has little bearing on the heat load calculations, especially if the ceiling is insulated. Press <ctrl-D> for a typical value.

```
$01,NAME for attic/roof or ceiling,\NAME,,,$02,,3,\\,\\
$02,Roof-Ceiling TYPE,\TYPE,ULC,U,$04,,5,\UUnfinished attic\LLow pitch roof\CCa
  thedral ceiling\,\U20.\L12.\C4.\
$04,Insulation TYPE,\INSULATION,NFLBCUPSV,N,#05\$04=N>#06\,,7,\NNo insulation\F
  Fiberglass batts\LFiberglass loose\BFiberglass boards\CCellulose fill\UUF-foa
  m\PPolyurethane boards\SPolystyrene boards\VVermiculite fill\\N0.0\F3.3\L3.0\
  B4.0\C3.4\U4.0\P6.0\S5.0\V2.2\
#05,Insulation THICKNESS,inches\,\INSULATION,0,30,{T02!2/},#06,,11
#06,Insulatable AIR SPACE,inches\,\SPACE,0,30,{T02!V05-!!0<*@},#07,,8
#07,Ceiling R-value,F-sqft/Btuh\|\|,\R-VALUE,1,50,2.0\$04"N>{T04!V05*!!5<.84*+2
  +}\,#08,,12
#08,Ceiling AREA,sqft\,\AREA,10,3000,1000,#14,,10
#14,No. of ceiling VENTS,count\,\HOLES,0,20,5,#09,,16
#09,No. of ceiling PENETRATIONS,count\,\HOLES,0,100,10,#10,,17
#10,Ceiling sp. LEAKAGE area,sqin/sqft\6.4516*\6.4516/,\LEAKG,0,0.3,{6!V14*4.5!
  V09*+V08/.2+6.4516/},#11,,6
#11,Roof PITCH,%\.01*\.01/,\ROOF,0,200\$02=L>30\,50\$02=L>20\$02=C>70\,$15,,15
$15,Roof top MATERIAL,\ROOF,ATWS,A,#12,,9,\AAsphalt Shingles\TTar & Gravel\WWoo
  d Shingles\SSpanish Tiles\,\A95\T85\W85\S80\
#12,Roof ABSORPTIVITY,%\.01*\.01/,\ROOF,0,100,{T15!},#13,,14
#13,Attic VENTILATION,cfm/sqft\,\VENTILATION,0,2.0,0.5\$02=L>0.2\$02=C>0.1\,$26
  ,,13
```

Subfloor

Subfloor NAME?

Next Question = $02: "Subfloor TYPE"

Data position = 3

Explanations:

A NAME is given to each subfloor or group of subfloors. If two or more subfloors have the same characteristics, they can be entered together under one name. The area of the subfloor would then be the sum of the areas of the individual subfloors. A house with a combination of subfloors--for example, a partial basement and crawlspace--should have two subfloor NAMES.

Retrofits chosen by the computer for each subfloor or group of subfloors will use this name to identify which subfloor they apply to.

Subfloor TYPE?

Acceptable Answer(s) and Associated [Value(s)]:

B - Basement	[1.0]
C - Crawlspace	[0.0]
S - Slab-on-grade	[0.0]

Default:

B - Basement	[1.0]

Next Question = $06: "Joist INSULATION"

IF $02: "Subfloor TYPE" **WAS** "Slab-on-grade" **THEN:**
Next Question = #09: "Floor AREA (Joists)"

Data position = 5

Explanations:

There are three SUBFLOOR TYPES:

BASEMENT: A space below the house generally used for storage, housing of HVAC equipment and its distribution system (ducts or pipes). Only walls exposed to the outside are to be considered, not walls shared with neighbors or adjacent subfloor structures. basement windows are assumed to be small and are not considered for retrofit. If they aren't, and if the basement is heated and/or cooled, the above-grade part should be input under WALLS, WINDOWS, etc. and only the below-grade walls and the floor should be input as SUBFLOOR.

CRAWLSPACE: A space below the living space with floor-to-ceiling height of less than 5'6", with exposed or partially covered earth as a floor, at the same level as outside grade. Crawlspaces are assumed to be vented to the outside. As for basements, only walls exposed to outside are to be considered.

SLAB-ON-GRADE: A slab of reinforced concrete directly supporting the living space. When measuring the perimeter, do not include any shared walls, e.g. with the garage or the house next door.

Joist INSULATION?

Acceptable Answer(s) and Associated [Value(s)]:

N - None	[0.0]
H - Heated basement	[0.0]
F - Fiberglass batts	[3.3]
L - Fiberglass loose	[3.0]
B - Fiberglass boards	[4.0]
C - Cellulose fill	[3.4]
U - UF-foam	[4.0]
P - Polyurethane boards	[6.0]
S - Polystyrene boards	[5.0]
V - Vermiculite fill	[2.2]

IF $02: "Subfloor TYPE" **WAS** "Crawlspace" **THEN:**

N - None	[0.0]
F - Fiberglass batts	[3.3]
B - Fiberglass boards	[4.0]
U - UF-foam	[4.0]
P - Polyurethane boards	[6.0]
S - Polystyrene boards	[5.0]

Default:

N - None [0.0]

Next Question = #07: "Joist insulation THICKNESS"

IF $06: "Joist INSULATION" **WAS** "None" **THEN:**
Next Question = #08: "Total joist R-VALUE"

IF $06: "Joist INSULATION" **WAS** "Heated basement" **THEN:**
Next Question = #08: "Total joist R-VALUE"

Data position = 7

Explanations:

INSULATION MATERIAL is the kind of insulation present. For a list, press <ctrl-L>

Joist insulation THICKNESS?

Minimum = 0 inches

Maximum = 16 inches

Default = 5.5 inches

Next question = #08: "Total joist R-VALUE"

Data position = 0

Explanations:

```
+----------------------------------------------------------------------+
|                                                                      |
|      Any floor insulation is assumed to be  in the cavities formed by the |
| ceiling joists.  The INSULATION THICKNESS is the depth of this insulation. |
|                                                                      |
+----------------------------------------------------------------------+
```

Total joist R-VALUE?

Minimum = 1 F-sqft/Btuh

Maximum = 15 F-sqft/Btuh

Default = 3.0 F-sqft/Btuh

IF $06: "Joist INSULATION" **WAS NOT** "None" **THEN:**
Default = value($06)*answr(#07)+?5<value($06)*answr(#07)?+3 F-sqft/Btuh

Legend: $06: Joist INSULATION
#07: Joist insulation THICKNESS
?xx? = -1 (if xx is true) = 0 (if xx is false)

Next question = #09: "Floor AREA (Joists)"

Data position = 8 —> **contains** 1/[Entry]

Explanations:

The joist R-VALUE is the total thermal resistance of the floor, from living space air to basement air. To obtain a default value based on your previous answers, press <ctrl-D>

Floor AREA (Joists)?

Minimum = 20 sqft

Maximum = 5000 sqft

Default = 1000 sqft

Next question = #04: "No. of floor PENETRATIONS"

IF $02: "Subfloor TYPE" **WAS** "Slab-on-grade" **THEN:**
Next question = #15: "Exposed PERIMETER"

Data position = 10

Explanations:

```
+----------------------------------------------------------------------------+
|                                                                            |
|     The floor AREA is the area of the floor above this subfloor space.     |
|                                                                            |
+----------------------------------------------------------------------------+
```

No. of floor PENETRATIONS?

Minimum = 0 No.

Maximum = 30 No.

Default = 10 No.

Next question = #23: "Floor sp. LEAKAGE AREA"

Data position = 0

Explanations:

```
+--------------------------------------------------------------------------+
|                                                                          |
|      The leakage area of a wall or subfloor is roughly the area of a single |
| hole which would leak air at the same rate as all the VENTS, PENETRATIONS, |
| and other leaks in the wall or subfloor put together.                    |
|                                                                          |
|      The SPECIFIC LEAKAGE AREA of a wall or subfloor is the total leakage |
| area divided by the wall or subfloor area. If you press <ctrl-D> the     |
| computer will give you a default value based on the number of VENTS,     |
| PENETRATIONS and WINDOWS you provided in answer to previous questions.   |
|                                                                          |
+--------------------------------------------------------------------------+
```

Floor sp. LEAKAGE AREA?

Minimum = 0. sqin/sqft

Maximum = 0.4 sqin/sqft

Default = {[4.5*answr(#04)]/answr(#09)+.2}/6.4516 sqin/sqft

Legend: #04: No. of floor PENETRATIONS
#09: Floor AREA (Joists)

Next question = $12: "Subfloor WALL INSULATION material"

Data position = 9 —> **contains** Entry*6.4516

Explanations:

The leakage area of a wall or subfloor is roughly the area of a single hole which would leak air at the same rate as all the VENTS, PENETRATIONS, and other leaks in the wall or subfloor put together.

The SPECIFIC LEAKAGE AREA of a wall or subfloor is the total leakage area divided by the wall or subfloor area. If you press <ctrl-D> the computer will give you a default value based on the number of VENTS, PENETRATIONS and WINDOWS you provided in answer to previous questions.

Subfloor WALL INSULATION material?

Acceptable Answer(s) and Associated [Value(s)]:

N - None	[0.0]
F - Fiberglass batts	[3.3]
L - Fiberglass loose	[3.0]
B - Fiberglass boards	[4.0]
C - Cellulose fill	[3.4]
U - UF-foam	[4.0]
P - Polyurethane boards	[6.0]
S - Polystyrene boards	[5.0]
V - Vermiculite fill	[2.2]

Default:

N - None [0.0]

Next Question = #13: "Wall insulation THICKNESS"

IF $12: "Subfloor WALL INSULATION material" **WAS** "None" **THEN:**
Next Question = #14: "Above-grade wall R-VALUE"

Data position = 11

Explanations:

INSULATION MATERIAL is the kind of insulation present. For a list of the available kinds of insulation, press <ctrl-L>

Wall insulation THICKNESS?

Minimum = 0 inches

Maximum = 10 inches

Default = 4 inches

Next question = #14: "Above-grade wall R-VALUE"

Data position = 0

Explanations:

Above-grade walls are present in basements and crawlspaces. The INSULATION THICKNESS is the thickness of any insulation between furring (or boards) and the foundation wall.

Above-grade wall R-VALUE?

Minimum = 1 F-sqft/Btuh

Maximum = 30 F-sqft/Btuh

Default = 2.2 F-sqft/Btuh

IF $12: "Subfloor WALL INSULATION material" **WAS NOT** "None" **THEN:**
Default = value($12)*answr(#13)+2.2 F-sqft/Btuh

Legend: $12: Subfloor WALL INSULATION material
#13: Wall insulation THICKNESS

Next question = #16: "ABOVE-Grade HEIGHT"

Data position = 12 —> **contains** 1/[Entry]

Explanations:

The R-VALUE is the thermal resistance from the air inside the basement or crawlspace through the above-grade wall to the outside air. If you press <ctrl-D> the computer will give a default value based on your previous answers. It is computed from information on wall INSULATION MATERIAL, on INSULATION THICKNESS and on the wall itself.

ABOVE-Grade HEIGHT?

Minimum = 0 feet

Maximum = 12 feet

Default = 3 feet

IF $02: "Subfloor TYPE" **WAS** "Crawlspace" **THEN:**
Default = 2 feet

Next question = #15: "Exposed PERIMETER"

Data position = 14

Explanations:

```
+--------------------------------------------------------------------+
|                                                                    |
|      Exposed PERIMETER is the total length of above-grade  walls  (or  slab |
| edge) which are exposed to the outside.                            |
|                                                                    |
|      ABOVE-GRADE HEIGHT is from grade level to subfloor ceiling.   |
|                                                                    |
+--------------------------------------------------------------------+
```

Exposed PERIMETER?

Minimum = 20 feet

Maximum = 1000 feet

Default = 100 feet

Next question = #03: "Soil CONDUCTIVITY"

Data position = 16

Explanations:

Exposed PERIMETER is the total length of above-grade walls (or slab edge) which are exposed to the outside.

ABOVE-GRADE HEIGHT is from grade level to subfloor ceiling.

Soil CONDUCTIVITY?

Minimum = 2.5 Btuh-in/F-sqft

Maximum = 60 Btuh-in/F-sqft

Default = 15 Btuh-in/F-sqft

Next question = #10: "No. of WINDOWS"

IF $02: "Subfloor TYPE" **WAS** "Crawlspace" **THEN:**
Next question = #05: "No. of wall VENTS"

IF $02: "Subfloor TYPE" **WAS** "Slab-on-grade" **THEN:**
Next question = #20: "Floor R-VALUE"

Data position = 6 —> **contains** Entry/12

Explanations:

The soil CONDUCTIVITY is the inverse of the R-value of a slice of soil one inch thick. Use the approximate values in the table below to pick the value for the nearest soil type. Note that moisture difference makes a considerable difference to conductivity.

TYPE OF SOIL	CONDUCTIVITY (Btu-in/hr-F-sqft).	
	4% moisture	10% moisture
Fine crushed quartz	16	20
Sand	11	15
Gravel or crushed granite	9	13
Loam	7	10
Clay	6	9

No. of WINDOWS?

Minimum = 0 No.

Maximum = 10 No.

Default = 2 No.

Next question = #05: "No. of wall VENTS"

Data position = 0

Explanations:

The leakage area of a wall or subfloor is roughly the area of a single hole which would leak air at the same rate as all the VENTS, PENETRATIONS, and other leaks in the wall or subfloor put together.

The SPECIFIC LEAKAGE AREA of a wall or subfloor is the total leakage area divided by the wall or subfloor area. If you press <ctrl-D> the computer will give you a default value based on the number of VENTS, PENETRATIONS and WINDOWS you provided in answer to previous questions.

No. of wall VENTS?

Minimum = 0 No.

Maximum = 20 No.

Default = 5 No.

Next question = #11: "No. of wall PENETRATIONS"

Data position = 0

Explanations:

The leakage area of a wall or subfloor is roughly the area of a single hole which would leak air at the same rate as all the VENTS, PENETRATIONS, and other leaks in the wall or subfloor put together.

The SPECIFIC LEAKAGE AREA of a wall or subfloor is the total leakage area divided by the wall or subfloor area. If you press <ctrl-D> the computer will give you a default value based on the number of VENTS, PENETRATIONS and WINDOWS you provided in answer to previous questions.

No. of wall PENETRATIONS?

Minimum = 0 No.

Maximum = 30 No.

Default = 10 No.

Next question = #24: "Wall specific LEAKAGE AREA"

Data position = 0

Explanations:

The leakage area of a wall or subfloor is roughly the area of a single hole which would leak air at the same rate as all the VENTS, PENETRATIONS, and other leaks in the wall or subfloor put together.

The SPECIFIC LEAKAGE AREA of a wall or subfloor is the total leakage area divided by the wall or subfloor area. If you press <ctrl-D> the computer will give you a default value based on the number of VENTS, PENETRATIONS and WINDOWS you provided in answer to previous questions.

Wall specific LEAKAGE AREA?

Minimum = 0. sqin/sqft

Maximum = 0.5 sqin/sqft

Default = {[6*answr(#05)+10*answr(#10)+4.5*answr(#11)]/[answr(#16)*answr(#15)]
+.5}/6.4516 sqin/sqft

Legend: #05: No. of wall VENTS
#10: No. of WINDOWS
#11: No. of wall PENETRATIONS
#16: ABOVE-Grade HEIGHT
#15: Exposed PERIMETER

Next question = #19: "Below-grade R-VALUE"

IF $02: "Subfloor TYPE" **WAS** "Slab-on-grade" **THEN:**
Next question = #20: "Floor R-VALUE"

Data position = 13 —> **contains** Entry*6.4516

Explanations:

The leakage area of a wall or subfloor is roughly the area of a single hole which would leak air at the same rate as all the VENTS, PENETRATIONS, and other leaks in the wall or subfloor put together.

The SPECIFIC LEAKAGE AREA of a wall or subfloor is the total leakage area divided by the wall or subfloor area. If you press <ctrl-D> the computer will give you a default value based on the number of VENTS, PENETRATIONS and WINDOWS you provided in answer to previous questions.

Below-grade R-VALUE?

Minimum = 2 F-sqft/Btuh

Maximum = 30 F-sqft/Btuh

Default = {({[7-answr(#16)]*1.5708}/answr(#03))*12}/{log([({[7-answr(#16)]
*1.5708}/answr(#03))*12]/answr(#14)+1)} F-sqft/Btuh

IF $02: "Subfloor TYPE" **WAS** "Crawlspace" **THEN:**
Default = 3/.71+[value($12)*answr(#13)]*.7 F-sqft/Btuh

Legend: #16: ABOVE-Grade HEIGHT
#03: Soil CONDUCTIVITY
#14: Above-grade wall R-VALUE
$12: Subfloor WALL INSULATION material
#13: Wall insulation THICKNESS

Next question = #20: "Floor R-VALUE"

Data position = 15 —> **contains** 1/[Entry]

Explanations:

Below-grade walls are present in basements and crawlspaces only. INSULATION THICKNESS (the thickness of any insulation between furring and the foundation wall) is assumed to be the same as for the above-grade section of the wall.

The below-grade R-VALUE is from basement or crawlspace air to outside, i.e. insulation + foundation + soil. To have the computer carry out this calculation for you, press <ctrl-D>

Floor R-VALUE?

Minimum = 0 F-sqft/Btuh

Maximum = 40 F-sqft/Btuh

Default = 4 F-sqft/Btuh

IF $02: "Subfloor TYPE" **WAS** "Basement" **THEN:**
Default = 2 F-sqft/Btuh

IF $02: "Subfloor TYPE" **WAS** "Crawlspace" **THEN:**
Default = 1 F-sqft/Btuh

Next question = #17: "SOIL RESISTANCE modifier"

Data position = 4

Explanations:

The FLOOR R-VALUE is the thermal resistance of the slab, if any, plus the air resistance above it. If you are standing in the basement or crawling in the crawlspace it is the thermal resistance between your feet and the dirt below, plus the resistance of an airfilm. To obtain a default value based on your previous answers, press <ctrl-D>

SOIL RESISTANCE modifier?

(Not asked explicitely)

Minimum = 0 none

Maximum = 200 none

Default = [(log({[answr(#03)/12]/answr(#15)}*answr(#20)))*(log({[answr(#03)/12]
/answr(#15)}*answr(#20)))]*.001073+{log({[answr(#03)/12]/answr(#15)}
answr(#20))}.01935-{[(log({[answr(#03)/12]/answr(#15)}
answr(#20)))(.4167/answr(#15))]*.1421}+.12081-[[(.4167/answr(#15))
*(.4167/answr(#15))]*20.336+({.4167/answr(#15)}*.2347)] none

Legend: #03: Soil CONDUCTIVITY
#15: Exposed PERIMETER
#20: Floor R-VALUE

Next question = #21: "Eqv Floor RESIST' outs'd"

Data position = 0

Explanations:

The SOIL RESISTANCE MODIFIER is an intermediate result in calculating subfloor heat loss.

Eqv Floor RESIST' outs'd?

Minimum = 2 F-sqft/Btuh

Maximum = 100 F-sqft/Btuh

Default = 34+answr(#20) F-sqft/Btuh

IF $02: "Subfloor TYPE" **WAS** "Crawlspace" **THEN:**
Default = 12+answr(#20) F-sqft/Btuh

IF $02: "Subfloor TYPE" **WAS** "Slab-on-grade" **THEN:**
Default = {[({.0904-[[(answr(#09)/{[answr(#15)/4]*[answr(#15)/4]})*(answr(#09)/{[answr(#15)/4]*[answr(#15)/4]})]*.2038+({answr(#09)/{[answr(#15)/4]*[answr(#15)/4]}}*1.1115)]}*answr(#15))/answr(#03)]*12}*answr(#17)+answr(#20) F-sqft/Btuh

Legend: #20: Floor R-VALUE
#09: Floor AREA (Joists)
#15: Exposed PERIMETER
#03: Soil CONDUCTIVITY
#17: SOIL RESISTANCE modifier

Next question = $26: "Which menu ITEM(S)"

Data position = 17 —> **contains** 1/[Entry]

Explanations:

The EQUIVALENT RESISTANCE TO OUTSIDE is the thermal resistance from the inside air, through the floor slab (if any) and the soil, to the outside air. To have the computer carry out this calculation for you, press <ctrl-D>

SUBFLOOR.INF

```
$01,Subfloor NAME,\NAME,,,$02,,3,\\,\\
$02,Subfloor TYPE,\TYPE,BCS,B,$06\$02=S>#09\,,5,\BBasement\CCrawlspace\SSlab-on
  -grade\,\B1.0\C0.0\S0.0\
$06,Joist INSULATION,\INSULATION,NHFLBCUPSV\$02=C>NFBUPS\,N,#07\$06=N>#08\$06=H
  >#08\,,7,\NNone\HHeated basement\FFiberglass batts\LFiberglass loose\BFibergl
  ass boards\CCellulose fill\UUF-foam\PPolyurethane boards\SPolystyrene boards\
  VVermiculite fill\,\N0.0\H0.0\F3.3\L3.0\B4.0\C3.4\U4.0\P6.0\S5.0\V2.2\
#07,Joist insulation THICKNESS,inches\,\JOIST,0,16,5.5,#08,,0
#08,Total joist R-VALUE,F-sqft/Btuh\|\|,\JOIST-R,1,15,3.0\$06"N>{T06!V07*!!5<+3
  +}\,#09,,8
#09,Floor AREA (Joists),sqft\,\AREA,20,5000,1000,#04\$02=S>#15\,,10
#04,No. of floor PENETRATIONS,No.\,\LEAKG,0,30,10,#23,,0
#23,Floor sp. LEAKAGE AREA,sqin/sqft\6.4516*\6.4516/,\LEAKG,0.,0.4,{4.5!V04*V09
  /.2+6.4516/},$12,,9
$12,Subfloor WALL INSULATION material,\INSULATION,NFLBCUPSV,N,#13\$12=N>#14\,,1
  1\NNone\FFiberglass batts\LFiberglass loose\BFiberglass boards\CCellulose fil
  l\UUF-foam\PPolyurethane boards\SPolystyrene boards\VVermiculite fill\\N0.0\F
  3.3\L3.0\B4.0\C3.4\U4.0\P6.0\S5.0\V2.2\
#13,Wall insulation THICKNESS,inches\,\ABOVE-G. WALLS,0,10,4,#14,,0
#14,Above-grade wall R-VALUE,F-sqft/Btuh\|\|,\WALL-R,1,30,2.2\$12"N>{T12!V13*2.
  2+}\,#16,,12
#16,ABOVE-Grade HEIGHT,feet\,\WALLS,0.1,12,3\$02=C>2\,#15,,14
#15,Exposed PERIMETER,feet\,\WALLS,20,1000,100,#03,,16
#03,Soil CONDUCTIVITY,Btuh-in/F-sqft\12/\12*,\SOIL,2.5,60,15,#10\$02=C>#05\$02=
  S>#20\,,6
#10,No. of WINDOWS,No.\,\LEAKG,0,10,2,#05,,0
#05,No. of wall VENTS,No.\,\LEAKG,0,20,5,#11,,0
#11,No. of wall PENETRATIONS,No.\,\LEAKG,0,30,10,#24,,0
#24,Wall specific LEAKAGE AREA,sqin/sqft\6.4516*\6.4516/,\LEAKG,0.,0.5,{6!V05*1
  0!V10*4.5!V11*++V16!V15*/.5+6.4516/},#19\$02=S>#20\,,13
#19,Below-grade R-VALUE,F-sqft/Btuh\|\|,\BELOW-G. WALLS,2,30,{7!V16-1.5708*V03/
  12*!!V14/1+L/}\$02=C>{3!.71/T12!V13*.7*+}\,#20,,15
#20,Floor R-VALUE,F-sqft/Btuh\,\FLOOR,0,40,4\$02=B>2\$02=C>1\,#17,,4
#17G,SOIL RESISTANCE modifier,none\,\MODIFIED,0,200,{V03!12/V15/V20*L!!!*.00107
  3*~.01935*+~.4167!V15/*.1421*-.12081+.4167!V15/!!*20.336*~.2347*--},#21,,0
#21,Eqv Floor RESIST' outs'd,F-sqft/Btuh\|\|,\EQUIV-R,2,100,{34!V20+}\$02=C>{12
  !V20+}\$02=S>{.0904!V09!V15!4/!*/!!*.2038*~1.1115*--V15*V03/12*V17*V20+}\,$26
  ,,17
```

Passive Solar

NAME of the solar wall?

Next Question = $02: "What TYPE of solar wall"

Data position = 3

Explanations:

```
+------------------------------------------------------------------------------+
|                                                                              |
|      A NAME is given to each solar wall or group of walls..  If two or more  |
| solar  walls  have  similar  characteristics,  (i.e. aspect ratio, thickness |
| etc.) they can be entered under one name.  The area  of  the  combined  wall |
| will then be the sum of the areas of the individual walls.                   |
|                                                                              |
|      Retrofits chosen by the computer for each solar  wall  will  use  this  |
| name to identify which wall they apply to.                                   |
|                                                                              |
+------------------------------------------------------------------------------+
```

What TYPE of solar wall?

Acceptable Answer(s):
T - Trombe wall
W - Water wall

Default:
T - Trombe wall

Next Question = #04: "AREA of solar wall"

Data position = 4

Explanations:

Only south-facing Trombe walls and Water walls (both vented and unvented) are now available. Of course, the computer always considers direct solar gain through windows. This is done under the WINDOWS option. GREENHOUSES are treated as a separate component, under GREENHOUSES.

A TROMBE WALL is a masonry wall (with or without vents) with glazing completely covering the outside, and a space of several inches between the glass and the wall.

A WATER WALL is a set of containers (usually drums or tubes) of water with glazing completely covering the outside, and a space of several inches between the glass and the containers.

AREA of solar wall?

Minimum = 50 sqft

Maximum = 2000 sqft

Default = 200 sqft

Next question = #05: "ASPECT ratio of solar wall"

Data position = 5

Explanations:

```
+--------------------------------------------------------------------------------+
|                                                                                |
|      This is the AREA of the glazing (in square feet) of  the  solar  wall,   |
| and is the same as the area of the wall itself.                                |
|                                                                                |
+--------------------------------------------------------------------------------+
```

ASPECT ratio of solar wall?

Minimum = 0.25 unitless

Maximum = 10 unitless

Default = 5 unitless

Next question = $08: "Is there NIGHT insulation"

> **IF** $02: "What TYPE of solar wall" **WAS** "Trombe wall" **THEN:**
> **Next question** = #06: "THICKNESS of Trombe wall"

Data position = 6

Explanations:

The ASPECT ratio is the width of the wall divided by the height of the wall. For example, an 8ft high Trombe wall that runs 32ft along the south side of a house has an aspect ratio of 4.

THICKNESS of Trombe wall?

Minimum = 6 inches

Maximum = 24 inches

Default = 18 inches

Next question = $08: "Is there NIGHT insulation"

Data position = 7

Explanations:

This is the THICKNESS (in inches) of the masonry part of the Trombe wall, excluding air space and glazing.

Is there NIGHT insulation?

Acceptable Answer(s):
Y - Yes
N - No

Default:
Y - Yes

Next Question = #09: "R-VALUE of night ins."

IF $08: "Is there NIGHT insulation" **WAS** "No" **THEN:**
Next Question = #07: "R-VALUE of wall"

Data position = 9

Explanations:

> If you have night insulation covering the glazing for 12 night hours answer Yes (Y). If there is no night insulation, answer No (N).
>
> The R-VALUE of the night insulation is the thermal resistance of that insulation alone. To obtain a common value used, press <ctrl-D>

R-VALUE of night ins.?

Minimum = 0 F-sqft/Btuh

Maximum = 24 F-sqft/Btuh

Default = 9 F-sqft/Btuh

Next question = #07: "R-VALUE of wall"

Data position = 10 **—> contains** 1/[Entry]

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|      If you have night insulation covering the glazing for 12  night  hours |
| answer Yes (Y).  If there is no night insulation, answer No (N).       |
|                                                                        |
|      The R-VALUE of the night insulation is the thermal resistance of  that |
| insulation alone.  To obtain a common value used, press <ctrl-D>       |
|                                                                        |
+------------------------------------------------------------------------+
```

R-VALUE of wall?

Minimum = 1 F-sqft/Btuh

Maximum = 50 F-sqft/Btuh

Default = answr(#06)/12+3.189 F-sqft/Btuh

IF $02: "What TYPE of solar wall" **WAS** "Water wall" **THEN:**
Default = 3 F-sqft/Btuh

Legend: #06: THICKNESS of Trombe wall

Next question = #10: "R-VALUE of wall system"

IF $08: "Is there NIGHT insulation" **WAS** "No" **THEN:**
Next question = #16: "R-VALUE of wall system"

Data position = 16 **—> contains** 1/[Entry]

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|      The R-VALUE of the wall is the thermal resistance of the wall only. |
| It does not include the night INSULATION.                              |
|                                                                        |
|      The default R-VALUE is calculated using your answers to previous |
| questions.                                                             |
|                                                                        |
+------------------------------------------------------------------------+
```

R-VALUE of wall system?

Minimum = 1 F-sqft/Btuh

Maximum = 50 F-sqft/Btuh

Default = answr(#09)/2+answr(#07) F-sqft/Btuh

Legend: #09: R-VALUE of night ins.
#07: R-VALUE of wall

Next question = $11: "Is there a GROUND reflector"

Data position = 8 —> **contains** 1/[Entry]

Explanations:

The R-VALUE of the WALL SYSTEM is the thermal resistance of the complete wall (from air inside to air outside), including the night INSULATION.

The default R-VALUE is calculated using your answers to previous questions.

R-VALUE of wall system?

(Not asked explicitely)

Minimum = 1 F-sqft/Btuh

Maximum = 50 F-sqft/Btuh

Default = answr(#07) F-sqft/Btuh

Legend: #07: R-VALUE of wall

Next question = $11: "Is there a GROUND reflector"

Data position = 8 —> **contains** 1/[Entry]

Explanations:

The R-VALUE of the WALL SYSTEM is the thermal resistance of the complete wall (from air inside to air outside), including the night INSULATION.

The default R-VALUE is calculated using your answers to previous questions.

Is there a GROUND reflector?

Acceptable Answer(s):

Y - Yes
N - No

Default:

N - No

Next Question = #12: "REFLECTANCE of grd. reflector"

IF $11: "Is there a GROUND reflector" **WAS** "No" **THEN:**
Next Question = #13: "Overhang PROTRUSION"

Data position = 12

Explanations:

If you use a ground reflector to increase the intensity of solar radiation, answer Yes (Y). The ground reflector should be the same size and shape as the wall and should be placed on the ground with one edge at the base of the wall.

REFLECTANCE of grd. reflector?

Minimum = 50 %

Maximum = 100 %

Default = 80 %

Next question = #13: "Overhang PROTRUSION"

Data position = 13 —> **contains** Entry*.01

Explanations:

In order to have an appreciable effect, the ground reflector should have a reflectance much higher than that of the ground alone. Press <ctrl-D> for a default value.

Overhang PROTRUSION?

Minimum = 0 inches

Maximum = 100 inches

Default = 24 inches

Next question = #14: "HEIGHT above top of wall"

IF #13: "Overhang PROTRUSION" **WAS** "0 inches" **THEN:**
Next question = #15: "Specific LEAKAGE AREA"

Data position = 14 **—> contains** Entry/12

Explanations:

The solar wall OVERHANG is any protrusion above the wall, such as an awning, a balcony or the roof itself.

The OVERHANG PROTRUSION is the distance that the tip of the overhang extends out beyond the plane of the wall glazing. Enter zero if there is no overhang.

The HEIGHT is the height of the tip of the overhang above the top of the solar wall.

HEIGHT above top of wall?

Minimum = 0 inches

Maximum = 30 inches

Default = 0 inches

Next question = #15: "Specific LEAKAGE AREA"

Data position = 15 —> **contains** Entry/12

Explanations:

The solar wall OVERHANG is any protrusion above the wall, such as an awning, a balcony or the roof itself.

The OVERHANG PROTRUSION is the distance that the tip of the overhang extends out beyond the plane of the wall glazing. Enter zero if there is no overhang.

The HEIGHT is the height of the tip of the overhang above the top of the solar wall.

Specific LEAKAGE AREA?

Minimum = 0 sqin/sqft

Maximum = 10 sqin/sqft

Default = .1 sqin/sqft

Next question = $26: "Which menu ITEM(S)"

Data position = 11 —> **contains** Entry*6.4516

Explanations:

The LEAKAGE AREA is roughly the area of the single hole which leaks air at the same rate as all the leaks in the solar wall put together.

The SPECIFIC LEAKAGE AREA is the leakage area, divided by the wall area. If you want to know more about leakage area, press <ctrl-H> when you are asked about leakage area in the INFILTRATION section.

PASSIVE-.INF

```
$01,NAME of the solar wall,\NAME,,,$02,,3,\\,\\
$02,What TYPE of solar wall,\TYPE,TW,T,#04,,4,\TTrombe wall\WWater wall\,\\
#04,AREA of solar wall,sqft\,\AREA,50,2000,200,#05,,5
#05,ASPECT ratio of solar wall,unitless\,\ASPECT,0.25,10,5,$08\$02=T>#06\,,6
#06,THICKNESS of Trombe wall,inches\,\THICK,6,24,18,$08,,7
$08,Is there NIGHT insulation,\NIGHT,YN,Y,#09\$08=N>#07\,,9,\YYes\NNo\,\\
#09,R-VALUE of night ins.,F-sqft/Btuh\|\|,\NIGHT,0,24,9,#07,,10
#07,R-VALUE of wall,F-sqft/Btuh\|\|,\RVALUE,1,50,{V06!12/3.189+}\$02=W>3\,#10\$
  08=N>#16\,,16
#10,R-VALUE of wall system,F-sqft/Btuh\|\|,\TOTRVALUE,1,50,{V09!2/V07+},$11,,8
#16G,R-VALUE of wall system,F-sqft/Btuh\|\|,\TOTRVALUE,1,50,{V07!},$11,,8
$11,Is there a GROUND reflector,\GROUND,YN,N,#12\$11=N>#13\,,12,\YYes\NNo\,\\
#12,REFLECTANCE of grd. reflector,%\.01*\.01/,\REFLEC,50,100,80,#13,,13
#13,Overhang PROTRUSION,inches\12/\12*,\OVERHANG,0,100,24,#14\#13=0>#15\,,14
#14,HEIGHT above top of wall,inches\12/\12*,\OVERHANG,0,30,0,#15,,15
#15,Specific LEAKAGE AREA,sqin/sqft\6.4516*\6.4516/,\LEAK,0,10,.1,$26,,11
```

NAME of the greenhouse?

Next Question = $02: "South COVER type"

Data position = 3

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|     A NAME is given to each greenhouse.  Any word is fine.             |
|                                                                        |
+------------------------------------------------------------------------+
```

South COVER type?

Acceptable Answer(s) and Associated [Value(s)]:

S - Single pane	[0.909]
D - Double pane	[1.724]
T - Triple pane	[2.564]

Default:

D - Double pane [1.724]

Next Question = #03: "TILT of the south glazing"

Data position = 4

Explanations:

The COVER TYPE is the kind of glazing there is on the greenhouse during the day, e.g. single pane. For a list of types, press <ctrl-L>

TILT of the south glazing?

Minimum = 30 degrees

Maximum = 90 degrees

Default = 90 degrees

Next question = #04: "AREA of the south glazing"

Data position = 6 —> **contains** Entry*.01745

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|  ---------+                               The TILT of the CEILING is the |
|           |    +                          angle, in degrees, which the |
|           |     _C___+                    ceiling makes with the horizontal, |
|           |          +                    angle C in the figure.       |
|           |           +                                                |
|   HOUSE   |             +                The TILT of the SOUTH glazing is |
|           |               +               the angle, in degrees, which the |
|           |              S  +             glass makes with the horizontal, |
|  ---------------------------------+      angle S in the figure.       |
|              GREENHOUSE                                                |
|                                                                        |
|                                                                        |
+------------------------------------------------------------------------+
```

AREA of the south glazing?

Minimum = 50 sqft

Maximum = 5000 sqft

Default = 200 sqft

Next question = $05: "Ceiling COVER type"

Data position = 7

Explanations:

```
+--------------------------------------------------------------------------+
|                                                                          |
|      The AREA of any glazing is its  length  times  its  breadth,  measured |
| along the slant if the glazing is sloping.                               |
|                                                                          |
+--------------------------------------------------------------------------+
```

Ceiling COVER type?

Acceptable Answer(s) and Associated [Value(s)]:

U - Uninsulated wall	[4.60]	
I - Insulated wall	[14.60]	
S - Single pane	[0.909]	
D - Double pane	[1.724]	
T - Triple pane	[2.564]	

Default:

D - Double pane [1.724]

Next Question = #06: "TILT of the ceiling"

Data position = 12

Explanations:

The COVER TYPE is the kind of glazing there is on the greenhouse during the day, e.g. single pane. For a list of types, press <ctrl-L>

TILT of the ceiling?

Minimum = 0 degrees

Maximum = 60 degrees

Default = 20 degrees

Next question = #07: "AREA of the ceiling"

Data position = 13 —> **contains** Entry*.01745

Explanations:

```
+-----------------------------------------------------------------------------+
|                                                                             |
|  ---------+                     The  TILT  of the CEILING  is  the          |
|           |     +               angle,  in   degrees,  which   the          |
|           |      _C__+          ceiling makes with the horizontal,          |
|           |           +         angle C in the figure.                      |
|           |            +                                                    |
|  HOUSE    |             +      The TILT of the SOUTH glazing  is           |
|           |              +     the angle, in  degrees, which the           |
|           |            S  +     glass  makes with the horizontal,           |
|  ------------------------------+ angle S in the figure.                      |
|             GREENHOUSE                                                      |
|                                                                             |
+-----------------------------------------------------------------------------+
```

AREA of the ceiling?

Minimum = 50 sqft

Maximum = 5000 sqft

Default = answr(#04)/2 sqft

Legend: #04: AREA of the south glazing

Next question = $08: "End walls COVER type"

Data position = 14

Explanations:

```
+------------------------------------------------------------------------------+
|                                                                              |
|      The AREA of any glazing is its  length  times  its  breadth,  measured |
| along the slant if the glazing is sloping.                                   |
|                                                                              |
+------------------------------------------------------------------------------+
```

End walls COVER type?

Acceptable Answer(s) and Associated [Value(s)]:

U	Uninsulated wall	[4.60]
I	Insulated wall	[14.60]
S	Single pane	[0.909]
D	Double pane	[1.724]
T	Triple pane	[2.564]

Default:

D - Double pane [1.724]

Next Question = #09: "End wall AREA (each)"

Data position = 15

Explanations:

The greenhouse has three walls: one shared with the house - the INTERIOR wall; two are exposed - the END walls.

The COVER type is what kind of wall the END WALL is, e.g. insulated wall, or single pane glass. For a list of covers, press <ctrl-L>

The END WALL AREA is the length times the height of one END WALL (not both).

End wall AREA (each)?

Minimum = 20 sqft

Maximum = 2000 sqft

Default = [answr(#07)/answr(#04)]*64 sqft

Legend: #07: AREA of the ceiling
#04: AREA of the south glazing

Next question = $10: "Interior wall TYPE"

Data position = 16

Explanations:

The greenhouse has three walls: one shared with the house - the INTERIOR wall; two are exposed - the END walls.

The COVER type is what kind of wall the END WALL is, e.g. insulated wall, or single pane glass. For a list of covers, press <ctrl-L>

The END WALL AREA is the length times the height of one END WALL (not both).

Interior wall TYPE?

Acceptable Answer(s):

T - Trombe wall
W - Water storage wall
O - Other

Default:

T - Trombe wall

Next Question = #11: "Interior wall AREA"

Data position = 17

Explanations:

The greenhouse has three walls: one shared with the house - the INTERIOR wall; two are exposed - the END walls.

The INTERIOR WALL TYPE is the kind of shared wall you have, e.g. two-by-four wood frame or solid brick. To obtain a list of available wall types, press <ctrl-L>

The INTERIOR WALL AREA is the length times the height of the shared wall.

The INTERIOR WALL R-VALUE is the thermal resistance of the shared wall. To obtain a default value based on your previous answers, press <ctrl-D>

NOTE: The INTERIOR WALL should NOT be entered with all other walls in the WALLS section. If you do, it will be counted twice.

Interior wall AREA?

Minimum = 50 sqft

Maximum = 5000 sqft

Default = answr(#04) sqft

Legend: #04: AREA of the south glazing

Next question = #12: "Interior wall R-VALUE"

Data position = 5

Explanations:

The greenhouse has three walls: one shared with the house - the INTERIOR wall; two are exposed - the END walls.

The INTERIOR WALL TYPE is the kind of shared wall you have, e.g. two-by-four wood frame or solid brick. To obtain a list of available wall types, press <ctrl-L>

The INTERIOR WALL AREA is the length times the height of the shared wall.

The INTERIOR WALL R-VALUE is the thermal resistance of the shared wall. To obtain a default value based on your previous answers, press <ctrl-D>

NOTE: The INTERIOR WALL should NOT be entered with all other walls in the WALLS section. If you do, it will be counted twice.

Interior wall R-VALUE?

Minimum = 1 F-sqft/Btuh

Maximum = 30 F-sqft/Btuh

Default = 4.69 F-sqft/Btuh

IF $10: "Interior wall TYPE" **WAS** "Water storage wall" **THEN:**
Default = 7.5 F-sqft/Btuh

Next question = #13: "R-VALUE of night ins."

Data position = 8 —> **contains** 1/[Entry]

Explanations:

The greenhouse has three walls: one shared with the house - the INTERIOR wall; two are exposed - the END walls.

The INTERIOR WALL TYPE is the kind of shared wall you have, e.g. two-by-four wood frame or solid brick. To obtain a list of available wall types, press <ctrl-L>

The INTERIOR WALL AREA is the length times the height of the shared wall.

The INTERIOR WALL R-VALUE is the thermal resistance of the shared wall. To obtain a default value based on your previous answers, press <ctrl-D>

NOTE: The INTERIOR WALL should NOT be entered with all other walls in the WALLS section. If you do, it will be counted twice.

R-VALUE of night ins.?

Minimum = 0 F-sqft/Btuh

Maximum = 20 F-sqft/Btuh

Default = 10 F-sqft/Btuh

Next question = #14: "Overall greenhouse R-VALUE"

Data position = 9 **—> contains** 1/[Entry]

Explanations:

The R-VALUE of the night insulation is the thermal resistance of the insulation placed on the greenhouse glazing at night.

To obtain a default value, press <ctrl-D>

Overall greenhouse R-VALUE?

Minimum = 4 F-sqft/Btuh

Maximum = 40 F-sqft/Btuh

Default = {1/[answr(#04)/[answr(#13)*.67+value($02)]+answr(#07)/{answr(#13)*.67 +value($05)}+answr(#09)/(answr(#13)*.67+value($08))]+answr(#12) /answr(#11)}*answr(#11) F-sqft/Btuh

Legend:
- $02: South COVER type
- #04: AREA of the south glazing
- #13: R-VALUE of night ins.
- #07: AREA of the ceiling
- $05: Ceiling COVER type
- $08: End walls COVER type
- #09: End wall AREA (each)
- #12: Interior wall R-VALUE
- #11: Interior wall AREA

Next question = #15: "Specific LEAKAGE AREA"

Data position = 10 —> **contains** 1/[Entry]

Explanations:

The OVERALL GREENHOUSE R-VALUE is the thermal resistance from inside the house, through the greenhouse to the outside. It is a composite of the R-values of the shared wall, the day and night glazing, and the end-wall. To have the computer carry out the calculation for you, press <ctrl-D>

Specific LEAKAGE AREA?

Minimum = 0 sqin/sqft

Maximum = 10 sqin/sqft

Default = .1 sqin/sqft

Next question = $26: "Which menu ITEM(S)"

Data position = 11 **—> contains** Entry*6.4516

Explanations:

```
+---------------------------------------------------------------------------+
|                                                                           |
|      The leakage area of a greenhouse is roughly the area of a single hole |
| which would leak air at the same rate as all the cracks in the greenhouse |
| put together.                                                             |
|                                                                           |
|      The SPECIFIC LEAKAGE AREA is the leakage area divided by the floor  |
| area of the greenhouse. It can be measured as explained in the INFILTRATION|
| section, or you can use the default value by pressing <ctrl-D>.          |
|                                                                           |
+---------------------------------------------------------------------------+
```

```
$01,NAME of the greenhouse,\NAME,,,$02,,3,\\,\\
$02,South COVER type,\COVER,SDT,D,#03,,4,\SSingle pane\DDouble pane\TTriple pan
  e\,S0.909\D1.724\T2.564\
#03,TILT of the south glazing,degrees\.01745*\.01745/,\TILT,30,90,90,#04,,6
#04,AREA of the south glazing,sqft\,\AREA,50,5000,200,$05,,7
$05,Ceiling COVER type,\COVER,UISDT,D,#06,,12,\UUninsulated wall\IInsulated wal
  l\SSingle pane\DDouble pane\TTriple pane\,\U4.60\I14.60\S0.909\D1.724\T2.564\
#06,TILT of the ceiling,degrees\.01745*\.01745/,\TILT,0,60,20,#07,,13
#07,AREA of the ceiling,sqft\,\AREA,50,5000,{V04!2/},$08,,14
$08,End walls COVER type,\ENDW,UISDT,D,#09,,15,\UUninsulated wall\IInsulated wa
  ll\SSingle pane\DDouble pane\TTriple pane\,\U4.60\I14.60\S0.909\D1.724\T2.564\
#09,End wall AREA (each),sqft\,\ENDW,20,2000,{V07!V04/64*},$10,,16
$10,Interior wall TYPE,\SHARE,TWO,T,#11,,17,\TTrombe wall\WWater storage wall\O
  Other\,\\
#11,Interior wall AREA,sqft\,\SHARE,50,5000,{V04!},#12,,5
#12,Interior wall R-VALUE,F-sqft/Btuh\|\|,\SHARE,1,30,4.69\$10=W>7.5\,#13,,8
#13,R-VALUE of night ins.,F-sqft/Btuh\|\|,\NIGHTR,0,20,10,#14,,9
#14,Overall greenhouse R-VALUE,F-sqft/Btuh\|\|,\WALLR,4,40,{V04!V13!.67*T02+/V0
  7!V13!.67*T05+/+V09!V13!.67*T08+/+|V12!V11/+V11*},#15,,10
#15,Specific LEAKAGE AREA,sqin/sqft\6.4516*\6.4516/,\LEAK,0,10,.1,$26,,11
```

Active Solar

Solar Collector NAME?

(Not asked explicitely)

Default:

Flat Plate

Next Question = $02: "USE of the collector"

Data position = 3

Explanations:

```
+--------------------------------------------------------------------+
|                                                                    |
|      This is given by a default.                                   |
|                                                                    |
+--------------------------------------------------------------------+
```

USE of the collector?

Acceptable Answer(s):

S - Space Heating Only
W - Water Heating Only
B - Both: Space and Water

Default:

W - Water Heating Only

Next Question = #03: "What is the ORIENTATION"

Data position = 4

Explanations:

An active solar system can provide space heating or domestic hot water heating or both. Domestic water heating requires less collector area than space heating and can be used all year; a space heating system usually provides both space heat and hot water.

What is the ORIENTATION?

Minimum = 0 degrees

Maximum = 360 degrees

Default = 180 degrees

Next question = #04: "SLOPE of the collector"

Data position = 5 —> **contains** Entry*.01745

Explanations:

The optimal ORIENTATION for solar collectors is south. If a roof surface of your house does not face directly south, collectors may have to be mounted in some other direction. While you can put in any collector orientation (N,W,E, or S), collectors should not be oriented more than about 45 degrees from true south. The ORIENTATION is defined as shown in the diagram; South is 180 degrees.

```
              N = 0

      W = 270         E = 90

              S = 180
```

SLOPE of the collector?

Minimum = 0 degrees

Maximum = 90 degrees

Default = 45 degrees

Next question = #05: "Average Winter EXPOSURE"

Data position = 6 —> **contains** Entry*.01745

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|      Collector SLOPE is the angle the collectors make  to  the  horizontal. |
| Roof-mounted  collectors  should  have  the  same  slope  as the roof; rack- |
| mounted collectors will have some slope between 0 and  90  degrees.  For  a |
| domestic hot water system, the optimal slope is equal to your latitude.  For |
| a space heating system, the best slope is your latitude plus 15 degrees.    |
|                                                                        |
|                                +                                       |
|                                  +                                     |
|                              Slope +                                   |
|      Horizontal   -----------------+                                   |
|                                                                        |
+------------------------------------------------------------------------+
```

Average Winter EXPOSURE?

Minimum = 10 %

Maximum = 100 %

Default = 90 %

Next question = $06: "What Kind of SYSTEM"

Data position = 7 —> **contains** Entry*.01

Explanations:

Average EXPOSURE is the percentage of total possible solar radiation that reaches the collectors through any visual obstacles, such as trees, nearby buildings, or hills. Solar exposure is usually measured with a "solar siting meter," a dome-shaped device that projects the view in any direction on a horizontal surface, with an acetate overlay with curves of the sun's path during different seasons. The curves are divided into sectors which receive 10% of the daily solar energy. So if three sectors are covered by surrounding trees and hills, the solar exposure will be 70%. Solar exposure will always be least in the winter (when the sun is lowest in the sky).

What Kind of SYSTEM?

Acceptable Answer(s):

L - Liquid System
A - Air System

IF $02: "USE of the collector" **WAS** "Water Heating Only" **OR** "Both: Space and Water" **THEN:**

L - Liquid System

Default:

L - Liquid System

Next Question = $07: "GLAZING"

Data position = 8

Explanations:

The kind of SYSTEM is the type of fluid that flows through the solar collectors. A liquid SYSTEM uses water or antifreeze mix; an air SYSTEM uses air. In most cases, the distribution fluid will be the same as the collector fluid, although some systems use a heat exchanger or fan coil to transfer heat from one fluid to another.

GLAZING?

Acceptable Answer(s):

S - Single cover
D - Double cover
T - Triple cover

Default:

S - Single cover

Next Question = #08: "Average glazing TRANSMITTANCE"

Data position = 9

Explanations:

Solar collectors are almost always covered with some type of GLAZING. In most climates, the collector has only one layer of glazing. In cold climates, there may be two or more.

Average glazing TRANSMITTANCE?

Minimum = 20 %

Maximum = 100 %

Default = 90 %

IF $07: "GLAZING" **WAS** "Double cover" **THEN:**
Default = 80 %

IF $07: "GLAZING" **WAS** "Triple cover" **THEN:**
Default = 70 %

Next question = #09: "Average glazing ABSORPTANCE"

Data position = 10 —> **contains** Entry*.01

Explanations:

```
+----------------------------------------------------------------------------+
|                                                                            |
|      Glazing TRANSMITTANCE is the amount of solar  radiation  striking  the |
| collector cover that actually passes through to be absorbed by the collector |
| fluid.  If you do not know  the  TRANSMITTANCE  of  your  collectors,  press |
| <ctrl-D>  and  the  computer  will  give you a result based on your previous |
| answers.                                                                   |
|                                                                            |
+----------------------------------------------------------------------------+
```

Average glazing ABSORPTANCE?

Minimum = 80 %

Maximum = 100 %

Default = 95 %

Next question = #10: "Average diffuse REFLECTANCE"

Data position = 11 —> **contains** Entry*.01

Explanations:

ABSORPTANCE is the percentage of the solar radiation striking the collector absorber surface that is actually absorbed. A typical value is 95%.

If you do not know the value for your collector, press <ctrl-D> to obtain a default value.

Average diffuse REFLECTANCE?

Minimum = 10 %

Maximum = 40 %

Default = 16 %

IF $07: "GLAZING" **WAS** "Double cover" **THEN:**
Default = 24 %

IF $07: "GLAZING" **WAS** "Triple cover" **THEN:**
Default = 29 %

Next question = $11: "Fluid CIRCULATION type"

Data position = 12 —> **contains** Entry*.01

Explanations:

Diffuse REFLECTANCE is the percentage of solar radiation that is reflected by the collector absorber surface and by the underside of the collector cover(s).

If you do not know the value for your system, press <ctrl-D> and the computer will give you a default value.

Fluid CIRCULATION type?

Acceptable Answer(s) and Associated [Value(s)]:

F - Forced	[2]
N - Natural	[0]

Default:

F - Forced [2]

Next Question = #13: "Collector EFFICIENCY Factor"

Data position = 13

Explanations:

Water CIRCULATION describes the way in which the collector fluid circulates through the collector into the storage tank. If pumps circulate the fluid, the circulation is FORCED. A thermosiphoning system (without pumps) uses NATURAL circulation.

Collector EFFICIENCY Factor?

Minimum = 50 %

Maximum = 100 %

Default = 91+value($11) %

IF $07: "GLAZING" **WAS** "Double cover" **THEN:**
Default = 93+value($11) %

IF $07: "GLAZING" **WAS** "Triple cover" **THEN:**
Default = 95+value($11) %

Legend: $11: Fluid CIRCULATION type

Next question = #14: "Collector LOSS Coeff."

Data position = 14 —> **contains** Entry*.01

Explanations:

The collector EFFICIENCY factor is the fraction of solar radiation falling upon the collector absorber surface that is converted into useful heat. (The total system efficiency is the product of this factor and the absorptance, transmittance, and reflectance.)

If you do not know this value for your system press <ctrl-D> and the computer will calculate a value based on your previous answers.

Collector LOSS Coeff.?

Minimum = .1 Btu/h.sqft.F

Maximum = 3 Btu/h.sqft.F

Default = 1.4 Btu/h.sqft.F

IF $07: "GLAZING" **WAS** "Double cover" **THEN:**
Default = .7 Btu/h.sqft.F

IF $07: "GLAZING" **WAS** "Triple cover" **THEN:**
Default = .35 Btu/h.sqft.F

Next question = #15: "Collector AREA"

Data position = 15

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|       The collector LOSS coefficient is how much heat is lost back through |
| the collector glazing during normal operation because the absorber surface |
| is at a higher temperature than the outside air. This type of heat loss is |
| due to conduction and radiation through the collector cover.           |
|                                                                        |
|       If you do not know this value for your system, press <ctrl-D> and the |
| computer will calculate an estimate for you, based on your previous answers. |
|                                                                        |
+------------------------------------------------------------------------+
```

Collector AREA?

Minimum = 10 sqft

Maximum = 1000 sqft

Default = 60 sqft

Next question = #16: "Water STORAGE Capacity"

IF $06: "What Kind of SYSTEM" **WAS** "Air System" **THEN:**
Next question = #17: "Collector Air FLOWRATE"

Data position = 16

Explanations:

The AREA is the glazed area only; exclude framing. A typical solar panel has an area of roughly 25 to 35 square feet, or one square meter.

Water STORAGE Capacity?

Minimum = 10 gal

Maximum = 7000 gal

Default = answr(#15)*1.85 gal

Legend: #15: Collector AREA

Next question = $26: "Which menu ITEM(S)"

Data position = 17

Explanations:

Water STORAGE capacity is the size of the storage tank that stores heat captured by the solar collectors. Domestic hot water systems typically have about 80 gallons of storage capacity (roughly 1.3 gallons per square foot of collector area). Space heating system storage capacity is usually a function of building heat load and local average insolation conditions.

Collector Air FLOWRATE?

Minimum = 1 cfm/sqft

Maximum = 4 cfm/sqft

Default = 2 cfm/sqft

Next question = $26: "Which menu ITEM(S)"

Data position = 17

Explanations:

```
+-----------------------------------------------------------------------------+
|                                                                             |
|      The AIR FLOWRATE is the rate at which air flows through  your  system, |
| with the fans on if it is a forced air system.                              |
|                                                                             |
+-----------------------------------------------------------------------------+
```

ACTIVE-S.INF

```
$01G,Solar Collector NAME,\NAME,,Flat Plate,$02,,3,\\,\\
$02,USE of the collector,\USE,SWB,W,#03,,4,\SSpace Heating Only\WWater Heating
  Only\BBoth: Space and Water\,\\
#03,What is the ORIENTATION,degrees\.01745*\.01745/,\ORIENT,0,360,180,#04,,5
#04,SLOPE of the collector,degrees\.01745*\.01745/,\SLOPE,0,90,45,#05,,6
#05,Average Winter EXPOSURE,%\.01*\.01/,\EXPOS,10,100,90,$06,,7
$06,What Kind of SYSTEM,\SYSTEM,LA\$02=WB>L\,L,$07,,8,\AAir System\LLiquid Syst
  em\,\\
$07,GLAZING,\GLASS,SDT,S,#08,,9,\SSingle cover\DDouble cover\TTriple cover\,\\
#08,Average glazing TRANSMITTANCE,%\.01*\.01/,\TRANS,20,100,90\$07=D>80\$07=T>7
  0\,#09,,10
#09,Average glazing ABSORPTANCE,%\.01*\.01/,\ABSORP,80,100,95,#10,,11
#10,Average diffuse REFLECTANCE,%\.01*\.01/,\REFLEC,10,40,16\$07=D>24\$07=T>29\
  ,$11,,12
$11,Fluid CIRCULATION type,\CIRCUL,FN,F,#13,,13,\FForced\NNatural\,\F2\N0\
#13,Collector EFFICIENCY Factor,%\.01*\.01/,\EFFIC,50,100,{91!T11+}\$07=D>{93!T
  11+}\$07=T>{95!T11+}\,#14,,14
#14,Collector LOSS Coeff.,Btu/h-sqft-F\,\LOSS,.1,3,1.4\$07=D>.7\$07=T>.35\,#15,
  ,15
#15,Collector AREA,sqft\,\AREA,10,1000,60,#16\$06=A>#17\,,16
#16,Water STORAGE Capacity,gal\,\STORE,10,7000,{V15!1.85*},$26,,17
#17,Collector Air FLOWRATE,cfm/sqft\,\FLOW,1,4,2,$26,,17
```

HVAC System

NAME for HVAC system?

(Not asked explicitely)

Default:

Heat-Cool

Next Question = $02: "What HEATING EQUIPMENT"

Data position = 3

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|      This is now given by a default.                                   |
|                                                                        |
+------------------------------------------------------------------------+
```

What HEATING EQUIPMENT?

Acceptable Answer(s):

G - Gas Furnace
L - Gas Boiler
F - Oil Furnace
B - Oil Boiler
H - Heat Pump
U - Unit Gas Heater(s)
E - Electric furnace
R - Electric Baseboard
S - Stove(s)
W - Wood Burning equipment
N - None

Default:

G - Gas Furnace

Next Question = #03: "Rated INPUT capacity"

IF $02: "What HEATING EQUIPMENT" **WAS** "Heat Pump" **THEN:**
Next Question = #04: "Rated OUTPUT capacity"

IF $02: "What HEATING EQUIPMENT" **WAS** "None" **THEN:**
Next Question = $10: "What COOLING EQUIPMENT"

Data position = 4

Explanations:

HEATING EQUIPMENT heats the house. Usually it is a furnace, a boiler or a heat pump. Sometimes, heating is achieved by localized equipment, such as UNIT HEATERS (also called Wall Heaters) or WOOD BURNING STOVES. Press <ctrl L>-ist for a list of heating equipment types.

Rated INPUT capacity?

Minimum = 20 kBtu/hr

Maximum = 300 kBtu/hr

Default = 100 kBtu/hr

Next question = #05: "Steady-state EFFICIENCY"

Data position = 5 —> **contains** Entry*1000

Explanations:

The Rated INPUT Capacity is the amount of fuel that the heating equipment burns in an hour in thousands of British Thermal Units per hour (kBtu/hr) This number is usually found on a label on the unit; if there are two numbers, (e.g. 100,000 and 80,000), use the HIGHER one, and divide it by 1,000. (In this case you would enter 100.)

Some heating units, such as Heat Pumps, are rated by their OUTPUT Capacity. This number is found on the manufacturer's label. If there are two numbers in a similar range around 100,000 Btu/hr, use the HIGHER one, and divide it by 1,000.

Rated OUTPUT capacity?

Minimum = 20 kBtu/hr

Maximum = 300 kBtu/hr

Default = 100 kBtu/hr

Next question = #05: "Steady-state EFFICIENCY"

Data position = 5 —> **contains** Entry*1000

Explanations:

The Rated INPUT Capacity is the amount of fuel that the heating equipment burns in an hour in thousands of British Thermal Units per hour (kBtu/hr) This number is usually found on a label on the unit; if there are two numbers, (e.g. 100,000 and 80,000), use the HIGHER one, and divide it by 1,000. (In this case you would enter 100.)

Some heating units, such as Heat Pumps, are rated by their OUTPUT Capacity. This number is found on the manufacturer's label. If there are two numbers in a similar range around 100,000 Btu/hr, use the HIGHER one, and divide it by 1,000.

Steady-state EFFICIENCY?

Minimum = 30 %

IF $02: "What HEATING EQUIPMENT" **WAS** "Heat Pump" **THEN:**
Minimum = 80 %

Maximum = 100 %

IF $02: "What HEATING EQUIPMENT" **WAS** "Heat Pump" **THEN:**
Maximum = 400 %

Default = 75 %

IF $02: "What HEATING EQUIPMENT" **WAS** "Heat Pump" **THEN:**
Default = 200 %

IF $02: "What HEATING EQUIPMENT" **WAS** "Wood Burning equipment" **THEN:**
Default = 20 %

IF $02: "What HEATING EQUIPMENT" **WAS** "Electric furnace"
OR "Electric Baseboard" **THEN:**
Default = 100 %

Next question = #15: "FLUE gas temperature"

IF $02: "What HEATING EQUIPMENT" **WAS** "Heat Pump"
OR "Electric furnace"
OR "Electric Baseboard" **THEN:**
Next question = $06: "What DISTRIBUTION system"

Data position = 6 —> **contains** Entry*.01

Explanations:

The Steady-State EFFICIENCY is the heat output divided by the total fuel burned, times 100. Heat output is defined as what leaves the furnace, not what reaches the living space. Efficiency is measured using Fyrite liquid, or by the Orsat method, or using electronic equipment.

If you don't have such equipment, the Steady-State EFFICIENCY can be read off the manufacturer's label.

If EFFICIENCY isn't listed, two numbers usually are: INPUT capacity and OUTPUT (or BONNET) capacity. Divide the smaller number (the OUTPUT) by the larger one, and multiply by 100. The result should be between 60% and 90%.

For HEAT PUMPS, divide the larger number by the smaller one, and multiply by 100. The result may be as high as 400%.

As a last resort, use the default by pressing <ctrl-D>

FLUE gas temperature?

Minimum = 75 degF

Maximum = 600 degF

Default = 250 degF

Next question = $06: "What DISTRIBUTION system"

Data position = 16

Explanations:

```
+--------------------------------------------------------------------------+
|                                                                          |
|      The FLUE gas temperature is measured with a thermometer probe inserted |
| in  a  small hole in the flue (tape it over when you've finished).  If there |
| is a draft hood, drill the hole in a place where the flue is exposed.  This |
| temperature  is  used to decide on installing a heat recovery device.  Press |
| <ctrl-D> if you can't do the measurement.                                |
|                                                                          |
+--------------------------------------------------------------------------+
```

What DISTRIBUTION system?

Acceptable Answer(s) and Associated [Value(s)]:

```
G - Gravity air                   [1.0]
R - In Room                       [1.0]

IF $02: "What HEATING EQUIPMENT" WAS "Gas Furnace"
                                  OR "Oil Furnace"
                                  OR "Electric furnace" THEN:
     F - Forced Air                    [1.0]
     G - Gravity air                   [1.0]

IF $02: "What HEATING EQUIPMENT" WAS "Gas Boiler"
                                  OR "Oil Boiler" THEN:
     S - Steam                         [0.5]
     W - Water                         [0.5]

IF $02: "What HEATING EQUIPMENT" WAS "Heat Pump" THEN:
     F - Forced Air                    [1.0]
     W - Water                         [0.5]

IF $02: "What HEATING EQUIPMENT" WAS "None" THEN:
     F - Forced Air                    [1.0]
     R - In Room                       [1.0]
```

Default:

```
F - Forced Air                    [1.0]

IF $02: "What HEATING EQUIPMENT" WAS "Gas Boiler"
                                  OR "Oil Boiler" THEN:
     W - Water                         [0.5]

IF $02: "What HEATING EQUIPMENT" WAS "Unit Gas Heater(s)"
                                  OR "Electric Baseboard"
                                  OR "Stove(s)"
                                  OR "Wood Burning equipment" THEN:
     R - In Room                       [1.0]
```

Next Question = $07: "WHERE are pipes or ducts"

```
IF $06: "What DISTRIBUTION system" WAS "Gravity air"
                                    OR "In Room" THEN:
     Next Question = #09: "Distribution LOSSES to outside"
```

Data position = 7

Explanations:

The DISTRIBUTION System transfers heat or "coolth" from the heating plant or air conditioner to the living space.

Often, the distribution system will be Forced Air (i.e.fans and ducts). With oil boilers, it will usually be a Steam- or Water-based system. Older heating installations, wood-burning equipment, and unit heaters often rely on Gravity to distribute the hot air.

If there is a heating system, the cooling distribution system is assumed to be "In-Room" for room air conditioners, while central air conditioners, heat pumps and evaporative coolers use a forced air distribution system.

WHERE are pipes or ducts?

Acceptable Answer(s) and Associated [Value(s)]:

B - Basement	[0.50]
C - Crawlspace	[0.75]
A - Attic	[0.75]
L - Living Space	[0.10]

Default:

B - Basement	[0.50]

Next Question = $08: "INSULATION on pipes or ducts"

Data position = 8

Explanations:

The DISTRIBUTION system may run either through unheated spaces, such as a basement or crawlspace, or through the heated living space.

WHERE the system runs controls how much of the heat or "coolth" is totally lost, and how much will still contribute indirectly to heating the living space. If registers are in the floor, the ducts may run through the basement or crawlspace. Registers located in the ceiling generally indicate ducts in the attic. Ducts can also run inside of partition walls. First floor radiators or baseboard heaters are generally fed by pipes running through an unheated basement; pipes running to higher floors usually pass through the living space.

INSULATION on pipes or ducts?

Acceptable Answer(s) and Associated [Value(s)]:

N - None	[50.]
O - One inch	[25.]
T - Two inches	[12.5]
R - Three inches	[5.]

Default:

N - None	[50.]

Next Question = #09: "Distribution LOSSES to outside"

IF $08: "INSULATION on pipes or ducts" **WAS** "None" **OR** "One inch" **THEN:**
Next Question = #14: "Insulatable duct/pipe LENGTH"

Data position = 9

Explanations:

The amount of INSULATION on pipes or ducts determines how much heat (or "coolth") is lost to the air around them. For a list of options, press <ctrl-L>

Insulatable duct/pipe LENGTH?

Minimum = 0 feet

Maximum = 500 feet

Default = answr(#03) feet

    IF $02: "What HEATING EQUIPMENT" **WAS** "Heat Pump" **THEN:**
    Default = answr(#04) feet

    IF $02: "What HEATING EQUIPMENT" **WAS** "None" **THEN:**
    Default = 100 feet

    Legend: #03: Rated INPUT capacity
    #04: Rated OUTPUT capacity

Next question = #09: "Distribution LOSSES to outside"

    IF $06: "What DISTRIBUTION system" **WAS** "Gravity air" **THEN:**
    Next question = #16: "Actual Fan FLOW"

Data position = 15

Explanations:

This is the total LENGTH of space heating ducts (or pipes) that can be insulated. Ducts in basements, attics and crawlspaces can generally be insulated. Ducts in partition walls or in floor slabs generally cannot.

Distribution LOSSES to outside?

Minimum = 0 %

Maximum = 90 %

Default = [value($08)*value($06)]*value($07) %

IF $02: "What HEATING EQUIPMENT" **WAS** "Unit Gas Heater(s)"
OR "Electric Baseboard"
OR "Stove(s)"
OR "Wood Burning equipment" **THEN:**
Default = 5 %

IF $06: "What DISTRIBUTION system" **WAS** "Gravity air" **THEN:**
Default = 10 %

IF $06: "What DISTRIBUTION system" **WAS** "In Room" **THEN:**
Default = 5 %

Legend: $08: INSULATION on pipes or ducts
$06: What DISTRIBUTION system
$07: WHERE are pipes or ducts

Next question = $10: "What COOLING EQUIPMENT"

IF $02: "What HEATING EQUIPMENT" **WAS** "None" **THEN:**
Next question = #11: "Rated TOTAL capacity"

Data position = 10 —> **contains** Entry*.01

Explanations:

The Distribution LOSSES to outside are those losses from the distribution system that do not re-enter the living space through indirect paths. The default value for LOSSES obtained by pressing <ctrl-D> are based on the type of heating or cooling system, the location of ducts or pipes, and the amount of insulation they have.

What COOLING EQUIPMENT?

Acceptable Answer(s):

N - None
C - Central Air Conditioning
R - Room Air Conditioning
E - Evaporative Cooler

IF $02: "What HEATING EQUIPMENT" **WAS** "Heat Pump" **THEN:**
N - None
H - Heat Pump

Default:

C - Central Air Conditioning

IF $02: "What HEATING EQUIPMENT" **WAS** "Heat Pump" **THEN:**
H - Heat Pump

Next Question = #11: "Rated TOTAL capacity"

IF $10: "What COOLING EQUIPMENT" **WAS** "None" **THEN:**
Next Question = #16: "Actual Fan FLOW"

IF $10: "What COOLING EQUIPMENT" **WAS** "Evaporative Cooler" **THEN:**
Next Question = #17: "Rated POWER"

IF $02: "What HEATING EQUIPMENT" **WAS** "None" **THEN:**
Next Question = $06: "What DISTRIBUTION system"

Data position = 11

Explanations:

The COOLING EQUIPMENT is usually one central unit, or room air conditioners or a heat pump. In forced air installations, the cooling coil is in the airstream near the fan, and the compressor is in a separate box outdoors.

Rated TOTAL capacity?

Minimum = 3 kBtu/hr

Maximum = 200 kBtu/hr

Default = 24 kBtu/hr

Next question = #13: "Rated SENSIBLE capacity"

IF $10: "What COOLING EQUIPMENT" **WAS** "Evaporative Cooler" **THEN:**
Next question = #12: "Rated COP"

Data position = 12 —> **contains** Entry*1000

Explanations:

The rated TOTAL CAPACITY of an air conditioner is the amount of heat (both sensible and latent) that the unit can remove from the house per hour at ARI rated conditions.

The rated SENSIBLE CAPACITY of an air conditioner is the amount of sensible heat that the unit can remove from the house per hour at ARI rated conditions.

The total capacity is generally listed on a label on the air conditioner. either in Btuh (Btu per hour), MBtuh (thousands of Btus per hour) or tons (one ton = 12,000 Btuh). The sensible capacity may be found from data books, or use the default by pressing <ctrl-D>

For an evaporative cooler, the RATED POWER is the electrical input for which the cooler is rated. It should be on the nameplate, or use the default.

Rated SENSIBLE capacity?

Minimum = 3 kBtu/hr

Maximum = 200 kBtu/hr

Default = answr(#11)*0.7 kBtu/hr

Legend: #11: Rated TOTAL capacity

Next question = #12: "Rated COP"

Data position = 14 —> **contains** Entry*1000

Explanations:

The rated TOTAL CAPACITY of an air conditioner is the amount of heat (both sensible and latent) that the unit can remove from the house per hour at ARI rated conditions.

The rated SENSIBLE CAPACITY of an air conditioner is the amount of sensible heat that the unit can remove from the house per hour at ARI rated conditions.

The total capacity is generally listed on a label on the air conditioner. either in Btuh (Btu per hour), MBtuh (thousands of Btus per hour) or tons (one ton = 12,000 Btuh). The sensible capacity may be found from data books, or use the default by pressing <ctrl-D>

For an evaporative cooler, the RATED POWER is the electrical input for which the cooler is rated. It should be on the nameplate, or use the default.

Rated COP?

Minimum = .5 unitless

Maximum = 4 unitless

Default = 2 unitless

Next question = #16: "Actual Fan FLOW"

Data position = 13

Explanations:

The Rated Coefficient of Performance, or COP, is the ratio of OUTPUT Capacity and INPUT energy, both in the same units. A unit with a COP of 2 removes twice as much heat as it consumes in equivalent units of electrical energy.

Sometimes the label will give an Energy Efficiency Ratio (EER). To obtain the COP, divide the EER by 3.414.

There is no available field measurement for the COP. , Take label information or use the default.

Actual Fan FLOW?

Minimum = 50 cfm

Maximum = 5000 cfm

Default = answr(#11)*50 cfm

IF $10: "What COOLING EQUIPMENT" **WAS** "Evaporative Cooler" **THEN:**
Default = answr(#18) cfm

Legend: #11: Rated TOTAL capacity
#18: Rated FLOW rate

Next question = $26: "Which menu ITEM(S)"

IF $10: "What COOLING EQUIPMENT" **WAS** "Evaporative Cooler" **THEN:**
Next question = #19: "Saturating EFFECTIVENESS"

Data position = 17 **—> contains** Entry*60

Explanations:

The ACTUAL FAN FLOW is the rate at which heated or cooled air is recirculated through the furnace (or air conditioner or heat pump or evaporative cooler), the ducts and the house at normal operating conditions.

The RATED FLOW is the air flow for which the evaporative cooler is rated.

Rated POWER?

Minimum = 100 Watts

Maximum = 1000 Watts

Default = 300 Watts

Next question = #18: "Rated FLOW rate"

Data position = 12 —> **contains** Entry*3.414

Explanations:

The rated TOTAL CAPACITY of an air conditioner is the amount of heat (both sensible and latent) that the unit can remove from the house per hour at ARI rated conditions.

The rated SENSIBLE CAPACITY of an air conditioner is the amount of sensible heat that the unit can remove from the house per hour at ARI rated conditions.

The total capacity is generally listed on a label on the air conditioner. either in Btuh (Btu per hour), MBtuh (thousands of Btus per hour) or tons (one ton = 12,000 Btuh). The sensible capacity may be found from data books, or use the default by pressing <ctrl-D>

For an evaporative cooler, the RATED POWER is the electrical input for which the cooler is rated. It should be on the nameplate, or use the default.

Rated FLOW rate?

Minimum = 500 cfm

Maximum = 6000 cfm

Default = answr(#17)*3.3 cfm

Legend: #17: Rated POWER

Next question = #16: "Actual Fan FLOW"

Data position = 14 —> **contains** Entry*60

Explanations:

The ACTUAL FAN FLOW is the rate at which cooled air is recirculated through the air conditioner (or heat pump or evaporative cooler), the ducts and the house at normal operating conditions.

The RATED FLOW is the air flow for which the evaporative cooler is rated.

Saturating EFFECTIVENESS?

Minimum = 70 %

Maximum = 100 %

Default = [-(exp(log(.15)/{[answr(#16)/answr(#18)]^[.355]})-1)]*100 %

Legend: #16: Actual Fan FLOW
#18: Rated FLOW rate

Next question = $26: "Which menu ITEM(S)"

Data position = 13 —> **contains** Entry*.01

Explanations:

The SATURATING EFFECTIVENESS is a measure of how effectively the evaporative cooler can reduce the air temperature by increasing its humidity. It is a characteristic of the cooler, and may be on the nameplate. Otherwise, use the default by pressing <ctrl-D>.

```
$01G,NAME for HVAC system,\NAME,,Heat-Cool,$02,,3,\\,\\
$02,What HEATING EQUIPMENT,\HEATING,GLFBHUERSWN,G,#03\$02=H>#04\$02=N>$10\,,4
  \GGas Furnace\LGas Boiler\FOil Furnace\BOil Boiler\HHeat Pump\UUnit Gas Heate
  r(s)\EElectric furnace\RElectric Baseboard\SStove(s)\WWood Burning equipment\
  NNone\,\\
#03,Rated INPUT capacity,kBtu/hr\1000*\1000/,\CAPACITY,20,300,100,#05,,5
#04,Rated OUTPUT capacity,kBtu/hr\1000*\1000/,\CAPACITY,20,300,100,#05,,5
#05,Steady-state EFFICIENCY,%\.01*\.01/,\EFFICIENCY,30\$02=H>80\,100\$02=H>400\
  ,75\$02=H>200\$02=W>20\$02=ER>100\,#15\$02=HER>$06\,,6
#15,FLUE gas temperature,degF\,\FLUE,75,600,250,$06,,16
$06,What DISTRIBUTION system,\DISTRIBUTION,GR\$02=GFE>FG\$02=LB>SW\$02=H>FW\$02
  =N>FR\,F\$02=LB>W\$02=URSW>R\,$07\$06=GR>#09\,,7,\FForced Air\SSteam\WWater\G
  Gravity air\RIn Room\,\F1.0\S0.5\W0.5\G1.0\R1.0\
$07,WHERE are pipes or ducts,\LOCATION,BCAL,B,$08,,8,\BBasement\CCrawlspace\AAt
  tic\LLiving Space\,\B0.50\C0.75\A0.75\L0.10\
$08,INSULATION on pipes or ducts,\INSULATION,NOTR,N,#09\$08=NO>#14\,,9,\NNone\O
  One inch\TTwo inches\RThree inches\,\N50.\O25.\T12.5\R5.\
#14,Insulatable duct/pipe LENGTH,feet\,\LENGTH,0,500,{V03!}\$02=H>{V04!}\$02=N>
  100\,#09\$06=G>#16\,,15
#09,Distribution LOSSES to outside,%\.01*\.01/,\LOSSES,0,90,{T08!T06*T07*}\$02=
  URSW>5\$06=G>10\$06=R>5\,$10\$02=N>#11\,,10
$10,What COOLING EQUIPMENT,\COOLING,NCRE\$02=H>NH\,C\$02=H>H\,#11\$10=N>$20\$10
  =E>#17\$02=N>$06\,,11,\NNone\CCentral Air Conditioning\HHeat Pump\RRoom Air C
  onditioning\EEvaporative Cooler\,\\
#11,Rated TOTAL capacity,kBtu/hr\1000*\1000/,\COOL-CAP,3,200,24,#13\$10=E>#12\,
  ,12
#13,Rated SENSIBLE capacity,kBtu/hr\1000*\1000/,\COOL-CAP,3,200,{V11!0.7*},#12,
  ,14
#12,Rated COP,unitless\,\COP,.5,4,2,#16,,13
#16,Actual Fan FLOW,cfm\60*\60/,\FLOW,50,5000,{V11!50*}\$10=E>{V18!}\,$26\$10=E
  >#19\,,17
#17,Rated POWER,Watts\3.414*\3.414/,\COOL-CAP,100,1000,300,#18,,12
#18,Rated FLOW rate,cfm\60*\60/,\FLOW,500,6000,{V17!3.3*},#16,,14
#19,Saturating EFFECTIVENESS,%\.01*\.01/,\EFF,70,100,{.15!LV16!V18/.355^/X1-@10
  0*},$26,,13
$20G,Liquid Heating DISTRIBUTION,\DISTRIBUTION,NL,L,#16\$02=N>$26\$06=SWGR>$26\
  ,,0,,
```

Infiltration
& Site Info.

NAME for Infiltration?

(Not asked explicitely)

Default:

Ventilation

Next Question = $04: "Is there MECHANICAL Ventilation"

Data position = 3

Explanations:

```
+--------------------------------------------------------------------------+
|                                                                          |
|       The NAME of this component is now given by a default.              |
|                                                                          |
+--------------------------------------------------------------------------+
```

Is there MECHANICAL Ventilation?

Acceptable Answer(s):

N - None
S - Summer only
W - Winter only
Y - Year round

Default:

N - None

Next Question = $09: "NATURAL Cooling Ventilation"

IF $04: "Is there MECHANICAL Ventilation" **WAS** "Summer only" **THEN:**
Next Question = #07: "Summer EXHAUST flow rate"

IF $04: "Is there MECHANICAL Ventilation" **WAS** "Winter only" **OR** "Year round" **THEN:**
Next Question = #05: "Winter EXHAUST flow rate"

Data position = 12

Explanations:

MECHANICAL Ventilation means any fans that provide ventilation (in addition to naturally occurring air infiltration). Included are kitchen fans, whole-house fans or regular fresh-air systems with special air intakes and/or exhausts. Enter the monthly average number of cubic feet per minute of air brought into the house by the fans; i.e. a 200 cfm kitchen fan that is only used once a month can be neglected.

EXHAUST (air taken out of the house) and SUPPLY (air brought into the house) rates can be different, and so can SUMMER and WINTER rates. If your system only supplies air and relies on cracks or vents for exhaust, enter only the SUPPLY flow rate and enter zero for the EXHAUST flow rate. The opposite applies for EXHAUST systems.

Winter EXHAUST flow rate?

Minimum = 0 cfm

Maximum = 1000 cfm

Default = 200 cfm

Next question = #06: "Winter SUPPLY flow rate"

Data position = 7 **—> contains** Entry*1.699

Explanations:

MECHANICAL Ventilation means any fans that provide ventilation (in addition to naturally occurring air infiltration). Included are kitchen fans, whole-house fans or regular fresh-air systems with special air intakes and/or exhausts. Enter the monthly average number of cubic feet per minute of air brought into the house by the fans; i.e. a 200 cfm kitchen fan that is only used once a month can be neglected.

EXHAUST (air taken out of the house) and SUPPLY (air brought into the house) rates can be different, and so can SUMMER and WINTER rates. If your system only supplies air and relies on cracks or vents for exhaust, enter only the SUPPLY flow rate and enter zero for the EXHAUST flow rate. The opposite applies for EXHAUST systems.

Winter SUPPLY flow rate?

Minimum = 0 cfm

Maximum = 1000 cfm

Default = answr(#05) cfm

Legend: #05: Winter EXHAUST flow rate

Next question = #07: "Summer EXHAUST flow rate"

Data position = 8 —> **contains** Entry*1.699

Explanations:

MECHANICAL Ventilation means any fans that provide ventilation (in addition to naturally occurring air infiltration). Included are kitchen fans, whole-house fans or regular fresh-air systems with special air intakes and/or exhausts. Enter the monthly average number of cubic feet per minute of air brought into the house by the fans; i.e. a 200 cfm kitchen fan that is only used once a month can be neglected.

EXHAUST (air taken out of the house) and SUPPLY (air brought into the house) rates can be different, and so can SUMMER and WINTER rates. If your system only supplies air and relies on cracks or vents for exhaust, enter only the SUPPLY flow rate and enter zero for the EXHAUST flow rate. The opposite applies for EXHAUST systems.

Summer EXHAUST flow rate?

Minimum = 0 cfm

Maximum = 15000 cfm

Default = 200 cfm

IF $04: "Is there MECHANICAL Ventilation" **WAS** "Winter only"
OR "Year round" **THEN:**
Default = answr(#05) cfm

Legend: #05: Winter EXHAUST flow rate

Next question = #08: "Summer SUPPLY flow rate"

Data position = 9 —> **contains** Entry*1.699

Explanations:

MECHANICAL Ventilation means any fans that provide ventilation (in addition to naturally occurring air infiltration). Included are kitchen fans, whole-house fans or regular fresh-air systems with special air intakes and/or exhausts. Enter the monthly average number of cubic feet per minute of air brought into the house by the fans; i.e. a 200 cfm kitchen fan that is only used once a month can be neglected.

EXHAUST (air taken out of the house) and SUPPLY (air brought into the house) rates can be different, and so can SUMMER and WINTER rates. If your system only supplies air and relies on cracks or vents for exhaust, enter only the SUPPLY flow rate and enter zero for the EXHAUST flow rate. The opposite applies for EXHAUST systems.

Summer SUPPLY flow rate?

Minimum = 0 cfm

Maximum = 15000 cfm

Default = answr(#07) cfm

Legend: #07: Summer EXHAUST flow rate

Next question = $16: "NATURAL Cooling Ventilation"

Data position = 10 —> **contains** Entry*1.699

Explanations:

MECHANICAL Ventilation means any fans that provide ventilation (in addition to naturally occurring air infiltration). Included are kitchen fans, whole-house fans or regular fresh-air systems with special air intakes and/or exhausts. Enter the monthly average number of cubic feet per minute of air brought into the house by the fans; i.e. a 200 cfm kitchen fan that is only used once a month can be neglected.

EXHAUST (air taken out of the house) and SUPPLY (air brought into the house) rates can be different, and so can SUMMER and WINTER rates. If your system only supplies air and relies on cracks or vents for exhaust, enter only the SUPPLY flow rate and enter zero for the EXHAUST flow rate. The opposite applies for EXHAUST systems.

NATURAL Cooling Ventilation?

Acceptable Answer(s):
Y - Yes
N - No

Default:
N - No

Next Question = $02: "TERRAIN class"

Data position = 11

Explanations:

NATURAL Cooling Ventilation is opening windows in the summer whenever the outside temperature is lower than the desired indoor temperature.

If you answer Yes (Y) to this question, the computer assumes that you run the air conditioner only when the outdoor temperature is higher than you want the indoor temperature to be. The outside temperature for which natural ventilation eliminates all cooling depends on the climate of the city chosen, but this outside temperature is always lower than your chosen indoor temperature.

NATURAL Cooling Ventilation?

(Not asked explicitely)

Acceptable Answer(s):

Y - Yes
N - No

Default:

N - No

Next Question = $02: "TERRAIN class"

Data position = 11

Explanations:

NATURAL Cooling Ventilation is opening windows in the summer whenever the outside temperature is lower than the desired indoor temperature.

If you answer Yes (Y) to this question, the computer assumes that you run the air conditioner only when the outdoor temperature is higher than you want the indoor temperature to be. The outside temperature for which natural ventilation eliminates all cooling depends on the climate of the city chosen, but this outside temperature is always lower than your chosen indoor temperature.

TERRAIN class?

Acceptable Answer(s):

1 - Class 1
2 - Class 2
3 - Class 3
4 - Class 4
5 - Class 5

Default:

3 - Class 3

Next Question = $03: "SHIELDING class"

Data position = 5

Explanations:

TERRAIN CLASS describes the size and occurrence of obstructions found within three miles of the building. Your answer will be used to adjust the standard values for air infiltration to fit your own location. Answer with a whole number between 1 and 5, using the table below:

1	Ocean or other body of water with at least 3 miles of unrestricted expanse.
2	Flat terrain with some isolated obstacles (e.g., buildings or trees well separated from each other).
3	Rural areas with low buildings & trees.
4	Urban, industrial or forest areas.
5	Center of large city, e.g., Manhattan.

SHIELDING class?

Acceptable Answer(s):

1 - Class 1
2 - Class 2
3 - Class 3
4 - Class 4
5 - Class 5

Default:

3 - Class 3

Next Question = #10: "HEIGHT of living space"

Data position = 6

Explanations:

SHIELDING CLASS describes by how much a building is shielded by objects in the immediate vicinity (within a few house heights). Your answer will be used to adjust the standard values for air infiltration to fit your own location. Answer with a whole number between 1 and 5, using the table below:

1	No obstructions or local shielding whatsoever.
2	Light local shielding with few obstructions. Perhaps a few trees, or a small shed.
3	Moderate local shielding, some obstructions within two house heights. A thick hedge or a solid fence, or one neighboring house.
4	Heavy shielding, obstructions around most of perimeter. Buildings or trees within 30ft in most directions. Typical suburban shielding.
5	Very heavy shielding, large obstructions surrounding perimeter within 2 house heights. Typical downtown shielding.

HEIGHT of living space?

Minimum = 6 feet

Maximum = 30 feet

Default = 10 feet

Next question = #15: "Approx. house VOLUME"

Data position = 4

Explanations:

```
+----------------------------------------------------------------------------+
|                                                                            |
|      The HEIGHT of the living space is the height from exterior grade to  |
| the highest ceiling in the living space. This is necessary in order to    |
| calculate both the volume of the house, and to calculate the infiltration |
| rate caused by hot air rising to the top of your house, and leaking out of|
| cracks.                                                                    |
|                                                                            |
+----------------------------------------------------------------------------+
```

Approx. house VOLUME?

Minimum = 800 cubic feet

Maximum = 80000 cubic feet

Default = answr(#10)*1000 cubic feet

Legend: #10: HEIGHT of living space

Next question = $14: "HOW was leakage area MEASURED"

Data position = 17

Explanations:

```
+-----------------------------------------------------------------------------+
|                                                                             |
|       The approximate house VOLUME is the volume of the  the  heated  living |
| space.                                                                      |
|                                                                             |
+-----------------------------------------------------------------------------+
```

HOW was leakage area MEASURED?

Acceptable Answer(s):
- T - Total only
- C - Ceiling & total
- F - Floor & total
- A - All three measured
- N - Not measured

Default:
N - Not measured

Next Question = #13: "TOTAL leakage area"

IF $14: "HOW was leakage area MEASURED" **WAS** "Not measured" **THEN:**
Next Question = $26: "Which menu ITEM(S)"

Data position = 16

Explanations:

The LEAKAGE AREA of a house is roughly the area of a single hole that would let air leak through it at the same rate as it does through all the leaks in your house.

Leakage area is measured with a blower door: air is blown into the house using a fan sealed in a door or a window, and the rate at which the air flows into the house is measured at several pressure differences. These flow and pressure measurements are put in a formula which gives the LEAKAGE AREA.

If you did not measure the leakage area, press <ctrl-D> The computer will estimate it based on the answers you gave to questions about vents, penetrations, windows, walls and doors.

TOTAL leakage area?

Minimum = .81 sqin

Maximum = 1000 sqin

Default = 150 sqin

Next question = #11: "CEILING leakage area"

IF $14: "HOW was leakage area MEASURED" **WAS** "Floor & total" **THEN:**
Next question = #12: "FLOOR leakage area"

IF $14: "HOW was leakage area MEASURED" **WAS** "Total only" **THEN:**
Next question = $26: "Which menu ITEM(S)"

Data position = 15 —> **contains** Entry*6.4516

Explanations:

```
+----------------------------------------------------------------------+
|                                                                      |
|      CEILING leakage occurs through the ceiling, FLOOR leakage occurs |
| through the floor, and WALL leakage occurs through the walls. TOTAL leakage |
| area is the sum of all three.                                        |
|                                                                      |
|      Usually, only total leakage area is measured, If you press <ctrl-D> |
| the computer will split up the total between ceiling, floors, and wall in a |
| ratio based on your answers about the specific leakage areas of walls, |
| windows, doors, etc. If you actually measured the individual areas, enter |
| your results.                                                        |
|                                                                      |
+----------------------------------------------------------------------+
```

CEILING leakage area?

Minimum = .2 sqin

Maximum = 500 sqin

Default = answr(#13)/4 sqin

Legend: #13: TOTAL leakage area

Next question = #12: "FLOOR leakage area"

IF $14: "HOW was leakage area MEASURED" **WAS** "Ceiling & total" **THEN:**
Next question = $26: "Which menu ITEM(S)"

Data position = 13 **—> contains** Entry*6.4516.

Explanations:

CEILING leakage occurs through the ceiling, FLOOR leakage occurs through the floor, and WALL leakage occurs through the walls. TOTAL leakage area is the sum of all three.

Usually, only total leakage area is measured, If you press <ctrl-D> the computer will split up the total between ceiling, floors, and wall in a ratio based on your answers about the specific leakage areas of walls, windows, doors, etc. If you actually measured the individual areas, enter your results.

FLOOR leakage area?

Minimum = .2 sqin

Maximum = 500 sqin

Default = answr(#13)/4 sqin

Legend: #13: TOTAL leakage area

Next question = $26: "Which menu ITEM(S)"

Data position = 14 —> **contains** Entry*6.4516

Explanations:

CEILING leakage occurs through the ceiling, FLOOR leakage occurs through the floor, and WALL leakage occurs through the walls. TOTAL leakage area is the sum of all three.

Usually, only total leakage area is measured, If you press <ctrl-D> the computer will split up the total between ceiling, floors, and wall in a ratio based on your answers about the specific leakage areas of walls, windows, doors, etc. If you actually measured the individual areas, enter your results.

INFILTRA.INF

```
$01G,NAME for Infiltration,\NAME,,Ventilation,$04,,3,\\,\\
$04,Is there MECHANICAL Ventilation,\FLOW,NSWY,N,$09\$04=S>#07\$04=WY>#05\,,12,
  \NNone\SSummer only\WWinter only\YYear round\,\\
#05,Winter EXHAUST flow rate,cfm\1.699*\1.699/,\FLOW,0,1000,200,#06,,7
#06,Winter SUPPLY flow rate,cfm\1.699*\1.699/,\FLOW,0,1000,{V05!},#07\$04=W>$09
  ,,8
#07,Summer EXHAUST flow rate,cfm\1.699*\1.699/,\FLOW,0,15000,200\$04=WY>{V05!}\
  ,#08,,9
#08,Summer SUPPLY flow rate,cfm\1.699*\1.699/,\FLOW,0,15000,{V07!},$16,,10
$09,NATURAL Cooling Ventilation,\NATURAL,YN,N,$02,,11,\YYes\NNo\,\\
$16G,NATURAL Cooling Ventilation,\NATURAL,YN,N,$02,,11,\YYes\NNo\,\\
$02,TERRAIN class,\TERRAIN,12345,3,$03,,5,\1Class 1\2Class 2\3Class 3\4Class 4\
  5Class 5\,\11.30!0.10\21.00!0.15\30.85!0.20\40.67!0.25\50.47!0.35\
$03,SHIELDING class,\SHIELDING,12345,3,#10,,6,\1Class 1\2Class 2\3Class 3\4Clas
  s 4\5Class 5\,\10.324\20.285\30.24\40.185\50.102\
#10,HEIGHT of living space,feet\,\HEIGHT,6,30,10,#15,,4
#15,Approx. house VOLUME,cubic feet\,\VOL,800,80000,{V10!1000*},$14,,17
$14,HOW was leakage area MEASURED,\HOW,TCFAN,N,#13\$14=N>$26\,,16,\TTotal only\
  CCeiling & total\FFloor & total\AAll three measured\NNot measured\,\\
#13,TOTAL leakage area,sqin\6.4516*\6.4516/,\LEAKG,.81,1000,150,#11\$14=F>#12\$
  14=T>$26\,,15
#11,CEILING leakage area,sqin\6.4516*\6.4516/,\LEAKG,.2,500,{V13!4/},#12\$14=C>
  $26\,,13
#12,FLOOR leakage area,sqin\6.4516*\6.4516/,\LEAKG,.2,500,{V13!4/},$26,,14
```

Landscape

NAME for Landscape?

(Not asked explicitely)

Default:

Yard & Trees

Next Question = $02: "Ground SURFACE TYPE"

Data position = 3

Explanations:

```
+----------------------------------------------------------------------+
|                                                                      |
|      This is now given by a default.                                 |
|                                                                      |
+----------------------------------------------------------------------+
```

Ground SURFACE TYPE?

Acceptable Answer(s) and Associated [Value(s)]:

N - New concrete	[32]
O - Old concrete	[22]
G - Green grass	[24]
C - Crushed rock	[20]
T - Tar & gravel	[14]
P - Parking lot	[10]
D - Default	[30]

Default:

D - Default [30]

Next Question = #03: "Ground REFLECTANCE"

Data position = 11

Explanations:

Ground SURFACE TYPE is used to calculate the default value for GROUND REFLECTANCE. This information is used to calculate how much of the sunlight that strikes the ground around your house is bounced back towards the windows and walls.

If you have a special ground reflector to bounce extra sunlight into your windows, it should be entered under PASSIVE.

Ground REFLECTANCE?

Minimum = 0 %

Maximum = 100 %

Default = value($02) %

Legend: $02: Ground SURFACE TYPE

Next question = #04: "SOUTH solar EXPOSURE - DECEMBER"

Data position = 4 —> **contains** Entry*.01

Explanations:

Ground SURFACE TYPE is used to calculate the default value for GROUND REFLECTANCE. This information is used to calculate how much of the sunlight that strikes the ground around your house is bounced back towards the windows and walls.

If you have a special ground reflector to bounce extra sunlight into your windows, it should be entered under PASSIVE.

SOUTH solar EXPOSURE - DECEMBER?

Minimum = 0. %

Maximum = 100. %

Default = 60. %

Next question = #05: "SOUTH solar EXPOSURE - JUNE"

Data position = 5 —> **contains** Entry*.01

Explanations:

The SOLAR EXPOSURE is the fraction of total possible solar radiation that reaches the house through any obstacles, such as trees, adjacent buildings or hills.

A house in the middle of a flat desert will have 100% solar exposure at all times. One on a large pasture in the mountains (or a house with some short trees around it) may still have almost 100% in summer, but maybe only 30% in winter when the sun is low. A house in the middle of Manhattan may have a very low exposure all year.

Solar exposure can be measured directly with a "solar siting meter", a dome-shaped device that projects the view in any direction on a horizontal surface, with an acetate overlay showing the solar path in different seasons. The solar path traces are divided into sectors which each represent 10% of the total daily radiation. So if three sectors are covered up by surrounding trees and hills, the solar exposure will be 70%.

If you do not have such a device, try to project the path of the sun from horizon to horizon during the appropriate months. Remember, the sun will be quite high in the sky during the summer and low in the winter. Also remember that the greatest insolation occurs during the middle of the day.

SOUTH solar EXPOSURE - JUNE?

Minimum = 0. %

Maximum = 100. %

Default = 80. %

Next question = #06: "EAST solar EXPOSURE - DECEMBER"

Data position = 6 —> **contains** Entry*.01

Explanations:

The SOLAR EXPOSURE is the fraction of total possible solar radiation that reaches the house through any obstacles, such as trees, adjacent buildings or hills.

A house in the middle of a flat desert will have 100% solar exposure at all times. One on a large pasture in the mountains (or a house with some short trees around it) may still have almost 100% in summer, but maybe only 30% in winter when the sun is low. A house in the middle of Manhattan may have a very low exposure all year.

Solar exposure can be measured directly with a "solar siting meter", a dome-shaped device that projects the view in any direction on a horizontal surface, with an acetate overlay showing the solar path in different seasons. The solar path traces are divided into sectors which each represent 10% of the total daily radiation. So if three sectors are covered up by surrounding trees and hills, the solar exposure will be 70%.

If you do not have such a device, try to project the path of the sun from horizon to horizon during the appropriate months. Remember, the sun will be quite high in the sky during the summer and low in the winter. Also remember that the greatest insolation occurs during the middle of the day.

EAST solar EXPOSURE - DECEMBER?

Minimum = 0. %

Maximum = 100. %

Default = 60. %

Next question = #07: "EAST solar EXPOSURE - JUNE"

Data position = 7 —> **contains** Entry*.01

Explanations:

The SOLAR EXPOSURE is the fraction of total possible solar radiation that reaches the house through any obstacles, such as trees, adjacent buildings or hills.

A house in the middle of a flat desert will have 100% solar exposure at all times. One on a large pasture in the mountains (or a house with some short trees around it) may still have almost 100% in summer, but maybe only 30% in winter when the sun is low. A house in the middle of Manhattan may have a very low exposure all year.

Solar exposure can be measured directly with a "solar siting meter", a dome-shaped device that projects the view in any direction on a horizontal surface, with an acetate overlay showing the solar path in different seasons. The solar path traces are divided into sectors which each represent 10% of the total daily radiation. So if three sectors are covered up by surrounding trees and hills, the solar exposure will be 70%.

If you do not have such a device, try to project the path of the sun from horizon to horizon during the appropriate months. Remember, the sun will be quite high in the sky during the summer and low in the winter. Also remember that the greatest insolation occurs during the middle of the day.

EAST solar EXPOSURE - JUNE?

Minimum = 0. %

Maximum = 100. %

Default = 80. %

Next question = #08: "WEST solar EXPOSURE - DECEMBER"

Data position = 8 —> **contains** Entry*.01

Explanations:

The SOLAR EXPOSURE is the fraction of total possible solar radiation that reaches the house through any obstacles, such as trees, adjacent buildings or hills.

A house in the middle of a flat desert will have 100% solar exposure at all times. One on a large pasture in the mountains (or a house with some short trees around it) may still have almost 100% in summer, but maybe only 30% in winter when the sun is low. A house in the middle of Manhattan may have a very low exposure all year.

Solar exposure can be measured directly with a "solar siting meter", a dome-shaped device that projects the view in any direction on a horizontal surface, with an acetate overlay showing the solar path in different seasons. The solar path traces are divided into sectors which each represent 10% of the total daily radiation. So if three sectors are covered up by surrounding trees and hills, the solar exposure will be 70%.

If you do not have such a device, try to project the path of the sun from horizon to horizon during the appropriate months. Remember, the sun will be quite high in the sky during the summer and low in the winter. Also remember that the greatest insolation occurs during the middle of the day.

WEST solar EXPOSURE - DECEMBER?

Minimum = 0. %

Maximum = 100. %

Default = 60. %

Next question = #09: "WEST solar EXPOSURE - JUNE"

Data position = 9 —> **contains** Entry*.01

Explanations:

The SOLAR EXPOSURE is the fraction of total possible solar radiation that reaches the house through any obstacles, such as trees, adjacent buildings or hills.

A house in the middle of a flat desert will have 100% solar exposure at all times. One on a large pasture in the mountains (or a house with some short trees around it) may still have almost 100% in summer, but maybe only 30% in winter when the sun is low. A house in the middle of Manhattan may have a very low exposure all year.

Solar exposure can be measured directly with a "solar siting meter", a dome-shaped device that projects the view in any direction on a horizontal surface, with an acetate overlay showing the solar path in different seasons. The solar path traces are divided into sectors which each represent 10% of the total daily radiation. So if three sectors are covered up by surrounding trees and hills, the solar exposure will be 70%.

If you do not have such a device, try to project the path of the sun from horizon to horizon during the appropriate months. Remember, the sun will be quite high in the sky during the summer and low in the winter. Also remember that the greatest insolation occurs during the middle of the day.

WEST solar EXPOSURE - JUNE?

Minimum = 0. %

Maximum = 100. %

Default = 80. %

Next question = $26: "Which menu ITEM(S)"

Data position = 10 —> **contains** Entry*.01

Explanations:

The SOLAR EXPOSURE is the fraction of total possible solar radiation that reaches the house through any obstacles, such as trees, adjacent buildings or hills.

A house in the middle of a flat desert will have 100% solar exposure at all times. One on a large pasture in the mountains (or a house with some short trees around it) may still have almost 100% in summer, but maybe only 30% in winter when the sun is low. A house in the middle of Manhattan may have a very low exposure all year.

Solar exposure can be measured directly with a "solar siting meter", a dome-shaped device that projects the view in any direction on a horizontal surface, with an acetate overlay showing the solar path in different seasons. The solar path traces are divided into sectors which each represent 10% of the total daily radiation. So if three sectors are covered up by surrounding trees and hills, the solar exposure will be 70%.

If you do not have such a device, try to project the path of the sun from horizon to horizon during the appropriate months. Remember, the sun will be quite high in the sky during the summer and low in the winter. Also remember that the greatest insolation occurs during the middle of the day.

```
$01G,NAME for Landscape,\NAME,,Yard & Trees,$02,,3,\\,\\
$02,Ground SURFACE TYPE,\GROUND,NOGCTPD,D,#03,,11,\NNew concrete\OOld concrete\
  GGreen grass\CCrushed rock\TTar & gravel\PParking lot\DDefault\,\N32\O22\G24\
  C20\T14\P10\D30\
#03,Ground REFLECTANCE,%\.01*\.01/,\GROUND,0,100,{T02!},#04,,4
#04,SOUTH solar EXPOSURE - DECEMBER,%\.01*\.01/,\EXPOS,0.,100.,60.,#05,,5
#05,SOUTH solar EXPOSURE - JUNE,%\.01*\.01/,\EXPOS,0.,100.,80.,#06,,6
#06,EAST solar EXPOSURE - DECEMBER,%\.01*\.01/,\EXPOS,0.,100.,60.,#07,,7
#07,EAST solar EXPOSURE - JUNE,%\.01*\.01/,\EXPOS,0.,100.,80.,#08,,8
#08,WEST solar EXPOSURE - DECEMBER,%\.01*\.01/,\EXPOS,0.,100.,60.,#09,,9
#09,WEST solar EXPOSURE - JUNE,%\.01*\.01/,\EXPOS,0.,100.,80.,$26,,10
```

NAME of occupants?

Next Question = #14: "How many DAYTIME OCCUPANTS"

Data position = 3

Explanations:

```
+--------------------------------------------------------------------------+
|                                                                          |
|      The NAME of the OCCUPANTS is of no consequence, and can be  chosen  by |
| the user at will.                                                        |
|                                                                          |
+--------------------------------------------------------------------------+
```

How many DAYTIME OCCUPANTS?

Minimum = 0 people

Maximum = 10 people

Default = 2 people

Next question = #15: "How many NIGHT OCCUPANTS"

Data position = 12 —> **contains** Entry*225

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|      The number of DAYTIME OCCUPANTS is the average number of people in the |
| house from 8 am to 8 pm.                                               |
|                                                                        |
|      The number of NIGHTTIME OCCUPANTS is the average number of  people  in |
| the house from 8 pm to 8 am.                                           |
|                                                                        |
+------------------------------------------------------------------------+
```

How many NIGHT OCCUPANTS?

Minimum = 0 people

Maximum = 10 people

Default = 4 people

Next question = #06: "DAILY hot water USE"

Data position = 13 —> **contains** Entry*198

Explanations:

```
+--------------------------------------------------------------------------+
|                                                                          |
|      The number of DAYTIME OCCUPANTS is the average number of people in the |
| house from 8 am to 8 pm.                                                 |
|                                                                          |
|      The number of NIGHTTIME OCCUPANTS is the average number of people in |
| the house from 8 pm to 8 am.                                             |
|                                                                          |
+--------------------------------------------------------------------------+
```

DAILY hot water USE?

Minimum = 0 gal/day

Maximum = 500 gal/day

Default = {[answr(#14)+answr(#15)]/2}*25 gal/day

Legend: #14: How many DAYTIME OCCUPANTS
#15: How many NIGHT OCCUPANTS

Next question = $08: "WATER HEATER type"

Data position = 17 —> **contains** [Entry*8.3]/24

Explanations:

Daily HOT WATER use is the amount of hot water you take from the tank each day. If you press <ctrl-D> the computer will give you a default based on your answers for OCCUPANTS.

WATER HEATER type?

Acceptable Answer(s) and Associated [Value(s)]:

G - Gas	[.031]
I - Gas - insulation added	[.024]
E - Electric	[.031]
A - Electric - insulation added	[.024]
T - Tankless Coil	[.035]
H - Heat Pump	[.062]

Default:

G - Gas [.031]

Next Question = #09: "Input RATING"

IF $08: "WATER HEATER type" **WAS** "Electric"
OR "Electric - insulation added"
OR "Heat Pump" **THEN:**
Next Question = #10: "Input RATING"

IF $08: "WATER HEATER type" **WAS** "Tankless Coil" **THEN:**
Next Question = #11: "BOILER input RATING"

Data position = 8

Explanations:

The water heater TYPE is the kind of water heater. For a list of available types, press <ctrl-L> A tankless coil is a coil inside the tank which supplies water to the space heating system.

The INPUT RATING is the amount of fuel used by the heater, in thousands of British Thermal Units per hour (kBtu/h) for gas heaters, and in kilowatts (kW) for electric heaters. It should be marked on the manufacturers label.

The STANDBY PLUMBING LOSS is the heat lost from the tank and from the hot water pipes. If you press <ctrl-D> the computer will calculate a default value based on your previous answers.

Input RATING?

Minimum = 0 kBtu/hr

Maximum = 200 kBtu/hr

Default = 40 kBtu/hr

Next question = #05: "Hot water THERMOSTAT setting"

Data position = 9 —> **contains** Entry*1000

Explanations:

The water heater TYPE is the kind of water heater. For a list of available types, press <ctrl-L> A tankless coil is a coil inside the tank which supplies water to the space heating system.

The INPUT RATING is the amount of fuel used by the heater, in thousands of British Thermal Units per hour (kBtu/h) for gas heaters, and in kilowatts (kW) for electric heaters. It should be marked on the manufacturers label.

The STANDBY PLUMBING LOSS is the heat lost from the tank and from the hot water pipes. If you press <ctrl-D> the computer will calculate a default value based on your previous answers.

Input RATING?

Minimum = 0.5 kW

Maximum = 10 kW

Default = 4 kW

Next question = #05: "Hot water THERMOSTAT setting"

Data position = 9 —> **contains** Entry*3414

Explanations:

The water heater TYPE is the kind of water heater. For a list of available types, press <ctrl-L> A tankless coil is a coil inside the tank which supplies water to the space heating system.

The INPUT RATING is the amount of fuel used by the heater, in thousands of British Thermal Units per hour (kBtu/h) for gas heaters, and in kilowatts (kW) for electric heaters. It should be marked on the manufacturers label.

The STANDBY PLUMBING LOSS is the heat lost from the tank and from the hot water pipes. If you press <ctrl-D> the computer will calculate a default value based on your previous answers.

BOILER input RATING?

Minimum = 0 kBtu/hr

Maximum = 300 kBtu/hr

Default = 100 kBtu/hr

Next question = #05: "Hot water THERMOSTAT setting"

Data position = 9 —> **contains** Entry*1000

Explanations:

> The boiler INPUT RATING is the energy input to the boiler which the tankless coil is in. It should be marked on the manufacturer's label.

Hot water THERMOSTAT setting?

Minimum = 50 degF

Maximum = 200 degF

Default = 140 degF

Next question = $13: "WHERE is water heater"

Data position = 6

Explanations:

The THERMOSTAT SETTING is the temperature at which the water inside the tank is kept. If the thermostat on the tank is not calibrated in degrees, use a thermometer to measure the temperature of hot water from the faucet closest to the tank.

WHERE is water heater?

Acceptable Answer(s) and Associated [Value(s)]:

L - Living space	[1.0]
G - Garage	[0.50]
B - Basement	[0.50]
C - Crawlspace	[0.25]

Default:

L - Living space [1.0]

Next Question = #04: "Water heater LOCATION/eff'cy"

Data position = 11

Explanations:

The WATER HEATER LOCATION is used to estimate how much of the waste heat from the water heater warms up the living space.

For a list of available locations, press <ctrl-L>

Water heater LOCATION/eff'cy?

(Not asked explicitely)

Minimum = 0 none

Maximum = 1 none

Default = value($13)+.00098 none

IF $08: "WATER HEATER type" **WAS** "Gas"
OR "Gas - insulation added"
OR "Tankless Coil" **THEN:**
Default = value($13)+.0007 none

IF $08: "WATER HEATER type" **WAS** "Heat Pump" **THEN:**
Default = value($13)+.002 none

Legend: $13: WHERE is water heater

Next question = #12: "Stdby/plumb. LOSSES"

Data position = 5

Explanations:

The WATER HEATER LOCATION/EFFICIENCY is an intermediate result in calculating standby losses from the water heater. It combines the effects of both the location of the water heater and its efficiency.

Stdby/plumb. LOSSES?

Minimum = 0 kBtu/hr

Maximum = 3500 kBtu/hr

Default = answr(#09)*value($08) kBtu/hr

IF $08: "WATER HEATER type" **WAS** "Electric"
OR "Electric - insulation added"
OR "Heat Pump" **THEN:**
Default = [answr(#10)*value($08)]*3.414 kBtu/hr

IF $08: "WATER HEATER type" **WAS** "Tankless Coil" **THEN:**
Default = answr(#11)*value($08) kBtu/hr

Legend: $08: WATER HEATER type
#09: Input RATING
#10: Input RATING
#11: BOILER input RATING

Next question = $02: "REFRIGERATOR type"

Data position = 10 —> **contains** Entry*1000

Explanations:

The water heater TYPE is the kind of water heater. For a list of available types, press <ctrl-L> A tankless coil is a coil inside the tank which supplies water to the space heating system.

The INPUT RATING is the amount of fuel used by the heater, in thousands of British Thermal Units per hour (kBtu/h) for gas heaters, and in kilowatts (kW) for electric heaters. It should be marked on the manufacturers label.

The STANDBY PLUMBING LOSS is the heat lost from the tank and from the hot water pipes. If you press <ctrl-D> the computer will calculate a default value based on your previous answers.

REFRIGERATOR type?

Acceptable Answer(s):

M - Man. defrost & freezer
A - Auto. defrost & freezer
S - Man. defrost & sep. freezer
F - Auto. defrost & sep. freeze

Default:

S - Man. defrost & sep. freezer

Next Question = #03: "Average MONTHLY CONSUMPTION"

Data position = 4

Explanations:

The REFRIGERATOR TYPE is used to estimate the monthly electricity use of the refrigerator.

However, it is best to obtain the actual average MONTHLY CONSUMPTION of electricity by your refrigerator from a data book if you can, since there is great variability from one unit to the next.

For a list of available types, press <ctrl-L>

Average MONTHLY CONSUMPTION?

Minimum = 20 kWh/mo

Maximum = 300 kWh/mo

Default = 100 kWh/mo

IF $02: "REFRIGERATOR type" **WAS** "Auto. defrost & freezer" **THEN:**
Default = 130 kWh/mo

IF $02: "REFRIGERATOR type" **WAS** "Man. defrost & freezer" **THEN:**
Default = 55 kWh/mo

IF $02: "REFRIGERATOR type" **WAS** "Auto. defrost & sep. freezer" **THEN:**
Default = 150 kWh/mo

IF $02: "REFRIGERATOR type" **WAS** "Man. defrost & sep. freezer" **THEN:**
Default = 65 kWh/mo

Next question = $17: "DRYER and RANGE type"

Data position = 7 —> **contains** Entry*4.742

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|      The REFRIGERATOR TYPE is used to estimate the monthly electricity  use |
| of the refrigerator.                                                   |
|                                                                        |
|      However, it is best to obtain the actual average  MONTHLY  CONSUMPTION |
| of electricity by your refrigerator from a data book if you can, since there |
| is great variability from one unit to the next.                        |
|                                                                        |
|      For a list of available types, press <ctrl-L>                     |
|                                                                        |
+------------------------------------------------------------------------+
```

DRYER and RANGE type?

Acceptable Answer(s):

G - Both Natural gas
E - Both Electric
D - Gas dryer - Electric range
R - Electric dryer - Gas range
S - No dryer - Gas range
C - No dryer - Electric range
N - None at all

Default:

E - Both Electric

Next Question = #18: "Internal MOISTURE generation"

Data position = 15

Explanations:

```
+------------------------------------------------------------------------+
|                                                                        |
|      RANGE TYPE is what kind of fuel your range uses.                  |
|                                                                        |
|      DRYER TYPE is what kind of fuel your clothes dryer  uses.         |
|                                                                        |
|      For  a  listing, press <ctrl-L>                                   |
|                                                                        |
+------------------------------------------------------------------------+
```

Internal MOISTURE generation?

Minimum = 0 lb/dy

Maximum = 150 lb/dy

Default = (answr(#06)/25)*1.12+1.0 lb/dy

Legend: #06: DAILY hot water USE

Next question = #16: "LIGHTS & OTHER HEAT GAINS"

Data position = 16 —> **contains** Entry/24

Explanations:

The INTERNAL MOISTURE GENERATION RATE is the average amount of water that evaporates into the air each day. The water comes from showers, cooking, watering plants and just breathing. If you want the computer to calculate a default based on the number of occupants and the daily hot water use, press <ctrl-D>

LIGHTS & OTHER HEAT GAINS?

Minimum = 0 kBtu/hr

Maximum = 5 kBtu/hr

Default = 1.0 kBtu/hr

Next question = $26: "Which menu ITEM(S)"

Data position = 14 —> **contains** Entry*1000

Explanations:

```
+----------------------------------------------------------------------------+
|                                                                            |
|      LIGHTS AND OTHER HEAT GAINS are any  sources  of  heat  not  mentioned |
| above,  e.g. all  the  electricity used by lights, a freezer or a dishwasher |
| (but not a range or dryer, which  are  the  subject  of  another  question). |
| Note:  A  100 watt bulb operated continuously produces 0.34 kBtu per hour of |
| heat.  If you want the computer to use a default value, press <ctrl-D>      |
|                                                                            |
+----------------------------------------------------------------------------+
```

```
$01,NAME of occupants,\NAME,,,#14,,3,\\,\\
#14,How many DAYTIME OCCUPANTS,people\225*\225/,\OCCUPANTS,0,10,2,#15,,12
#15,How many NIGHT OCCUPANTS,people\198*\198/,\OCCUPANTS,0,10,4,#06,,13
#06,DAILY hot water USE,gal/day\8.3*24/\24*8.3/,\USE,0,500,{V14!V15+2/25*},$08,
  ,17
$08,WATER HEATER type,\DHW,GIEATH,G,#09\$08=EAH>#10\$08=T>#11\,,8,\GGas\IGas -
  insulation added\EElectric\AElectric - insulation added\TTankless Coil\HHeat
  Pump\,\G.031\I.024\E.031\A.024\T.035\H.062\
#09,Input RATING,kBtu/hr\1000*\1000/,\DHW,0,200,40,#05,,9
#10,Input RATING,kW\3414*\3414/,\DHW,0.5,10,4,#05,,9
#11,BOILER input RATING,kBtu/hr\1000*\1000/,\BOILER,0,300,100,#05,,9
#05,Hot water THERMOSTAT setting,degF\,\THERMOS,50,200,140,$13,t=U06={D06!V05-}
  :,6
$13,WHERE is water heater,\LOCATION,LGBC,L,#04,,11,\LLiving space\BBasement\CCr
  awlspace\GGarage\,\L1.0\B0.50\C0.25\G0.50\
#04G,Water heater LOCATION/eff'cy,none\,\LOC,0,1,{T13!.00098+}\$08=GIT>{T13!.00
  07+}\$08=H>{T13!.002+}\,#12,,5
#12,Stdby/plumb. LOSSES,kBtu/hr\1000*\1000/,\DHW,0,3500,{V09!T08*}\$08=EAH>{V10
  !T08*3.414*}\$08=T>{V11!T08*}\,$02,,10
$02,REFRIGERATOR type,\REFRIG,MASF,S,#03,,4,\MMan. defrost & freezer\AAuto. def
  rost & freezer\SMan. defrost & sep. freezer\FAuto. defrost & sep. freezer\,\\
#03,Average MONTHLY CONSUMPTION,kWh/mo\4.742*\4.742/,\REFRIG,20,300,100\$02=A>1
  30\$02=M>55\$02=F>150\$02=S>65\,$17,r=U07={D07!V03!4.742*-}:,7
$17,DRYER and RANGE type,\TYPE,GEDRSCN,E,#18,,15,\GBoth Natural gas\EBoth Elect
  ric\DGas dryer - Electric range\RElectric dryer - Gas range\SNo dryer - Gas r
  ange\CNo dryer - Electric range\NNone at all\,\\
#18,Internal MOISTURE generation,lb/dy\24/\24*,\MOIST,0,150,{V14!V15+2/6.84*V06
  !25/1.12*1.0+},#16,,16
#16,LIGHTS & OTHER HEAT GAINS,kBtu/hr\1000*\1000/,\OTHER,0,5,1.0,$26,,14
```

RETROFIT LIBRARY

Section IX

RETROFIT LIBRARY

Introduction

The CIRA Retrofit Library is a complete listing of the energy conservation retrofits used in the CIRA program. Each retrofit listing has twelve fields which describe the retrofit in detail. The user may change any of the field data to suit his or her particular needs. For example, a user might want to change the ceiling insulation data to fit local prices. In the following pages we define the field codes, present a sample retrofit listing, define the symbols and operators, and list the Retrofit Library. With this information the careful user may also create new retrofits.

Field Codes

Each field is of the form "FC=xxxxx," where FC is the field code and xxxxx is the data in that field. A comma separates the fields in a retrofit listing.

ID = Identification number	AC = Retrofit Action
CO = Component	UN = Retrofit Unaction
DE = Retrofit Description	UC = Do-it-yourself Cost
PL = Location on Component	CC = Contractor Cost
UT = Unit for Cost Analysis	RY = Replacement Factor
VL = Component Requirements	RF = Reference

ID — Identification Number

ID is the unique retrofit identification number within the retrofit file for each component, in the retrofit sample 003.

CO — Component

CO is the name of the component to which the retrofit applies, in this example WINDOWS. See the headings in the table on page 3 for a list of components that are eligible to receive retrofits.

SAMPLE RETROFIT LISTING

```
ID=003,CO=WINDOWS,DE=Install summmer exterior SHADE,PL=o,UT=sqft;10,VL=V04#H:V05=DHF:,AC=A12=(D12|.2+|):A14=(D14|.25*):,UN=*,UC=50;1,1,CC=100;1,1,RY=50;15,RF=Jim,
```

- ID=003 — Identification number
- CO=WINDOWS — Component
- DE=Install summmer exterior SHADE — Retrofit description
- PL=o — Location on component
- UT=sqft;10 — Unit for cost analysis (unit:data position)
- VL=V04#H:V05=DHF: — Component requirements
- AC=A12=(D12|.2+|):A14=(D14|.25*): — Retrofit action
- UN=* — Retrofit unaction
- UC=50;1,1 — Do-it-yourself cost (fixed:marginal)
- CC=100;1,1 — Contractor cost (fixed:marginal)
- RY=50;15 — Percent replacement over N years (percent:years)
- RF=Jim — Reference

DE — Retrofit Description

DE is the description of the retrofit. This is the description that is later used on the retrofit optimization output form. A maximum of 40 characters is permitted.

PL — Location on Component

PL is the location or plane on the component that receives the retrofit. Some components have more than one plane on which retrofits may be installed. Only one plane may be specified for each retrofit. The following table presents the plane codes used in CIRA.

PLANE CODES

APPLIANC	DOORS	GENERAL	HVAC-SYS	INFILTRA
p - dhw pipes	d - door	t - thermostat	c - cooling	f - fan
r - refrigerator	i - inside	c - cooling thermostat	d - ducts	
s - showerhead	o - outside	s - setback	f - flue	
t - thermostat			h - heating	
w - water heater			p - pilot	

ROOF/CEI	SUBFLOOR	WALLS	WINDOWS
a - attic	d - door	c - cavity	d - drape
e - edge	i - insulate	i - inside	e - edge
h - hatch	j - joists	o - outside	g - glazing
i - in attic or cavity	w - wall surface		i - inside frame
	x - wall insulation		o - outer
			r - roll shade
			s - outside frame

UT — Unit for Cost Analysis

UT is the unit associated with the marginal cost of a retrofit (see discussion of UC and CC, user and contractor costs), in the sample retrofit, sqft, which is stored in data position 10.

VL — Component Requirements

VL are the requirements which must be met for a retrofit to be considered for a particular component. For example, if the code for this field is VL=V04#H:V05=DHF, then the retrofit will be considered only if the character stored in data position 4 (window orientation) is not H (Horizontal) and the character stored in data position 5 (window type) is either D, H, or F (Double hung, Horizontal sliding, or Fixed).

AC — Retrofit Action

AC is the action taken (in reverse polish notation, RPN) once a retrofit is considered. In most cases, the action taken is to change one or more parameters that describe the component to reflect the physical impact of a retrofit on that component. In this case, there are two actions: a) to take the value in data position 12 (U-value), invert it, add 0.2 and invert the result; and b) to take the value in data position 14 (summer solar gain factor) and multiply it by 0.25.

UN — Retrofit Unaction

UN is the action taken to reverse the effect of a previous retrofit if a new retrofit is installed on the same plane of the component. If the code for the field is UN=* as it is in this case, then the unaction is the same as the retrofit action, except multiplication is changed to division (and vice versa), and addition is changed to subtraction (and vice versa).

UC — Do-it-yourself Cost

UC is the do-it-yourself or user cost ($) of implementing a retrofit. This cost is separated into two values, the fixed and marginal costs. The fixed cost is the cost of getting started on the work, or in the case where no marginal cost is used, the fixed cost becomes the total cost of implementing the retrofit. The marginal cost is the cost per unit (for example, square foot or linear foot) in addition to the fixed cost. A value of -99 for the user cost means that it is not considered to be a do-it-yourself retrofit. In the sample retrofit, the cost is 50 plus $1.10 per square foot.

CC — Contractor Cost

CC is the contractor cost of implementing a retrofit. Like the do-it-yourself cost, this cost is separated into fixed and marginal costs. In the sample retrofit, the cost is $100 plus $1.10 per square foot.

RY — Replacement Factor

RY is the factor associated with the replacement and maintenance costs that are calculated for the retrofit. In the sample retrofit, the factor is 50% replacement after 15 years.

RF — Reference

RF is a reference for the retrofit entry provided for the user to document the source of the retrofit information. Any code is permissable.

KEY TO SYMBOLS USED IN <COMPONENT>.RET FILES

D12 is the data stored in the HOUSE.DAT file, in the row corresponding to the component being considered and in column 12.

V06 is used to scan the data in the HOUSE.DAT file, in the row corresponding to the component and in column 6.

A14 is the new value for column 14 resulting from a retrofit action.

U14 is the value of column 14 following a retrofit unaction.

OPERATORS

(i) Reverse Polish

!	enter	*	multiply	/	divide	+	plus
-	minus	'	absolute value	¦	invert	^	is y^x
@	change sign	>	is x > y?	<	is x < y?	=	is x = y?
#	is x ≠ y?	)	is x >= y?	(	is x <= y?	L	ln(x)
X	exp (x)	~	exchange x and y				

All operators work exactly like those in a Hewlett-Packard calculator (complete with 4 internal registers) except for the logical operations. Rather than branching as in an HP calculator, a "true" result of a logical test places "-1" into the x register, while a "false" result places a "0" there, while all upper registers are "rolled" down one step.

(ii) Other

, a comma separates each field

: a colon separates values in a field when two or more are present.

DETAILED RETROFIT LISTINGS

The values of the twelve field codes for each retrofit listed in the Retrofit Library are presented in the following pages in a more "readable" format, one line for each field in a retrofit. The <Component>.RET files (found on disk "B") contain a complete string of field codes for each retrofit without carriage returns.

CIRA is designed so the retrofit description, user and contractor costs, replacement factors, and references can be changed if more appropriate information is available. User and contractor costs are based on a sampling of retailers, contractors, utilities, and government research laboratories. We recommend that the user compare these estimates with the average costs in their region and change them where necessary. However, we advise the unwary user not to change the retrofit actions and unactions, units, and component requirements on the program disk.

APPLIANC retrofits: 1 to 4

```
Identification NUMBER........... 001
COMPONENT....................... APPLIANCES
Retrofit DESCRIPTION............ Install LOW FLOW SHOWERHEAD
UNITS for cost analysis......... each:
LOCATION on component........... s
Component REQUIREMENTS.......... V17>10:
Retrofit ACTIONS................ A17={D17!0.65*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 15:0
Fixed:Marginal CONTRACTOR costs. 30:0
Percent REPLACEMENT:YEARS....... 100:10
REFERENCE....................... JBD/RCS

Identification NUMBER........... 002
COMPONENT....................... APPLIANCES
Retrofit DESCRIPTION............ Set water htr. thermostat to 120 F
UNITS for cost analysis......... each:
LOCATION on component........... t
Component REQUIREMENTS.......... V06>125:
Retrofit ACTIONS................ A06={120!}:
Retrofit UNACTIONS.............. U06={D06!120-}:
Fixed:Marginal USER costs....... 0.5:0
Fixed:Marginal CONTRACTOR costs. 0.5:0
Percent REPLACEMENT:YEARS....... 1:50
REFERENCE....................... RCS

Identification NUMBER........... 003
COMPONENT....................... APPLIANCES
Retrofit DESCRIPTION............ Install R-6 water htr. blanket
UNITS for cost analysis......... each:
LOCATION on component........... w
Component REQUIREMENTS.......... V08=GE:
Retrofit ACTIONS................ A10={D10!.76*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 18:0
Fixed:Marginal CONTRACTOR costs. 30:0
Percent REPLACEMENT:YEARS....... 100:10
REFERENCE....................... Clear/BD/RCS

Identification NUMBER........... 004
COMPONENT....................... APPLIANCES
Retrofit DESCRIPTION............ New HEAT PUMP water heater
UNITS for cost analysis......... each:
LOCATION on component........... w
Component REQUIREMENTS.......... V08=EA:
Retrofit ACTIONS................ A05={D05!.0015+}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 800:0
Fixed:Marginal CONTRACTOR costs. 1100:0
Percent REPLACEMENT:YEARS....... 100:15
REFERENCE....................... LC03
```

```
Identification NUMBER........... 005
COMPONENT....................... APPLIANCES
Retrofit DESCRIPTION............ Insulate hot water pipes
UNITS for cost analysis......... each:
LOCATION on component........... p
Component REQUIREMENTS.......... V10>1000:V00=Y:
Retrofit ACTIONS................ A10={D10!.90*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 25:0
Fixed:Marginal CONTRACTOR costs. 100:0
Percent REPLACEMENT:YEARS....... 50:10
REFERENCE....................... LC09
```

```
Identification NUMBER........... 006
COMPONENT....................... APPLIANCES
Retrofit DESCRIPTION............ Buy new EFFICIENT REFRIGERATOR
UNITS for cost analysis......... each:
LOCATION on component........... r
Component REQUIREMENTS.......... V07>500:
Retrofit ACTIONS................ A07={261!}:
Retrofit UNACTIONS.............. U07={D07!261-}:
Fixed:Marginal USER costs....... 700:0
Fixed:Marginal CONTRACTOR costs. 700:0
Percent REPLACEMENT:YEARS....... 100:25
REFERENCE....................... RCS
```

```
ID=001,CO=APPLIANCES,DE=Install LOW FLOW SHOWERHEAD,PL=s,UT=each:,
  VL=V17>10:,AC=A17={D17!0.65*}:,UN=*,UC=15:0,CC=30:0,RY=100:10,RF
  =JBD/RCS,
ID=002,CO=APPLIANCES,DE=Set water htr. thermostat to 120 F,PL=t,UT
  =each:,VL=V06>125:,AC=A06={120!}:,UN=U06={D06!120-}:,UC=0.5:0,CC
  =0.5:0,RY=1:50,RF=RCS,
ID=003,CO=APPLIANCES,DE=Install R-6 water htr. blanket,PL=w,UT=each
  :,VL=V08=GE:,AC=A10={D10!.76*}:,UN=*,UC=18:0,CC=30:0,RY=100:10,RF
  =Clear/BD/RCS,
ID=004,CO=APPLIANCES,DE=New HEAT PUMP water heater,PL=w,UT=each:,VL
  =V08=EA:,AC=A05={D05!.0015+}:,UN=*,UC=800:0,CC=1100:0,RY=100:15,
  RF=LC03,
ID=005,CO=APPLIANCES,DE=Insulate hot water pipes,PL=p,UT=each:,VL=
  V10>1000:V00=Y:,AC=A10={D10!.90*}:,UN=*,UC=25:0,CC=100:0,RY=50:
  10,RF=LC09,
ID=006,CO=APPLIANCES,DE=Buy new EFFICIENT REFRIGERATOR,PL=r,UT=each
  ,RY=100:25,RF=RCS,
```

DOORS retrofits: 1 to 4

```
Identification NUMBER........... 001
COMPONENT....................... DOORS
Retrofit DESCRIPTION............ Install EXTERIOR alum. STORM
UNITS for cost analysis......... sqft:10
LOCATION on component........... o
Component REQUIREMENTS.......... V05=PSF:V07=NI:
Retrofit ACTIONS................ A12={D12|1.0+|}:A13={D13!0.6*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 0:3.50
Fixed:Marginal CONTRACTOR costs. 0:10.0
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... ASHRAE/port. ge/RCS/DD

Identification NUMBER........... 002
COMPONENT....................... DOORS
Retrofit DESCRIPTION............ Install INTERIOR STORM
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V05=PSF:V07=NO:
Retrofit ACTIONS................ A12={D12|1.0+|}:A13={D13!0.6*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 0:3.10
Fixed:Marginal CONTRACTOR costs. 0:9.50
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... ASHRAE/RCS/DD

Identification NUMBER........... 003
COMPONENT....................... DOORS
Retrofit DESCRIPTION............ Install NEW insulating DOOR
UNITS for cost analysis......... sqft:10
LOCATION on component........... d
Component REQUIREMENTS.......... V05#X:V06#UP:
Retrofit ACTIONS................ A12={D12!1000/7.14+|}:A13={D13!1000/.015+}:
Retrofit UNACTIONS.............. U12={D12|7.14-1000*}:U13={D13!.015-1000*}:
Fixed:Marginal USER costs....... 15:5.0
Fixed:Marginal CONTRACTOR costs. 20:7.00
Percent REPLACEMENT:YEARS....... 100:30
REFERENCE....................... RCS/JBD

Identification NUMBER........... 004
COMPONENT....................... DOORS
Retrofit DESCRIPTION............ WEATHERSTRIP
UNITS for cost analysis......... sqft:10
LOCATION on component........... d
Component REQUIREMENTS.......... V05#X:V09#T:
Retrofit ACTIONS................ A13={D13!0.75*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 5:0.30
Fixed:Marginal CONTRACTOR costs. 10:0.9
Percent REPLACEMENT:YEARS....... 25:5
REFERENCE....................... RCS/JBD
```

```
ID=001,CO=DOORS,DE=Install EXTERIOR alum. STORM,PL=o,UT=sqft:10,VL
  =V05=PSF:V07=NI:,AC=A12={D12|1.0+|}:A13={D13!0.6*}:,UN=*,UC=0:3.5
  0,CC=0:10.0,RY=100:20,RF=ASHRAE/port. ge/RCS/DD,
ID=002,CO=DOORS,DE=Install INTERIOR STORM,PL=i,UT=sqft:10,VL=V05
  =PSF:V07=NO:,AC=A12={D12|1.0+|}:A13={D13!0.6*}:,UN=*,UC=0:3.10,
  CC=0:9.50,RY=100:20,RF=ASHRAE/RCS/DD,
ID=003,CO=DOORS,DE=Install NEW insulating DOOR,PL=d,UT=sqft:10,VL
  =V05#X:V06#UP:,AC=A12={D12!1000/7.14+|}:A13={D13!1000/.015+}:,UN
  =U12={D12|7.14-1000*}:U13={D13!.015-1000*}:,UC=15:5.0,CC=20:7.00,
  RY=100:30,RF=RCS/JBD,
ID=004,CO=DOORS,DE=WEATHERSTRIP,PL=d,UT=sqft:10,VL=V05#X:V09#T:,AC
  =A13={D13!0.75*}:,UN=*,UC=5:.30,CC=10:0.9,RY=25:5,RF=pge/RCS/JBD
```

GENERAL retrofits: 1 to 4

```
Identification NUMBER........... 001
COMPONENT....................... GENERAL
Retrofit DESCRIPTION............ Lower Htg. THERMOSTAT by 3 F always
UNITS for cost analysis......... each:
LOCATION on component........... t
Component REQUIREMENTS.......... V17=HD:V08>65:
Retrofit ACTIONS................ A08={D08!3-}:A09={D09!3-}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... .5:0
Fixed:Marginal CONTRACTOR costs. .5:0
Percent REPLACEMENT:YEARS....... 1:50
REFERENCE....................... JBD/RCS
```

```
Identification NUMBER........... 002
COMPONENT....................... GENERAL
Retrofit DESCRIPTION............ Lower Htg. THERMOSTAT by 5 F always
UNITS for cost analysis......... each:
LOCATION on component........... t
Component REQUIREMENTS.......... V17=HD:V08>65:V00=Y:
Retrofit ACTIONS................ A08={D08!5-}:A09={D09!5-}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... .5:0
Fixed:Marginal CONTRACTOR costs. .5:0
Percent REPLACEMENT:YEARS....... 1:50
REFERENCE....................... JBD/RCS
```

```
Identification NUMBER........... 003
COMPONENT....................... GENERAL
Retrofit DESCRIPTION............ Raise Clg. THERMOSTAT by 3 F always
UNITS for cost analysis......... each:
LOCATION on component........... c
Component REQUIREMENTS.......... V17=CD:V10<80:V00=Y:
Retrofit ACTIONS................ A10={D10!3+}:A11={D11!3+}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... .5:0
Fixed:Marginal CONTRACTOR costs. .5:0
Percent REPLACEMENT:YEARS....... 1:50
REFERENCE....................... JBD/RCS
```

```
Identification NUMBER........... 004
COMPONENT....................... GENERAL
Retrofit DESCRIPTION............ Raise Clg. THERMOSTAT by 5 F always
UNITS for cost analysis......... each:
LOCATION on component........... c
Component REQUIREMENTS.......... V17=CD:V10<80:V00=Y:
Retrofit ACTIONS................ A10={D10!5+}:A11={D09!5+}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... .5:0
Fixed:Marginal CONTRACTOR costs. .5:0
Percent REPLACEMENT:YEARS....... 1:50
REFERENCE....................... JBD/RCS
```

GENERAL retrofits: 5 to 8

```
Identification NUMBER........... 005
COMPONENT....................... GENERAL
Retrofit DESCRIPTION............ Install AUTO. 5 F Htg. NIGHT SETBACK
UNITS for cost analysis......... each:
LOCATION on component........... s
Component REQUIREMENTS.......... V17=H:V09>60:
Retrofit ACTIONS................ A09={D09!5-}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 75:0
Fixed:Marginal CONTRACTOR costs. 120:0
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... JBD/RCS

Identification NUMBER........... 006
COMPONENT....................... GENERAL
Retrofit DESCRIPTION............ Install AUTO. 10 F Htg. NIGHT SETBACK
UNITS for cost analysis......... each:
LOCATION on component........... s
Component REQUIREMENTS.......... V17=H:V09>60:V00=Y:
Retrofit ACTIONS................ A09={D09!10-}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 75:0
Fixed:Marginal CONTRACTOR costs. 120:0
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... JBD/RCS

Identification NUMBER........... 007
COMPONENT....................... GENERAL
Retrofit DESCRIPTION............ Install AUTO. 5 F Clg. NIGHT SETBACK
UNITS for cost analysis......... each:
LOCATION on component........... s
Component REQUIREMENTS.......... V17=C:V11<85:
Retrofit ACTIONS................ A11={D11!5+}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 75:0
Fixed:Marginal CONTRACTOR costs. 120:0
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... JBD/RCS

Identification NUMBER........... 008
COMPONENT....................... GENERAL
Retrofit DESCRIPTION............ Install AUTO. 10 F Clg. NIGHT SETBACK
UNITS for cost analysis......... each:
LOCATION on component........... s
Component REQUIREMENTS.......... V17=C:V11<85:V00=Y:
Retrofit ACTIONS................ A11={D11!10+}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 75:0
Fixed:Marginal CONTRACTOR costs. 120:0
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... JBD/RCS
```

GENERAL retrofits: 9 to 10

```
Identification NUMBER........... 009
COMPONENT....................... GENERAL
Retrofit DESCRIPTION............ AUTO. 5 F Htg. & Clg. NIGHT SETBACK
UNITS for cost analysis......... each:
LOCATION on component........... s
Component REQUIREMENTS.......... V17=D:V09>60:V11<85:
Retrofit ACTIONS................ A09={D09!5-}:A11={D11!5+}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 75:0
Fixed:Marginal CONTRACTOR costs. 120:0
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... JBD/RCS
```

```
Identification NUMBER........... 010
COMPONENT....................... GENERAL
Retrofit DESCRIPTION............ AUTO. 10 F Htg. & Clg. NIGHT SETBACK
UNITS for cost analysis......... each:
LOCATION on component........... s
Component REQUIREMENTS.......... V17=D:V09>60:V11<85:V00=Y:
Retrofit ACTIONS................ A09={D09!10-}:A11={D11!10+}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 75:0
Fixed:Marginal CONTRACTOR costs. 120:0
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... JBD/RCS
```

```
ID=001,CO=GENERAL,DE=Lower Htg. THERMOSTAT by 3 F always,PL=t,UT
  =each:,VL=V17=HD:V08>65:,AC=A08={D08!3-}:A09={D09!3-}:,UN=*,UC
  =.5:0,CC=.5:0,RY=1:50,RF=JBD/RCS,
ID=002,CO=GENERAL,DE=Lower Htg. THERMOSTAT by 5 F always,PL=t,UT
  =each:,VL=V17=HD:V08>65:V00=Y:,AC=A08={D08!5-}:A09={D09!5-}:,UN
  =*,UC=.5:0,CC=.5:0,RY=1:50,RF=JBD/RCS,
ID=003,CO=GENERAL,DE=Raise Clg. THERMOSTAT by 3 F always,PL=c,UT
  =each:,VL=V17=CD:V10<80:V00=Y:,AC=A10={D10!3+}:A11={D11!3+}:,UN
  =*,UC=.5:0,CC=.5:0,RY=1:50,RF=JBD/RCS,
ID=004,CO=GENERAL,DE=Raise Clg. THERMOSTAT by 5 F always,PL=c,UT
  =each:,VL=V17=CD:V10<80:V00=Y:,AC=A10={D10!5+}:A11={D09!5+}:,UN
  =*,UC=.5:0,CC=.5:0,RY=1:50,RF=JBD/RCS,
ID=005,CO=GENERAL,DE=Install AUTO. 5 F Htg. NIGHT SETBACK,PL=s,UT
  =each:,VL=V17=HD:V09>60:,AC=A09={D09!5-}:,UN=*,UC=75:0,CC=120:0,
  RY=100:20,RF=JBD/RCS,
ID=006,CO=GENERAL,DE=Install AUTO. 10 F Htg. NIGHT SETBACK,PL=s,UT
  =each:,VL=V17=HD:V09>60:V00=Y:,AC=A09={D09!10-}:,UN=*,UC=75:0,CC
  =120:0,RY=100:20,RF=JBD/RCS,
ID=007,CO=GENERAL,DE=Install AUTO. 5 F Clg. NIGHT SETBACK,PL=s,UT
  =each:,VL=V17=CD:V11<85:,AC=A11={D11!5+}:,UN=*,UC=75:0,CC=120:0,
  RY=100:20,RF=JBD/RCS,
ID=008,CO=GENERAL,DE=Install AUTO. 10 F Clg. NIGHT SETBACK,PL=s,UT
  =each:,VL=V17=CD:V11<85:V00=Y:,AC=A11={D11!10+}:,UN=*,UC=75:0,CC
  =120:0,RY=100:20,RF=JBD/RCS,
ID=009,CO=GENERAL,DE=AUTO. 5 F Htg. & Clg. NIGHT SETBACK,PL=s,UT
  =each:,VL=V17=D:V09>60:V11<85:,AC=A09={D09!5-}:A11={D11!5+}:,UN
  =*,UC=75:0,CC=120:0,RY=100:20,RF=JBD/RCS,
ID=010,CO=GENERAL,DE=AUTO. 10 F Htg. & Clg. NIGHT SETBACK,PL=s,UT
  =each:,VL=V17=D:V09>60:V11<85:V00=Y:,AC=A09={D09!10-}:A11={D11!
  10+}:,UN=*,UC=75:0,CC=120:0,RY=100:20,RF=JBD/RCS,
```

```
Identification NUMBER........... 001
COMPONENT....................... HVAC-SYS
Retrofit DESCRIPTION............ Tune up burner
UNITS for cost analysis......... each:
LOCATION on component........... h
Component REQUIREMENTS.......... V04=GLBF:V06<.70:
Retrofit ACTIONS................ A06={D06!1.05*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... -99:-99
Fixed:Marginal CONTRACTOR costs. 60:0
Percent REPLACEMENT:YEARS....... 100:5
REFERENCE....................... BNL-CE/RCS
```

```
Identification NUMBER........... 002
COMPONENT....................... HVAC-SYS
Retrofit DESCRIPTION............ Reduce boiler water temp.
UNITS for cost analysis......... each:
LOCATION on component........... h
Component REQUIREMENTS.......... V04=BL:
Retrofit ACTIONS................ A06={D06!1.05*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 50:0
Fixed:Marginal CONTRACTOR costs. 50:0
Percent REPLACEMENT:YEARS....... 10:30
REFERENCE....................... BNL-CE
```

```
Identification NUMBER........... 003
COMPONENT....................... HVAC-SYS
Retrofit DESCRIPTION............ Replace oil burner nozzle
UNITS for cost analysis......... each:
LOCATION on component........... h
Component REQUIREMENTS.......... V04=FB:
Retrofit ACTIONS................ A06={D06!1.04*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... -99:-99
Fixed:Marginal CONTRACTOR costs. 70:0
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... BNL-CE
```

```
Identification NUMBER........... 004
COMPONENT....................... HVAC-SYS
Retrofit DESCRIPTION............ Install flame retention burner
UNITS for cost analysis......... each:
LOCATION on component........... h
Component REQUIREMENTS.......... V04=FB:
Retrofit ACTIONS................ A06={D06!1.14*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 0:0
Fixed:Marginal CONTRACTOR costs. 350:0
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... BNL
```

HVAC-SYS retrofits: 5 to 8

```
Identification NUMBER........... 005
COMPONENT....................... HVAC-SYS
Retrofit DESCRIPTION............ New oil boiler w/ flame ret. burner
UNITS for cost analysis......... each:
LOCATION on component........... h
Component REQUIREMENTS.......... V04=B:
Retrofit ACTIONS................ A06={D06!100/.90+}:
Retrofit UNACTIONS.............. U06={D06!.90-100*}:
Fixed:Marginal USER costs....... -99:-99
Fixed:Marginal CONTRACTOR costs. 1800:0
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... BNL

Identification NUMBER........... 006
COMPONENT....................... HVAC-SYS
Retrofit DESCRIPTION............ Reduce gas orifice
UNITS for cost analysis......... each:
LOCATION on component........... h
Component REQUIREMENTS.......... V04=GL:
Retrofit ACTIONS................ A06={D06!1.05*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... -99:-99
Fixed:Marginal CONTRACTOR costs. 50:0
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... adl

Identification NUMBER........... 007
COMPONENT....................... HVAC-SYS
Retrofit DESCRIPTION............ New regenerative gas furnace
UNITS for cost analysis......... each:
LOCATION on component........... h
Component REQUIREMENTS.......... V04=GL:
Retrofit ACTIONS................ A06={D06!100/.85+}:
Retrofit UNACTIONS.............. U06={D06!.85-100*}:
Fixed:Marginal USER costs....... -99:-99
Fixed:Marginal CONTRACTOR costs. 2000:0
Percent REPLACEMENT:YEARS....... 100:30
REFERENCE....................... pg&e

Identification NUMBER........... 008
COMPONENT....................... HVAC-SYS
Retrofit DESCRIPTION............ Install flue economizer
UNITS for cost analysis......... each:
LOCATION on component........... f
Component REQUIREMENTS.......... V04=FB:V06<.9:V16>300:
Retrofit ACTIONS................ A06={D06!1.11*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... -99:-99
Fixed:Marginal CONTRACTOR costs. 650:0
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... BNL
```

Identification NUMBER...........	009
COMPONENT.......................	HVAC-SYS
Retrofit DESCRIPTION............	**Install electrical flue damper**
UNITS for cost analysis.........	each:
LOCATION on component...........	f
Component REQUIREMENTS..........	V04=FB:V06<.8:
Retrofit ACTIONS................	A06={D06!1.08*}:
Retrofit UNACTIONS..............	*
Fixed:Marginal USER costs.......	-99:-99
Fixed:Marginal CONTRACTOR costs.	200:0
Percent REPLACEMENT:YEARS.......	100:20
REFERENCE.......................	adl

Identification NUMBER...........	010
COMPONENT.......................	HVAC-SYS
Retrofit DESCRIPTION............	**Install electrical flue damper**
UNITS for cost analysis.........	each:
LOCATION on component...........	f
Component REQUIREMENTS..........	V04=GL:V06<.8:
Retrofit ACTIONS................	A06={D06!1.09*}:
Retrofit UNACTIONS..............	*
Fixed:Marginal USER costs.......	-99:-99
Fixed:Marginal CONTRACTOR costs.	180:0
Percent REPLACEMENT:YEARS.......	100:20
REFERENCE.......................	adl

Identification NUMBER...........	011
COMPONENT.......................	HVAC-SYS
Retrofit DESCRIPTION............	**Install thermal flue damper**
UNITS for cost analysis.........	each:
LOCATION on component...........	f
Component REQUIREMENTS..........	V04=GL:V06<.8:
Retrofit ACTIONS................	A06={D06!1.05*}:
Retrofit UNACTIONS..............	*
Fixed:Marginal USER costs.......	-99:-99
Fixed:Marginal CONTRACTOR costs.	65:0
Percent REPLACEMENT:YEARS.......	100:20
REFERENCE.......................	adl

Identification NUMBER...........	012
COMPONENT.......................	HVAC-SYS
Retrofit DESCRIPTION............	**Install electronic pilot**
UNITS for cost analysis.........	each:
LOCATION on component...........	p
Component REQUIREMENTS..........	V04=GL:V06<.85:
Retrofit ACTIONS................	A06={D06!1.05*}:
Retrofit UNACTIONS..............	*
Fixed:Marginal USER costs.......	-99:-99
Fixed:Marginal CONTRACTOR costs.	170:0
Percent REPLACEMENT:YEARS.......	100:20
REFERENCE.......................	pge

HVAC-SYS retrofits: 13 to 16

```
Identification NUMBER........... 013
COMPONENT....................... HVAC-SYS
Retrofit DESCRIPTION............ Seal & insulate ducts
UNITS for cost analysis......... 1ft:15
LOCATION on component........... d
Component REQUIREMENTS.......... V07=F:V08#L:V09=N:
Retrofit ACTIONS................ A10={D10!0.4*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 25:0.5
Fixed:Marginal CONTRACTOR costs. 50:1.0
Percent REPLACEMENT:YEARS....... 30:20
REFERENCE....................... RCS/JBD
```

```
Identification NUMBER........... 014
COMPONENT....................... HVAC-SYS
Retrofit DESCRIPTION............ Seal ducts
UNITS for cost analysis......... 1ft:15
LOCATION on component........... d
Component REQUIREMENTS.......... V07=F:V08#L:
Retrofit ACTIONS................ A10={D10!0.75*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 25:0.1
Fixed:Marginal CONTRACTOR costs. 50:0.6
Percent REPLACEMENT:YEARS....... 30:20
REFERENCE....................... RCS/JBD
```

```
Identification NUMBER........... 015
COMPONENT....................... HVAC-SYS
Retrofit DESCRIPTION............ Insulate heating pipes
UNITS for cost analysis......... 1ft:15
LOCATION on component........... d
Component REQUIREMENTS.......... V07=SW:V08#L:V09=N:
Retrofit ACTIONS................ A10={D10!0.5*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 25:0.2
Fixed:Marginal CONTRACTOR costs. 50:1.0
Percent REPLACEMENT:YEARS....... 30:20
REFERENCE....................... RCS/JBD
```

```
Identification NUMBER........... 016
COMPONENT....................... HVAC-SYS
Retrofit DESCRIPTION............ New EFFICIENT central A/C
UNITS for cost analysis......... each:
LOCATION on component........... c
Component REQUIREMENTS.......... V13<3.5:V11#N:V07=F:
Retrofit ACTIONS................ A13={D13!1000/4.2+}:
Retrofit UNACTIONS.............. U13={D13!4.2-1000*}:
Fixed:Marginal USER costs....... 3000:0
Fixed:Marginal CONTRACTOR costs. 4000:0
Percent REPLACEMENT:YEARS....... 10:5
REFERENCE....................... LC04/Lenox
```

HVAC-SYS retrofits: 17 to 17

```
Identification NUMBER........... 017
COMPONENT....................... HVAC-SYS
Retrofit DESCRIPTION............ Switch A/C to EVAPORATIVE COOLER
UNITS for cost analysis......... each:
LOCATION on component........... c
Component REQUIREMENTS.......... V13<3.5:V11#NE:V07=F:
Retrofit ACTIONS................ A13={.85!}:A12={1366!}:A14={V17!}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 600:0
Fixed:Marginal CONTRACTOR costs. 1600:0
Percent REPLACEMENT:YEARS....... 10:5
REFERENCE....................... LC06
```

```
ID=001,CO=HVAC-SYS,DE=Tune up burner,PL=h,UT=each:,VL=V04=GLBF:V06<
  .70:,AC=A06={D06!1.05*}:,UN=*,UC=-99:-99,CC=60:0,RY=100:5,RF=BNL
  -CE/RCS,
ID=002,CO=HVAC-SYS,DE=Reduce boiler water temp.,PL=h,UT=each:,VL=V0
  4=BL:,AC=A06={D06!1.05*}:,UN=*,UC=50:0,CC=50:0,RY=10:30,RF=BNL-CE,
ID=003,CO=HVAC-SYS,DE=Replace oil burner nozzle,PL=h,UT=each:,VL=V0
  4=FB:,AC=A06={D06!1.04*}:,UN=*,UC=-99:-99,CC=70:0,RY=100:20,RF=
  BNL-CE,
ID=004,CO=HVAC-SYS,DE=Install flame retention burner,PL=h,UT=each:,
  VL=V04=FB:,AC=A06={D06!1.14*}:,UN=*,UC=0:0,CC=350:0,RY=100:20,RF
  =BNL,
ID=005,CO=HVAC-SYS,DE=New oil boiler w/ flame ret. burner,PL=h,UT=e
  ach:,VL=V04=B:,AC=A06={D06!100/.90+}:,UN={D06!.90-100*},UC=-99:
  -99,CC=1800:0,RY=100:20,RF=BNL,
ID=006,CO=HVAC-SYS,DE=Reduce gas orifice,PL=h,UT=each:,VL=V04=GL:,A
  C=A06={D06!1.05*}:,UN=*,UC=-99:-99,CC=50:0,RY=100:20,RF=adl,
ID=007,CO=HVAC-SYS,DE=New regenerative gas furnace,PL=h,UT=each:,VL
  =V04=GL:,AC=A06={D06!100/.85+}:,UN={D06!.85-100*},UC=-99:-99,CC=
  2000:0,RY=100:30,RF=pg&e,
ID=008,CO=HVAC-SYS,DE=Install flue economizer,PL=f,UT=each:,VL=V04=
  FB:V06<.9:V16>300:,AC=A06={D06!1.11*}:,UN=*,UC=-99:-99,CC=650:0,
  RY=100:20,RF=BNL,
ID=009,CO=HVAC-SYS,DE=Install electrical flue damper,PL=f,UT=each:,
  VL=V04=FB:V06<.8:,AC=A06={D06!1.08*}:,UN=*,UC=-99:-99,CC=200:0,
  RY=100:20,RF=adl,
ID=010,CO=HVAC-SYS,DE=Install electrical flue damper,PL=f,UT=each:,
  VL=V04=GL:V06<.8:,AC=A06={D06!1.09*}:,UN=*,UC=-99:-99,CC=180:0,
  RY=100:20,RF=adl,
ID=011,CO=HVAC-SYS,DE=Install thermal flue damper,PL=f,UT=each:,VL=
  V04=GL:V06<.8:,AC=A06={D06!1.05*}:,UN=*,UC=-99:-99,CC=65:0,RY=
  100:20,RF=adl,
ID=012,CO=HVAC-SYS,DE=Install electronic pilot,PL=p,UT=each:,VL=V04
  =GL:V06<.85:,AC=A06={D06!1.05*}:,UN=*,UC=-99:-99,CC=170:0,RY=100:
  20,RF=pge,
ID=013,CO=HVAC-SYS,DE=Seal & insulate ducts,PL=d,UT=1ft:15,VL=V07=F
  :V08#L:V09=N:,AC=A10={D10!0.4*}:,UN=*,UC=25:0.5,CC=50:1.0,RY=30:
  20,RF=RCS/JBD,
ID=014,CO=HVAC-SYS,DE=Seal ducts,PL=d,UT=1ft:15,VL=V07=F:V08#L:V14
  #C:,AC=A10={D10!0.75*}:,UN=*,UC=25:0.1,CC=50:0.6,RY=30:20,RF=RCS
  /JBD,
ID=015,CO=HVAC-SYS,DE=Insulate heating pipes,PL=d,UT=1ft:15,VL=V07=
  SW:V08#L:V09=N:,AC=A10={D10!0.5*}:,UN=*,UC=25:0.2,CC=50:1.0,RY=
  30:20,RF=RCS/JBD,
ID=016,CO=HVAC-SYS,DE=New EFFICIENT central A/C,PL=c,UT=each:,VL=V1
  3<3.5:V11#N:V07=F:,AC=A13={D13!1000/4.2+}:,UN=U13={D13!4.2-1000*
  }:,UC=3000:0,CC=4000:0,RY=10:5,RF=LC04/Lenox,
ID=017,CO=HVAC-SYS,DE=Switch A/C to EVAPORATIVE COOLER,PL=c,UT=each
  :,VL=V13<3.5:V11#NE:V07=F:,AC=A13={.85!}:A12={1366!}:A14={V17!}:,
  UN=*,UC=600:0,CC=1600:0,RY=10:5,RF=LC06,
```

ROOF-CEI retrofits: 1 to 4

Identification NUMBER........... 001
COMPONENT....................... ROOF-CEI
Retrofit DESCRIPTION............ **Install small attic fan**
UNITS for cost analysis......... each:
LOCATION on component........... a
Component REQUIREMENTS.......... V13<0.5:V10<999.5:
Retrofit ACTIONS................ A13={D13!1.0+}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 80:0
Fixed:Marginal CONTRACTOR costs. 280:0
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... DA-UE/CE/RCS

Identification NUMBER........... 002
COMPONENT....................... ROOF-CEI
Retrofit DESCRIPTION............ **Install large attic fan**
UNITS for cost analysis......... each:
LOCATION on component........... a
Component REQUIREMENTS.......... V13<0.5:V10>999.5:
Retrofit ACTIONS................ A13={D13!1.0+}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 180:0
Fixed:Marginal CONTRACTOR costs. 380:0
Percent REPLACEMENT:YEARS....... 100:20
REFERENCE....................... DA-UE/CE/RCS

Identification NUMBER........... 003
COMPONENT....................... ROOF-CEI
Retrofit DESCRIPTION............ **Seal largest cracks & holes**
UNITS for cost analysis......... sqft:10
LOCATION on component........... e
Component REQUIREMENTS.......... V05=U:V06>.26:
Retrofit ACTIONS................ A06={D06!.60*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 10:.05
Fixed:Marginal CONTRACTOR costs. 30:.1
Percent REPLACEMENT:YEARS....... 100:15
REFERENCE....................... CSA-CE/RCS/JBD

Identification NUMBER........... 004
COMPONENT....................... ROOF-CEI
Retrofit DESCRIPTION............ **Seal cracks & holes thoroughly**
UNITS for cost analysis......... sqft:10
LOCATION on component........... e
Component REQUIREMENTS.......... V05=U:V06>.26:
Retrofit ACTIONS................ A06={D06!.40*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 10:.1
Fixed:Marginal CONTRACTOR costs. 60:.2
Percent REPLACEMENT:YEARS....... 100:15
REFERENCE....................... CSA-CE/RCS/JBD

ROOF-CEI retrofits: 5 to 8

```
Identification NUMBER........... 005
COMPONENT....................... ROOF-CEI
Retrofit DESCRIPTION............ Weatherstrip attic hatch
UNITS for cost analysis......... each:
LOCATION on component........... h
Component REQUIREMENTS.......... V05#C:
Retrofit ACTIONS................ A06={D06!15!D10/-}:
Retrofit UNACTIONS.............. U06={D06!15!D10/+}:
Fixed:Marginal USER costs....... 4:0
Fixed:Marginal CONTRACTOR costs. 12:0
Percent REPLACEMENT:YEARS....... 100:15
REFERENCE....................... CSA-CE/JBD
```

```
Identification NUMBER........... 006
COMPONENT....................... ROOF-CEI
Retrofit DESCRIPTION............ Install 13 inches of loose fiberglass
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V08>12.9:
Retrofit ACTIONS................ A12={D12|38+|}:A06={D06!.95*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 10:.65
Fixed:Marginal CONTRACTOR costs. 20:.85
Percent REPLACEMENT:YEARS....... 25:20
REFERENCE....................... PGE/JBD
```

```
Identification NUMBER........... 007
COMPONENT....................... ROOF-CEI
Retrofit DESCRIPTION............ Install 6 inches of loose fiberglass
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V08>5.9:
Retrofit ACTIONS................ A12={D12|19+|}:A06={D06!.95*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 10:.30
Fixed:Marginal CONTRACTOR costs. 20:.45
Percent REPLACEMENT:YEARS....... 25:20
REFERENCE....................... PGE/JBD
```

```
Identification NUMBER........... 008
COMPONENT....................... ROOF-CEI
Retrofit DESCRIPTION............ Install 4 inches of loose fiberglass
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V08>3.9:
Retrofit ACTIONS................ A12={D12|11+|}:A06={D06!.95*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 10:.20
Fixed:Marginal CONTRACTOR costs. 20:.30
Percent REPLACEMENT:YEARS....... 25:20
REFERENCE....................... PGE/JBD
```

ROOF-CEI retrofits: 9 to 11

Identification NUMBER...........	009
COMPONENT.......................	ROOF-CEI
Retrofit DESCRIPTION............	**Install 11 inches of cellulose**
UNITS for cost analysis.........	sqft:10
LOCATION on component...........	i
Component REQUIREMENTS..........	V08>10.9:
Retrofit ACTIONS................	A12={D12|38+|}:A06={D06!.95*}:
Retrofit UNACTIONS..............	*
Fixed:Marginal USER costs.......	10:.50
Fixed:Marginal CONTRACTOR costs.	30:.85
Percent REPLACEMENT:YEARS.......	25:20
REFERENCE.......................	port.ge/RCS/JBD

Identification NUMBER...........	010
COMPONENT.......................	ROOF-CEI
Retrofit DESCRIPTION............	**Install 8 inches cellulose**
UNITS for cost analysis.........	sqft:10
LOCATION on component...........	i
Component REQUIREMENTS..........	V08>7.9:
Retrofit ACTIONS................	A12={D12|30+|}:A06={D06!.95*}:
Retrofit UNACTIONS..............	*
Fixed:Marginal USER costs.......	10:.40
Fixed:Marginal CONTRACTOR costs.	30:.55
Percent REPLACEMENT:YEARS.......	25:20
REFERENCE.......................	port.ge-UE/JBD

Identification NUMBER...........	011
COMPONENT.......................	ROOF-CEI
Retrofit DESCRIPTION............	**Install 5 inches of cellulose**
UNITS for cost analysis.........	sqft:10
LOCATION on component...........	i
Component REQUIREMENTS..........	V08>4.9:
Retrofit ACTIONS................	A12={D12|19+|}:A06={D06!.95*}:
Retrofit UNACTIONS..............	*
Fixed:Marginal USER costs.......	10:.25
Fixed:Marginal CONTRACTOR costs.	30:.40
Percent REPLACEMENT:YEARS.......	25:20
REFERENCE.......................	port.ge/RCS/JBD

```
ID=001,CO=ROOF-CEI,DE=Install small attic fan,PL=a,UT=each:,VL=V13
  <0.5:V10<999.5:,AC=A13={D13!1.0+}:,UN=*,UC=80:0,CC=280:0,RY=100:
  20,RF=DA-UE/CE/RCS,
ID=002,CO=ROOF-CEI,DE=Install large attic fan,PL=a,UT=each:,VL=V13
  <0.5:V10>999.5:,AC=A13={D13!1.0+}:,UN=*,UC=180:0,CC=380:0,RY=100:
  20,RF=DA-UE/CE/RCS,
ID=003,CO=ROOF-CEI,DE=Seal largest cracks & holes,PL=e,UT=sqft:10,
  VL=V05=U:V06>0.26:,AC=A06={D06!.60*}:,UN=*,UC=10:.05,CC=30:.1,
  RY=100:15,RF=CSA-CE/RCS/JBD,
ID=004,CO=ROOF-CEI,DE=Seal cracks & holes thoroughly,PL=e,UT=sqft:
  10,VL=V05=U:V06>0.26:,AC=A06={D06!.40*}:,UN=*,UC=10:.1,CC=60:.2,
  RY=100:15,RF=CSA-CE/RCS,
ID=005,CO=ROOF-CEI,DE=Weatherstrip attic hatch,PL=h,UT=each:,VL=
  V05#C:,AC=A06={D06!15!D10/-}:,UN=U06={D06!15!D10/+}:,UC=4:0,CC
  =12:0,RY=100:15,RF=CSA-CE/JBD,
ID=006,CO=ROOF-CEI,DE=Install 13 inches of loose fiberglass,PL=i,
  UT=sqft:10,VL=V08>12.9:,AC=A12={D12|38+|}:A06={D06!.95*}:,UN=*,
  UC=10:.65,CC=20:.85,RY=25:20,RF=PGE/JBD,
ID=007,CO=ROOF-CEI,DE=Install 6 inches of loose fiberglass,PL=i,UT
  =sqft:10,VL=V08>5.9:,AC=A12={D12|19+|}:A06={D06!.95*}:,UN=*,UC
  =10:.30,CC=20:.45,RY=25:20,RF=PGE/JBD,
ID=008,CO=ROOF-CEI,DE=Install 4 inches of loose fiberglass,PL=i,
  UT=sqft:10,VL=V08>3.9:,AC=A12={D12|11+|}:A06={D06!.95*}:,UN=*,
  UC=10:.20,CC=20:.30,RY=25:20,RF=PGE/JBD,
ID=009,CO=ROOF-CEI,DE=Install 11 inches of cellulose,PL=i,UT=sqft:
  10,VL=V08>10.9:,AC=A12={D12|38+|}:A06={D06!.95*}:,UN=*,UC=10:
  .50,CC=30:.85,RY=25:20,RF=port.ge/RCS/JBD,
ID=010,CO=ROOF-CEI,DE=Install 8 inches cellulose,PL=i,UT=sqft:10,
  VL=V08>7.9:,AC=A12={D12|30+|}:A06={D06!.95*}:,UN=*,UC=10:.40,CC
  =30:.55,RY=25:20,RF=port.ge-UE/JBD,
ID=011,CO=ROOF-CEI,DE=Install 5 inches of cellulose,PL=i,UT=sqft:10
  ,VL=V08>4.9:,AC=A12={D12|19+|}:A06={D06!.95*}:,UN=*,UC=10:.25,CC
  =30:.40,RY=25:20,RF=port.ge/RCS/JBD,
```

SUBFLOOR retrofits: 1 to 4

```
Identification NUMBER........... 001
COMPONENT....................... SUBFLOOR
Retrofit DESCRIPTION............ Seal largest cracks & holes in floor
UNITS for cost analysis......... sqft:10
LOCATION on component........... j
Component REQUIREMENTS.......... V05#S:V09>.3:
Retrofit ACTIONS................ A09={D09!.60*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 10:.05
Fixed:Marginal CONTRACTOR costs. 20:.1
Percent REPLACEMENT:YEARS....... 100:15
REFERENCE....................... JBD/RCS
```

```
Identification NUMBER........... 002
COMPONENT....................... SUBFLOOR
Retrofit DESCRIPTION............ Seal cracks & holes thoroughly
UNITS for cost analysis......... sqft:10
LOCATION on component........... j
Component REQUIREMENTS.......... V05#S:V09>.3:
Retrofit ACTIONS................ A09={D09!.40*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 20:.1
Fixed:Marginal CONTRACTOR costs. 40:.2
Percent REPLACEMENT:YEARS....... 100:15
REFERENCE....................... JBD/RCS
```

```
Identification NUMBER........... 003
COMPONENT....................... SUBFLOOR
Retrofit DESCRIPTION............ Weatherstrip basement door
UNITS for cost analysis......... each:
LOCATION on component........... d
Component REQUIREMENTS.......... V05=B:
Retrofit ACTIONS................ A09={D09!15!D10/-}:
Retrofit UNACTIONS.............. U09={D09!15!D10/+}:
Fixed:Marginal USER costs....... 4:0
Fixed:Marginal CONTRACTOR costs. 12:0
Percent REPLACEMENT:YEARS....... 100:15
REFERENCE....................... JBD/RCS
```

```
Identification NUMBER........... 004
COMPONENT....................... SUBFLOOR
Retrofit DESCRIPTION............ Put 3.5" fiberglass batts und. floor
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V05=B:V07#H:V08<.325:V08>.11:
Retrofit ACTIONS................ A08={D08|11+|}:A09={D09!.95*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 20:.25
Fixed:Marginal CONTRACTOR costs. 40:.42
Percent REPLACEMENT:YEARS....... 25:15
REFERENCE....................... PGE-HUD/RCS
```

SUBFLOOR retrofits: 5 to 8

```
Identification NUMBER........... 005
COMPONENT....................... SUBFLOOR
Retrofit DESCRIPTION............ Put 5.5" fiberglass batts und. floor
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V05=B:V07#H:V08>.33:
Retrofit ACTIONS................ A08={D08|19+|}:A09={D09!.95*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 20:.35
Fixed:Marginal CONTRACTOR costs. 40:.55
Percent REPLACEMENT:YEARS....... 25:20
REFERENCE....................... PGE-HUD/RCS
```

```
Identification NUMBER........... 006
COMPONENT....................... SUBFLOOR
Retrofit DESCRIPTION............ Put 3.5" fiberglass batts und. floor
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V05=C:V08<.325:V08>.11:
Retrofit ACTIONS................ A08={D08|11+|}:A09={D09!.95*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 20:.25
Fixed:Marginal CONTRACTOR costs. 40:.85
Percent REPLACEMENT:YEARS....... 25:20
REFERENCE....................... CSA/RCS
```

```
Identification NUMBER........... 007
COMPONENT....................... SUBFLOOR
Retrofit DESCRIPTION............ Put 5.5" fiberglass batts und. floor
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V05=C:V08>.33
Retrofit ACTIONS................ A08={D08|19+|}:A09={D09!.95*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 20:.35
Fixed:Marginal CONTRACTOR costs. 40:1.0
Percent REPLACEMENT:YEARS....... 25:20
REFERENCE....................... port. ge/RCS
```

```
Identification NUMBER........... 008
COMPONENT....................... SUBFLOOR
Retrofit DESCRIPTION............ SEAL lgst. cracks & holes in walls
UNITS for cost analysis......... perim:16
LOCATION on component........... w
Component REQUIREMENTS.......... V05=B:V13>0.6:
Retrofit ACTIONS................ A13={D13!0.6*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 50:0.15
Fixed:Marginal CONTRACTOR costs. 50:0.30
Percent REPLACEMENT:YEARS....... 50:10
REFERENCE....................... LBL/RCS/JBD
```

SUBFLOOR retrofits: 9 to 11

Identification NUMBER...........	009
COMPONENT.......................	SUBFLOOR
Retrofit DESCRIPTION............	**SEAL wall cracks & holes thor'ly**
UNITS for cost analysis.........	perim:16
LOCATION on component...........	w
Component REQUIREMENTS..........	V05=B:V13>0.6:
Retrofit ACTIONS................	A13={D13!0.4*}:
Retrofit UNACTIONS..............	*
Fixed:Marginal USER costs.......	50:0.30
Fixed:Marginal CONTRACTOR costs.	50:0.60
Percent REPLACEMENT:YEARS.......	50:10
REFERENCE.......................	LBL/RCS/JBD

Identification NUMBER...........	010
COMPONENT.......................	SUBFLOOR
Retrofit DESCRIPTION............	**Frame & INSULATE with 3.5" fiberglass**
UNITS for cost analysis.........	perim:16
LOCATION on component...........	x
Component REQUIREMENTS..........	V05=B:V11=N:
Retrofit ACTIONS................	A12={D12|11+|}:A15={D15|11+|}:
Retrofit UNACTIONS..............	*
Fixed:Marginal USER costs.......	50:2.80
Fixed:Marginal CONTRACTOR costs.	100:8.75
Percent REPLACEMENT:YEARS.......	100:50
REFERENCE.......................	LBL/RCS

Identification NUMBER...........	011
COMPONENT.......................	SUBFLOOR
Retrofit DESCRIPTION............	**Frame & INSULATE with 5.5" fiberglass**
UNITS for cost analysis.........	perim:16
LOCATION on component...........	x
Component REQUIREMENTS..........	V05=B:V11=N:
Retrofit ACTIONS................	A12={D12|19+|}:A15={D15|19+|}:
Retrofit UNACTIONS..............	*
Fixed:Marginal USER costs.......	75:4.20
Fixed:Marginal CONTRACTOR costs.	150:12.95
Percent REPLACEMENT:YEARS.......	100:50
REFERENCE.......................	LBL/RCS

SUBFLOOR.RET


```
ID=001,CO=SUBFLOOR,DE=Seal largest cracks & holes in floor,PL=j,UT
  =sqft:10,VL=V05#S:V09>.3:,AC=A09={D09!.60*}:,UN=*,UC=10:.05,CC=20
  :.1,RY=100:15,RF=JBD/RCS,
ID=002,CO=SUBFLOOR,DE=Seal cracks & holes thoroughly,PL=j,UT=sqft:
  10,VL=V05#S:V09>.3:,AC=A09={D09!.40*}:,UN=*,UC=20:.1,CC=40:.2,RY
  =100:15,RF=JBD/RCS,
ID=003,CO=SUBFLOOR,DE=Weatherstrip basement door,PL=d,UT=each:,VL=
  V05=B:,AC=A09={D09!15!D10/-}:,UN=U09={D09!15!D10/+}:,UC=4:0,CC=
  12:0,RY=100:15,RF=JBD/RCS,
ID=004,CO=SUBFLOOR,DE=Put 3.5" fiberglass batts und. floor,PL=i,UT
  =sqft:10,VL=V05=B:V07#H:V08<.325:V08>.11:,AC=A08={D08|11+|}:A09
  ={D09!.95*}:,UN=*,UC=20:.25,CC=40:.42,RY=25:20,RF=PGE-HUD/RCS,
ID=005,CO=SUBFLOOR,DE=Put 5.5" fiberglass batts und. floor,PL=i,UT
  =sqft:10,VL=V05=B:V07#H:V08>.33:,AC=A08={D08|19+|}:A09={D09!.95*}
  :,UN=*,UC=20:.35,CC=40:.55,RY=25:20,RF=PGE-HUD/RCS,
ID=006,CO=SUBFLOOR,DE=Put 3.5" fiberglass batts und. floor,PL=i,UT
  =sqft:10,VL=V05=C:,AC=A08={D08|11+|}:A09={D09!.95*}:,UN=*,UC=20:
  .25,CC=40:.85,RY=25:20,RF=CSA/RCS,
ID=007,CO=SUBFLOOR,DE=Put 5.5" fiberglass batts und. floor,PL=i,UT
  =sqft:10,VL=V05=C:V08>.33:,AC=A08={D08|19+|}:A09={D09!.95*}:,UN
  =*,UC=20:.35,CC=40:1.0,RY=25:20,RF=port. ge/RCS,
ID=008,CO=SUBFLOOR,DE=SEAL lgst. cracks & holes in walls,PL=w,UT=
  perim:16,VL=V05=B:V13>0.6:,AC=A13={D13!0.6*}:,UN=*,UC=50:0.15,CC
  =50:0.30,RY=50:10,RF=LBL/RCS,
ID=009,CO=SUBFLOOR,DE=SEAL wall cracks & holes thor'ly,PL=w,UT=
  perim:16,VL=V05=B:V13>0.6:,AC=A13={D13!0.4*}:,UN=*,UC=50:0.30,CC
  =50:0.60,RY=50:10,RF=LBL/RCS,
ID=010,CO=SUBFLOOR,DE=Frame & INSULATE with 3.5" fiberglass,PL=x,
  UT=perim:16,VL=V05=B:V11=N:,AC=A12={D12|11+|}:A15={D15|11+|}:,
  UN=*,UC=50:2.80,CC=100:8.75,RY=100:50,RF=LBL/RCS,
ID=011,CO=SUBFLOOR,DE=Frame & INSULATE with 5.5" fiberglass,PL=x,
  UT=perim:16,VL=V05=B:V11=N:,AC=A12={D12|19+|}:A15={D15|19+|}:,UN
  =*,UC=75:4.20,CC=150:12.95,RY=100:50,RF=LBL/RCS,
```

WALLS retrofits: 1 to 4

Identification NUMBER........... 001
COMPONENT....................... WALLS
Retrofit DESCRIPTION............ **SEAL largest cracks & holes**
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V17>0.1:
Retrofit ACTIONS................ A17={D17!0.6*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 40:0.02
Fixed:Marginal CONTRACTOR costs. 20:0.15
Percent REPLACEMENT:YEARS....... 50:10
REFERENCE....................... JBD/RCS/DD

Identification NUMBER........... 002
COMPONENT....................... WALLS
Retrofit DESCRIPTION............ **SEAL cracks & holes thoroughly**
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V17>0.1:
Retrofit ACTIONS................ A17={D17!0.4*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 40:0.04
Fixed:Marginal CONTRACTOR costs. 30:0.30
Percent REPLACEMENT:YEARS....... 50:10
REFERENCE....................... JBD/RCS/DD

Identification NUMBER........... 003
COMPONENT....................... WALLS
Retrofit DESCRIPTION............ **INSULATE with 3.5" blown-in cellulose**
UNITS for cost analysis......... sqft:10
LOCATION on component........... c
Component REQUIREMENTS.......... V08>3.4:V08<4.5:V05=FGT:
Retrofit ACTIONS................ A16={D16|9.76+||}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 0:.45
Fixed:Marginal CONTRACTOR costs. 100:1.00
Percent REPLACEMENT:YEARS....... 100:50
REFERENCE....................... JBD/RCS/DD

Identification NUMBER........... 004
COMPONENT....................... WALLS
Retrofit DESCRIPTION............ **INSULATE with 5.5" blown-in cellulose**
UNITS for cost analysis......... sqft:10
LOCATION on component........... c
Component REQUIREMENTS.......... V08>4.5:V08<6.1:V05=T:
Retrofit ACTIONS................ A16={D16|14.93+||}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 0:0.65
Fixed:Marginal CONTRACTOR costs. 150:1.20
Percent REPLACEMENT:YEARS....... 100:50
REFERENCE....................... JBD/RCS/DD

WALLS retrofits: 5 to 7

Identification NUMBER	005
COMPONENT	WALLS
Retrofit DESCRIPTION	**INSULATE with 3.5" loose fiberglass**
UNITS for cost analysis	sqft:10
LOCATION on component	c
Component REQUIREMENTS	V08>3.4:V08<4.5:V05=FGT:V00=Y:
Retrofit ACTIONS	A16={D16|8.62+|}:
Retrofit UNACTIONS	*
Fixed:Marginal USER costs	50:.30
Fixed:Marginal CONTRACTOR costs	100:1.00
Percent REPLACEMENT:YEARS	100:50
REFERENCE	LBL/RCS/DD

Identification NUMBER	006
COMPONENT	WALLS
Retrofit DESCRIPTION	**INSULATE with 5.5" loose fiberglass**
UNITS for cost analysis	sqft:10
LOCATION on component	c
Component REQUIREMENTS	V08>4.5:V08<6.1:V05=T:V00=Y:
Retrofit ACTIONS	A16={D16|13.33+|}:
Retrofit UNACTIONS	*
Fixed:Marginal USER costs	75:.45
Fixed:Marginal CONTRACTOR costs	150:1.50
Percent REPLACEMENT:YEARS	100:50
REFERENCE	LBL/RCS/DD

Identification NUMBER	007
COMPONENT	WALLS
Retrofit DESCRIPTION	**Add 2" exterior insulating sheathing**
UNITS for cost analysis	sqft:10
LOCATION on component	o
Component REQUIREMENTS	V07=N:V05#G:V00=Y:
Retrofit ACTIONS	A16={D16|10.0+|}:
Retrofit UNACTIONS	*
Fixed:Marginal USER costs	0:.85
Fixed:Marginal CONTRACTOR costs	100:1.40
Percent REPLACEMENT:YEARS	100:50
REFERENCE	LBL/RCS/DD

```
ID=001,CO=WALLS,DE=SEAL largest cracks & holes,PL=i,UT=sqft:10,VL=
  V17>0.1:,AC=A17={D17!0.6*}:,UN=*,UC=40:0.02,CC=20:0.15,RY=50:10,
  RF=JBD/RCS/DD,
ID=002,CO=WALLS,DE=SEAL cracks & holes thoroughly,PL=i,UT=sqft:10,
  VL=V17>0.1:,AC=A17={D17!0.4*}:,UN=*,UC=40:0.04,CC=30:0.30,RY=50:
  10,RF=JBD/RCS/DD,
ID=003,CO=WALLS,DE=INSULATE with 3.5" blown-in cellulose,PL=c,UT
  =sqft:10,VL=V08>3.4:V08<4.5:V05=FGT:,AC=A16={D16|9.76+|}:,UN=*,
  UC=0:.45,CC=100:1.00,RY=100:50,RF=JBD/RCS/DD,
ID=004,CO=WALLS,DE=INSULATE with 5.5" blown-in cellulose,PL=c,UT
  =sqft:10,VL=V08>4.5:V08<6.1:V05=T:,AC=A16={D16|14.93+|}:,UN=*,UC
  =0:0.65,CC=150:1.20,RY=100:50,RF=JBD/RCS/DD,
ID=005,CO=WALLS,DE=INSULATE with 3.5" loose fiberglass,PL=c,UT=
  sqft:10,VL=V08>3.4:V08<4.5:V05=FGT:V00=Y:,AC=A16={D16|8.62+|}:,
  UN=*,UC=50:.30,CC=100:1.00,RY=100:50,RF=LBL/RCS/DD,
ID=006,CO=WALLS,DE=INSULATE with 5.5" loose fiberglass,PL=c,UT
  =sqft:10,VL=V08>4.5:V08<6.1:V05=T:V00=Y:,AC=A16={D16|13.33+|}:
  ,UN=*,UC=75:.45,CC=150:1.50,RY=100:50,RF=LBL/RCS/DD,
ID=007,CO=WALLS,DE=Add 2" exterior insulating sheathing,PL=o,UT
  =sqft:10,VL=V07=N:V05#G:V00=Y:,AC=A16={D16|10.0+|}:,UN=*,UC=0:
  .85,CC=100:1.40,RY=100:50,RF=LBL/RCS/DD,
```

```
Identification NUMBER........... 001
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install exterior seasonal REFLECTOR/SHADE
UNITS for cost analysis......... sqft:10
LOCATION on component........... o
Component REQUIREMENTS.......... V04=H:
Retrofit ACTIONS................ A09={D09!.9*}:A14={D14!.45*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 160:3
Fixed:Marginal CONTRACTOR costs. 250:3.5
Percent REPLACEMENT:YEARS....... 25:10
REFERENCE....................... JBD/RCS
```

```
Identification NUMBER........... 002
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install exterior SHUTTER
UNITS for cost analysis......... sqft:10
LOCATION on component........... o
Component REQUIREMENTS.......... V04#H:V05=DHF:V00=Y:
Retrofit ACTIONS................ A12={D12|1+|}:A14={D14!.5*}:A09={D09!.5*}:
Retrofit UNACTIONS.............. *
                                                      A13={D13!.9*}:
Fixed:Marginal USER costs....... 75:1.2
Fixed:Marginal CONTRACTOR costs. 125:1.3
Percent REPLACEMENT:YEARS....... 50:15
REFERENCE....................... Jim
```

```
Identification NUMBER........... 003
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install summer exterior SHADE
UNITS for cost analysis......... sqft:10
LOCATION on component........... o
Component REQUIREMENTS.......... V04#H:V05=DHF:
Retrofit ACTIONS................ A12={D12|.2+|}:A14={D14!.25*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 50:1
Fixed:Marginal CONTRACTOR costs. 100:1.1
Percent REPLACEMENT:YEARS....... 50:15
REFERENCE....................... Jim
```

```
Identification NUMBER........... 004
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install winter exterior GLASS STORM
UNITS for cost analysis......... sqft:10
LOCATION on component........... s
Component REQUIREMENTS.......... V04#H:V05=DHCF:V06#OQ:
Retrofit ACTIONS................ A12={D12|.92+|}:A13={D13!.6*}:
Retrofit UNACTIONS.............. *               A09={D09!.88*}:
Fixed:Marginal USER costs....... 50:3.33
Fixed:Marginal CONTRACTOR costs. 100:10
Percent REPLACEMENT:YEARS....... 100:30
REFERENCE....................... PG&E/RCS
```

WINDOWS retrofits: 5 to 8

```
Identification NUMBER........... 005
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install winter exterior PLASTIC STORM
UNITS for cost analysis......... sqft:10
LOCATION on component........... s
Component REQUIREMENTS.......... V04#H:V06#OQ:V00=Y:
Retrofit ACTIONS................ A12={D12|.92+|}:A13={D13!.6*}:
Retrofit UNACTIONS.............. *               A09={D09!.85*}:
Fixed:Marginal USER costs....... 20:1.1
Fixed:Marginal CONTRACTOR costs. 40:1.2
Percent REPLACEMENT:YEARS....... 100:3
REFERENCE....................... W21/Jim/RCS

Identification NUMBER........... 006
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ DOUBLE glaze
UNITS for cost analysis......... sqft:10
LOCATION on component........... g
Component REQUIREMENTS.......... V06=S:V05=DHCF:
Retrofit ACTIONS................ A12={D12|1.724+|}:A14={D14!.77*}:
Retrofit UNACTIONS.............. *                  A09={D09!.77*}:
Fixed:Marginal USER costs....... 27:1.6
Fixed:Marginal CONTRACTOR costs. 60:1.8
`Percent REPLACEMENT:YEARS....... 100:30
REFERENCE....................... CSA

Identification NUMBER........... 007
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ TRIPLE glaze
UNITS for cost analysis......... sqft:10
LOCATION on component........... g
Component REQUIREMENTS.......... V04#H:V06#T:V05=DHCF:
Retrofit ACTIONS................ A12={D12|2.564+|}:A14={D14!.67*}:
Retrofit UNACTIONS.............. *                  A09={D09!.67*}:
Fixed:Marginal USER costs....... 30:2
Fixed:Marginal CONTRACTOR costs. 60:3
Percent REPLACEMENT:YEARS....... 100:30
REFERENCE....................... CSA/Ue

Identification NUMBER........... 008
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install low emissivity FILM
UNITS for cost analysis......... sqft:10
LOCATION on component........... c
Component REQUIREMENTS.......... V05#O:V00=Y:
Retrofit ACTIONS................ A12={D12|.3+|}:A14={D14!.5*}:A09={D09!.5*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 15:1
Fixed:Marginal CONTRACTOR costs. 25:1.5
Percent REPLACEMENT:YEARS....... 100:9
REFERENCE....................... CSA/RCS
```

WINDOWS retrofits: 9 to 12

```
Identification NUMBER........... 009
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ WEATHERSTRIP
UNITS for cost analysis......... sqft:10
LOCATION on component........... e
Component REQUIREMENTS.......... V05=DHCT:V07#T:
Retrofit ACTIONS................ A13={D13!.75*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 10:.2
Fixed:Marginal CONTRACTOR costs. 20:.33
Percent REPLACEMENT:YEARS....... 25:5
REFERENCE....................... PG&E/RCS/JBD
```

```
Identification NUMBER........... 010
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install winter interior GLASS STORM
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V05#GJT:V06#IP:V00=Y:
Retrofit ACTIONS................ A12={D12|.9+|}:A13={D13!.6*}:A09={D09!.89*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 26.5:1.5
Fixed:Marginal CONTRACTOR costs. 53:3.0
Percent REPLACEMENT:YEARS....... 2.5:10
REFERENCE....................... W10/RCS
```

```
Identification NUMBER........... 011
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install winter interior PLASTIC STORM
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V05#GJT:V06#IP:
Retrofit ACTIONS................ A12={D12|.9+|}:A13={D13!.6*}:A09={D09!.87*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 20:1
Fixed:Marginal CONTRACTOR costs. 40:1.1
Percent REPLACEMENT:YEARS....... 100:3
REFERENCE....................... W10/Jim/RCS
```

```
Identification NUMBER........... 012
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install nighttime R-4 INSULATION
UNITS for cost analysis......... sqft:10
LOCATION on component........... r
Component REQUIREMENTS.......... V04#H:
Retrofit ACTIONS................ A12={D12|2.68+|}:A13={D13!0.9*}:
Retrofit UNACTIONS.............. *        A09={D09!0.9*}:A14={D14!0.9*}:
Fixed:Marginal USER costs....... 25:1.9
Fixed:Marginal CONTRACTOR costs. 50:4.8
Percent REPLACEMENT:YEARS....... 25:10
REFERENCE....................... JBD/RCS
```

```
Identification NUMBER........... 013
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install nighttime R-6 INSULATION
UNITS for cost analysis......... sqft:10
LOCATION on component........... r
Component REQUIREMENTS.......... V04#H:
Retrofit ACTIONS................ A12={D12|4.02+|}:A13={D13!0.9*}:
Retrofit UNACTIONS.............. *        A09={D09!0.9*}:A14={D14!0.9*}:
Fixed:Marginal USER costs....... 25:2.8
Fixed:Marginal CONTRACTOR costs. 50:7.0
Percent REPLACEMENT:YEARS....... 25:10
REFERENCE....................... JBD/RCS
```

```
Identification NUMBER........... 014
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install nighttime R-8 INSULATION
UNITS for cost analysis......... sqft:10
LOCATION on component........... r
Component REQUIREMENTS.......... V04#H:
Retrofit ACTIONS................ A12={D12|5.36+|}:A13={D13!0.9*}:
Retrofit UNACTIONS.............. *        A09={D09!0.9*}:A14={D14!0.9*}:
Fixed:Marginal USER costs....... 25:3.6
Fixed:Marginal CONTRACTOR costs. 50:8.5
Percent REPLACEMENT:YEARS....... 25:10
REFERENCE....................... JBD/RCS
```

```
Identification NUMBER........... 015
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install interior REFLECTIVE SHADE
UNITS for cost analysis......... sqft:10
LOCATION on component........... r
Component REQUIREMENTS.......... V04#H:
Retrofit ACTIONS................ A12={D12|.3+|}:A14={D14!.3*}:A09={D09!.9*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 25:.5
Fixed:Marginal CONTRACTOR costs. 50:.6
Percent REPLACEMENT:YEARS....... 50:10
REFERENCE....................... Jim
```

```
Identification NUMBER........... 016
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Hang inside DRAPES - close in summer
UNITS for cost analysis......... sqft:10
LOCATION on component........... d
Component REQUIREMENTS.......... V04#H:V00=Y:
Retrofit ACTIONS................ A12={D12|1+|}:A14={D14!.55*}:A09={D09!.9*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 50:.8
Fixed:Marginal CONTRACTOR costs. 90:.9
Percent REPLACEMENT:YEARS....... 25:10
REFERENCE....................... JBD/RCS
```

```
ID=001,CO=WINDOWS,DE=Install exterior seasonal REFLECTOR/SHADE,PL=
  o,UT=sqft:10,VL=V04=H:,AC=A09={D09!.9*}:A14={D14!0.45*}:,UN=*,UC
  =160:3,CC=250:3.5,RY=25:10,RF=RCS/JBD,
ID=002,CO=WINDOWS,DE=Install exterior SHUTTER,PL=o,UT=sqft:10,VL
  =V04#H:V05=DHF:V00=Y:,AC=A12={D12|1+|}:A14={D14!.5*}:A09={D09!.5
  *}:A13={D13!.9*}:,UN=*,UC=75:1.2,CC=125:1.3,RY=50:15,RF=Jim,
ID=003,CO=WINDOWS,DE=Install summer exterior SHADE,PL=o,UT=sqft:10
  ,VL=V04#H:V05=DHF:,AC=A12={D12|.2+|}:A14={D14!.25*}:,UN=*,UC=50:1
  ,CC=100:1.1,RY=50:15,RF=Jim,
ID=004,CO=WINDOWS,DE=Install winter exterior GLASS STORM,PL=s,UT
  =sqft:10,VL=V04#H:V05=DHCF:V06#OQ:,AC=A12={D12|.92+|}:A13={D13!.
  6*}:A09={D09!.88*}:,UN=*,UC=50:3.33,CC=100:10,RY=100:30,RF=PG&E/RCS,
ID=005,CO=WINDOWS,DE=Install winter exterior PLASTIC STORM,PL=s,UT
  =sqft:10,VL=V04#H:V06#OQ:V00=Y:,AC=A12={D12|.92+|}:A13={D13!.6*}
  :A09={D09!.85*}:,UN=*,UC=20:1.1,CC=40:1.2,RY=100:3,RF=W21/Jim/RCS,
ID=006,CO=WINDOWS,DE=DOUBLE glaze,PL=g,UT=sqft:10,VL=V06=S:V05=DHCF
  :,AC=A12={D12|1.724+|}:A14={D14!.77*}:A09={D09!.77*}:,UN=*,UC=27
  :1.6,CC=60:1.8,RY=100:30,RF=CSA,
ID=007,CO=WINDOWS,DE=TRIPLE glaze,PL=g,UT=sqft:10,VL=V04#H:V06#T:
  V05=DHCF:,AC=A12={D12|2.564+|}:A14={D14!.67*}:A09={D09!.67*}:,UN
  =*,UC=30:2,CC=60:3,RY=100:30,RF=CSA/Ue,
ID=008,CO=WINDOWS,DE=Install low emissivity FILM,PL=c,UT=sqft:10,
  VL=V05#O:V00=Y:,AC=A12={D12|.3+|}:A14={D14!.5*}:A09={D09!.5*}:
  ,UN=*,UC=15:1,CC=25:1.5,RY=100:9,RF=CSA/RCS,
ID=009,CO=WINDOWS,DE=WEATHERSTRIP,PL=e,UT=sqft:10,VL=V05=DHCT:
  V07#T:,AC=A13={D13!.75*}:,UN=*,UC=10:.2,CC=20:.33,RY=25:5,RF
  =PG&E/RCS/JBD,
ID=010,CO=WINDOWS,DE=Install winter interior GLASS STORM,PL=i,UT
  =sqft:10,VL=V05#GJT:V06#IP:V00=Y:,AC=A12={D12|.9+|}:A13={D13!.6*}
  :A09={D09!.89*}:,UN=*,UC=26.5:1.5,CC=53:3.0,RY=2.5:10,RF=W10/RCS,
ID=011,CO=WINDOWS,DE=Install winter interior PLASTIC STORM,PL=i,UT
  =sqft:10,VL=V05#GJT:V06#IP:,AC=A12={D12|.9+|}:A13={D13!.6*}:A09=
  {D09!.87*}:,UN=*,UC=20:1,CC=40:1.1,RY=100:3,RF=W10/Jim/RCS,
ID=012,CO=WINDOWS,DE=Install nighttime R-4 INSULATION,PL=r,UT=sqft:
  10,VL=V04#H:,AC=A12={D12|2.68+|}:A13={D13!0.9*}:A09={D09!0.9*}:
  A14={D14!0.9*}:,UN=*,UC=25:1.9,CC=50:4.8,RY=25:10,RF=JBD/RCS,
ID=013,CO=WINDOWS,DE=Install nighttime R-6 INSULATION,PL=r,UT=sqft:
  10,VL=V04#H:,AC=A12={D12|4.02+|}:A13={D13!0.9*}:A09={D09!0.9*}:
  A14={D14!0.9*}:,UN=*,UC=25:2.8,CC=50:7.0,RY=25:10,RF=JBD/RCS,
ID=014,CO=WINDOWS,DE=Install nighttime R-8 INSULATION,PL=r,UT=sqft:
  10,VL=V04#H:,AC=A12={D12|5.36+|}:A13={D13!0.9*}:A09={D09!0.9*}:
  A14={D14!0.9*}:,UN=*,UC=25:3.6,CC=50:8.5,RY=25:10,RF=JBD/RCS,
ID=015,CO=WINDOWS,DE=Install interior REFLECTIVE SHADE,PL=r,UT=sqft
  :10,VL=V04#H:,AC=A12={D12|.3+|}:A14={D14!.3*}:A09={D09!.9*}:,UN=
  *,UC=25:.5,CC=50:.6,RY=50:10,RF=Jim,
ID=016,CO=WINDOWS,DE=Hang inside DRAPES - close in summer,PL=d,UT=
  sqft:10,VL=V04#H:,AC=A12={D12|1+|}:A14={D14!.55*}:A09={D09!.9*}:,
  UN=*,UC=50:.8,CC=90:.9,RY=25:10,RF=JBD/RCS,
```

WINDOWS retrofits: 1 to 4

```
Identification NUMBER........... 001
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install exterior seasonal REFLECTOR/SHADE
UNITS for cost analysis......... sqft:10
LOCATION on component........... o
Component REQUIREMENTS.......... V04=H:
Retrofit ACTIONS................ A09={D14!.45*}:A14={D09!1.7*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 160:3
Fixed:Marginal CONTRACTOR costs. 250:3.5
Percent REPLACEMENT:YEARS....... 25:10
REFERENCE....................... Update/RCS

Identification NUMBER........... 002
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install exterior SHUTTER
UNITS for cost analysis......... sqft:10
LOCATION on component........... o
Component REQUIREMENTS.......... V04#H:V05=DHF:V00=Y:
Retrofit ACTIONS................ A12={D12¦1+¦}:A14={D14!.5*}:
Retrofit UNACTIONS.............. *
                                              A09={D09!.5*}:A13={D13!.9*}:
Fixed:Marginal USER costs....... 75:1.2
Fixed:Marginal CONTRACTOR costs. 125:1.3
Percent REPLACEMENT:YEARS....... 50:15
REFERENCE....................... Jim

Identification NUMBER........... 003
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install summer exterior SHADE
UNITS for cost analysis......... sqft:10
LOCATION on component........... o
Component REQUIREMENTS.......... V04#H:V05=DHF:
Retrofit ACTIONS................ A12={D12¦.2+¦}:A14={D14!.25*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 50:1
Fixed:Marginal CONTRACTOR costs. 100:1.1
Percent REPLACEMENT:YEARS....... 50:15
REFERENCE....................... Jim

Identification NUMBER........... 004
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install winter exterior GLASS STORM
UNITS for cost analysis......... sqft:10
LOCATION on component........... s
Component REQUIREMENTS.......... V04#H:V05=DHCF:V06#OQ:
Retrofit ACTIONS................ A12={D12¦.92+¦}:A13={D13!.6*}:
Retrofit UNACTIONS.............. *
                                                A09={D09!.88*}:
Fixed:Marginal USER costs....... 50:3.33
Fixed:Marginal CONTRACTOR costs. 100:10
Percent REPLACEMENT:YEARS....... 100:30
REFERENCE....................... PG&E/RCS
```

WINDOWS retrofits: 5 to 8

```
Identification NUMBER........... 005
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install winter exterior PLASTIC STORM
UNITS for cost analysis......... sqft:10
LOCATION on component........... s
Component REQUIREMENTS.......... V04#H:V06#OQ:V00=Y:
Retrofit ACTIONS................ A12={D12¦.92+¦}:A13={D13!.6*}:
                                          A09={D09!.85*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 20:1.1
Fixed:Marginal CONTRACTOR costs. 40:1.2
Percent REPLACEMENT:YEARS....... 100:3
REFERENCE....................... W21/Jim/RCS
```

```
Identification NUMBER........... 006
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ DOUBLE glaze
UNITS for cost analysis......... sqft:10
LOCATION on component........... g
Component REQUIREMENTS.......... V06=S:V05=DHCF:
Retrofit ACTIONS................ A12={D12¦1.724+¦}:A14={D14!.77*}:
                                          A09={D09!.77*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 27:1.6
Fixed:Marginal CONTRACTOR costs. 60:1.8
Percent REPLACEMENT:YEARS....... 100:30
REFERENCE....................... CSA
```

```
Identification NUMBER........... 007
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ TRIPLE glaze
UNITS for cost analysis......... sqft:10
LOCATION on component........... g
Component REQUIREMENTS.......... V04#H:V06#T:V05=DHCF:
Retrofit ACTIONS................ A12={D12¦2.564+¦}:A14={D14!.67*}:
                                          A09={D09!.67*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 30:2
Fixed:Marginal CONTRACTOR costs. 60:3
Percent REPLACEMENT:YEARS....... 100:30
REFERENCE....................... CSA/Ue
```

```
Identification NUMBER........... 008
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install low emissivity FILM
UNITS for cost analysis......... sqft:10
LOCATION on component........... c
Component REQUIREMENTS.......... V05#O:V00=Y:
Retrofit ACTIONS................ A12={D12¦.3+¦}:A14={D14!.5*}:
                                          A09={D09!.5*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 15:1
Fixed:Marginal CONTRACTOR costs. 25:1.5
Percent REPLACEMENT:YEARS....... 100:9
REFERENCE....................... CSA/RCS
```

WINDOWS retrofits: 9 to 12

```
Identification NUMBER........... 009
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ WEATHERSTRIP
UNITS for cost analysis......... sqft:10
LOCATION on component........... e
Component REQUIREMENTS.......... V05=DHCT:V07#T:
Retrofit ACTIONS................ A13={D13!.5*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 10:.2
Fixed:Marginal CONTRACTOR costs. 20:.33
Percent REPLACEMENT:YEARS....... 25:5
REFERENCE....................... PG&E/RCS/JBD

Identification NUMBER........... 010
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install winter interior GLASS STORM
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V05#GJT:V06#IP:V00=Y:
Retrofit ACTIONS................ A12={D12¦.9+¦}:A13={D13!.6*}:
Retrofit UNACTIONS.............. *              A09={D09!.89*}:
Fixed:Marginal USER costs....... 26.5:1.5
Fixed:Marginal CONTRACTOR costs. 53:3.0
Percent REPLACEMENT:YEARS....... 2.5:10
REFERENCE....................... W10/RCS

Identification NUMBER........... 011
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install winter interior PLASTIC STORM
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V05#GJT:V06#IP:
Retrofit ACTIONS................ A12={D12¦.9+¦}:A13={D13!.6*}:
Retrofit UNACTIONS.............. *              A09={D09!.87*}:
Fixed:Marginal USER costs....... 20:1
Fixed:Marginal CONTRACTOR costs. 40:1.1
Percent REPLACEMENT:YEARS....... 100:3
REFERENCE....................... W10/Jim/RCS

Identification NUMBER........... 012
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Use nighttime magnetic INSULATING PANEL
UNITS for cost analysis......... sqft:10
LOCATION on component........... i
Component REQUIREMENTS.......... V05#JG:
Retrofit ACTIONS................ A12={D12¦4+¦}:A13={D13!.8*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 10:.5
Fixed:Marginal CONTRACTOR costs. 20:.8
Percent REPLACEMENT:YEARS....... 50:3
REFERENCE....................... W18/Jim/RCS
```

WINDOWS retrofits: 13 to 16

```
Identification NUMBER........... 013
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install interior VENETIAN BLINDS
UNITS for cost analysis......... sqft:10
LOCATION on component........... r
Component REQUIREMENTS.......... V04#H:V05#GJ:V00=Y:
Retrofit ACTIONS................ A14={D14!.5*}:A09={D09!.9*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 40:1.2         A12={D12¦0.2+¦}:
Fixed:Marginal CONTRACTOR costs. 80:1.3
Percent REPLACEMENT:YEARS....... 25:10
REFERENCE....................... DA/Jim

Identification NUMBER........... 014
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install interior REFLECTIVE SHADE
UNITS for cost analysis......... sqft:10
LOCATION on component........... r
Component REQUIREMENTS.......... V04#H:
Retrofit ACTIONS................ A12={D12¦.3+¦}:A14={D14!.3*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 25:.5            A09={D09!.9*}:
Fixed:Marginal CONTRACTOR costs. 50:.6
Percent REPLACEMENT:YEARS....... 50:10
REFERENCE....................... Jim

Identification NUMBER........... 015
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Install interior SHADE
UNITS for cost analysis......... sqft:10
LOCATION on component........... r
Component REQUIREMENTS.......... V04#H:V00=Y:
Retrofit ACTIONS................ A12={D12¦.2+¦}:A14={D14!.4*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 20:.3            A09={D09!.95*}:
Fixed:Marginal CONTRACTOR costs. 40:.4
Percent REPLACEMENT:YEARS....... 50:10
REFERENCE....................... Jim

Identification NUMBER........... 016
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Hang inside REFLECTIVE DRAPES
UNITS for cost analysis......... sqft:10
LOCATION on component........... d
Component REQUIREMENTS.......... V04#H:
Retrofit ACTIONS................ A12={D12¦3.2+¦}:A14={D14!.2*}:A09={D09!.8*}
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 50:1             :A13={D13!.9*}:
Fixed:Marginal CONTRACTOR costs. 90:1.1
Percent REPLACEMENT:YEARS....... 25:10
REFERENCE....................... Jim
```

WINDOWS retrofits: 17 to 18

```
Identification NUMBER........... 017
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Hang inside DRAPES
UNITS for cost analysis......... sqft:10
LOCATION on component........... d
Component REQUIREMENTS.......... V04#H:V00=Y:
Retrofit ACTIONS................ A12={D12¦3+¦}:A14={D14!.3*}:
Retrofit UNACTIONS.............. *
                                           A09={D09!.85*}:A13={D13!.9*}:
Fixed:Marginal USER costs....... 50:.8
Fixed:Marginal CONTRACTOR costs. 90:.9
Percent REPLACEMENT:YEARS....... 25:10
REFERENCE....................... Jim

Identification NUMBER........... 018
COMPONENT....................... WINDOWS
Retrofit DESCRIPTION............ Hang interior CURTAINS
UNITS for cost analysis......... sqft:10
LOCATION on component........... d
Component REQUIREMENTS.......... V04#H:V00=Y:
Retrofit ACTIONS................ A12={D12¦.2+¦}:A14={D14!.6*}:
Retrofit UNACTIONS.............. *
Fixed:Marginal USER costs....... 50:.5      A09={D09!.6*}:
Fixed:Marginal CONTRACTOR costs. 90:.6
Percent REPLACEMENT:YEARS....... 25:10
REFERENCE....................... Jim
```

WINDOWS.RET

```
ID=001,CO=WINDOWS,DE=Install exterior seasonal REFLECTOR/SHADE,PL=
  o,UT=sqft:10,VL=V04=H:,AC=A09={D14!.45*}:A14={D09!1.7*}:,UN=*,UC
  =160:3,CC=250:3.5,RY=25:10,RF=Update/RCS,
ID=002,CO=WINDOWS,DE=Install exterior SHUTTER,PL=o,UT=sqft:10,VL
  =V04#H:V05=DHF:V00=Y:,AC=A12={D12¦1+¦}:A14={D14!.5*}:A09={D09!.5
  *}:A13={D13!.9*}:,UN=*,UC=75:1.2,CC=125:1.3,RY=50:15,RF=Jim,
ID=003,CO=WINDOWS,DE=Install summer exterior SHADE,PL=o,UT=sqft:10
  ,VL=V04#H:V05=DHF:,AC=A12={D12¦.2+¦}:A14={D14!.25*}:,UN=*,UC=50:1
  ,CC=100:1.1,RY=50:15,RF=Jim,
ID=004,CO=WINDOWS,DE=Install winter exterior GLASS STORM,PL=s,UT
  =sqft:10,VL=V04#H:V05=DHCF:V06#OQ:,AC=A12={D12¦.92+¦}:A13={D13!.
  6*}:A09={D09!.88*}:,UN=*,UC=50:3.33,CC=100:10,RY=100:30,RF=PG&E/RCS,
ID=005,CO=WINDOWS,DE=Install winter exterior PLASTIC STORM,PL=s,UT
  =sqft:10,VL=V04#H:V06#OQ:V00=Y:,AC=A12={D12¦.92+¦}:A13={D13!.6*}
  :A09={D09!.85*}:,UN=*,UC=20:1.1,CC=40:1.2,RY=100:3,RF=W21/Jim/RCS,
ID=006,CO=WINDOWS,DE=DOUBLE glaze,PL=g,UT=sqft:10,VL=V06=S:V05=DHCF
  :,AC=A12={D12¦1.724+¦}:A14={D14!.77*}:A09={D09!.77*}:,UN=*,UC=27
  :1.6,CC=60:1.8,RY=100:30,RF=CSA,
ID=007,CO=WINDOWS,DE=TRIPLE glaze,PL=g,UT=sqft:10,VL=V04#H:V06#T:
  V05=DHCF:,AC=A12={D12¦2.564+¦}:A14={D14!.67*}:A09={D09!.67*}:,UN
  =*,UC=30:2,CC=60:3,RY=100:30,RF=CSA/Ue,
ID=008,CO=WINDOWS,DE=Install low emissivity FILM,PL=c,UT=sqft:10,
  VL=V05#O:V00=Y:,AC=A12={D12¦.3+¦}:A14={D14!.5*}:A09={D09!.5*}:
  ,UN=*,UC=15:1,CC=25:1.5,RY=100:9,RF=CSA/RCS,
ID=009,CO=WINDOWS,DE=WEATHERSTRIP,PL=e,UT=sqft:10,VL=V05=DHCT:
  V07#T:,AC=A13={D13!.5*}:,UN=*,UC=10:.2,CC=20:.33,RY=25:5,RF
  =PG&E/RCS/JBD,
```

ID=010,CO=WINDOWS,DE=Install winter interior GLASS STORM,PL=i,UT
=sqft:10,VL=V05#GJT:V06#IP:V00=Y:,AC=A12={D12¦.9+¦}:A13={D13!.6*}
:A09={D09!.89*}:,UN=*,UC=26.5:1.5,CC=53:3.0,RY=2.5:10,RF=W10/RCS,
ID=011,CO=WINDOWS,DE=Install winter interior PLASTIC STORM,PL=i,UT
=sqft:10,VL=V05#GJT:V06#IP:,AC=A12={D12¦.9+¦}:A13={D13!.6*}:A09=
{D09!.87*}:,UN=*,UC=20:1,CC=40:1.1,RY=100:3,RF=W10/Jim/RCS,
ID=012,CO=WINDOWS,DE=Use nighttime magnetic INSULATING PANEL,PL=i,
UT=sqft:10,VL=V05#JG:,AC=A12={D12¦4+¦}:A13={D13!.8*}:,UN=*,UC=10:
.5,CC=20:.8,RY=50:3,RF=W18/Jim/RCS,
ID=013,CO=WINDOWS,DE=Install interior VENETIAN BLINDS,PL=r,UT=sqft:
10,VL=V04#H:V05#GJ:V00=Y:,AC=A14={D14!.5*}:A09={D09!.9*}:A12={D12
¦0.2+¦}:,UN=*,UC=40:1.2,CC=80:1.3,RY=25:10,RF=DA/Jim,
ID=014,CO=WINDOWS,DE=Install interior REFLECTIVE SHADE,PL=r,UT=sqft
:10,VL=V04#H:,AC=A12={D12¦.3+¦}:A14={D14!.3*}:A09={D09!.9*}:,UN=
*,UC=25:.5,CC=50:.6,RY=50:10,RF=Jim,
ID=015,CO=WINDOWS,DE=Install interior SHADE,PL=r,UT=sqft:10,VL=V04#
H:V00=Y:,AC=A12={D12¦.2+¦}:A14={D14!.4*}:A09={D09!.95*}:,UN=*,UC
=20:.3,CC=40:.4,RY=50:10,RF=Jim,
ID=016,CO=WINDOWS,DE=Hang inside REFLECTIVE DRAPES,PL=d,UT=sqft:10,
VL=V04#H:,AC=A12={D12¦3.2+¦}:A14={D14!.2*}:A09={D09!.8*}:A13={D13
!.9*}:,UN=*,UC=50:1,CC=90:1.1,RY=25:10,RF=Jim,
ID=017,CO=WINDOWS,DE=Hang inside DRAPES,PL=d,UT=sqft:10,VL=V04#H:
V00=Y:,AC=A12={D12¦3+¦}:A14={D14!.3*}:A09={D09!.85*}:A13={D13!.9
}:,UN=,UC=50:.8,CC=90:.9,RY=25:10,RF=Jim,
ID=018,CO=WINDOWS,DE=Hang interior CURTAINS,PL=d,UT=sqft:10,VL=V04#
H:V00=Y:,AC=A12={D12¦.2+¦}:A14={D14!.6*}:A09={D09!.6*}:,UN=*,UC=
50:.5,CC=90:.6,RY=25:10,RF=Jim,

WEATHER LIBRARY

Section X

WEATHER LIBRARY

Introduction

CIRA is set up to contain 12 cities' weather files on the disk. On the following pages are printed files for over 150 other cities. If you want to run CIRA for one of these cities, you must delete one of the original 12 files and type the desired file onto the CIRA disk. The CIRACTY program will help you do this.

The data in the CIRA weather files is derived from hourly records of dry bulb and wet bulb temperature, wind speed, and cloud cover information. The hourly records are chosen from "Test Reference Year" (TRY) and "Typical Meteorological Year" (TMY) weather tapes as determined for each city by the U.S. National Climatic Center. Additional weather files based on California climate zone weather data (RCTZ tapes) and National Weather Service 1440 series tapes (for Denver, Des Moines, and Honolulu) are included at the end of the library. These tapes do not necessarily represent long term weather patterns. If you wish to construct your own weather files, see "Create Your Own Weather File" below.

CIRACTY

CIRACTY is a utility program to substitute new weather files for the weather files provided with CIRA. You may add, edit, or delete weather files when using CIRACTY. CIRACTY automatically alters the GENERAL.INF, CITIES, and <Weather FILE>.CTY files on CIRA disk "A".

To run the CIRACTY program, put a copy of your CIRA disk A into any drive and put your copy of CIRA disk C into any other drive (do not use the original disks that we supplied you). Log into the drive that your CIRA disk A is in. Next, type the letter corresponding to the drive where your CIRA disk C is located, followed by ":CIRACTY". For example, if you put your CIRA disk A in drive A and CIRA disk C in drive B, you would then log into drive A and type:

B:CIRACTY

The computer will respond by displaying the current weather files, for example:

The 12 cities currently included in A:GENERAL are:

Code LETTER	City NAME	Weather FILE	ELEVATION	LATTITUDE
A	Albuquerque	ALBUQUE	5311	35.9
B	Buffalo	BUFFAL	705	42.8
C	Sacramento	SACTO	17	38.5
D	San Diego	SANDIEG	19	32.4
F	Fresno	FRESNO	326	36.4
L	Los Angeles	LOSANG	99	33.9
M	Minneapolis	MINNEAP	822	44.8
N	Atlanta	ATLANTA	800	33.6
P	Portland	PORTLAND	21	45.6
S	San Francisco	SANFRAN	8	37.7
T	Seattle	SEATTLE	400	47.5
W	Washington DC	WASH-DC	14	38.8

D - Delete, A - Add, E - Edit or Q - QUIT ?

If there are already 12 files, before adding a file you must first delete at least one file. To do this, type D and the computer will respond:

Enter code letters to REMOVE, (ctrl)-A for ALL or (ctrl)-N for NONE :

Type the code letter(s) for the cities you want to remove, then press carriage return. Let's say you decide to remove Albuquerque and Buffalo. Type AB then press carriage return. The city names will be deleted from the directory in the file GENERAL.INF, but the weather files themselves (with names like ALBUQUE.CTY) will be left on the disk so that you can move them to another disk for storage. Remove the unwanted files later or they will soon clog up the disk. The computer prints out:

Hit <ANY KEY> to continue.

and then:

The 10 cities now included in A:GENERAL are:

Code LETTER	City NAME	Weather FILE	ELEVATION	LATTITUDE
C	Sacramento	SACTO	17	38.5
D	San Diego	SANDIEG	19	32.4
F	Fresno	FRESNO	326	36.4
L	Los Angeles	LOSANG	99	33.9
M	Minneapolis	MINNEAP	822	44.8
N	Atlanta	ATLANTA	800	33.6
P	Portland	PORTLAND	21	45.6
S	San Francisco	SANFRAN	8	37.7
T	Seattle	SEATTLE	400	47.5
W	Washington DC	WASH-DC	14	38.8

D - Delete, A - Add, E - Edit or Q - QUIT ?

Now you can add two cities. To add a city, type A. The computer responds:

Enter the next city (up to 2 NEW cities, use <ctrl>-D when DONE)

Code LETTER	**City NAME**	**Weather FILE**	**ELEVATION**	**LATITUDE**
_	_________	__________	________	__.__

Fill in each blank, pressing carriage return to get to the next blank. Choose a Code LETTER of your liking. The City NAME is self-explanatory, for example, Boston. The Weather FILE must be eight characters or less (we suggest that you use the abbreviations listed in the Weather Library). For example, BOSTONTR.CTY is the name of the weather file that contains data for Boston, Massachusetts. Do not use the file extension ".CTY" as CIRACTY adds it automatically. After you have filled in ELEVATION and LATITUDE, the screen will clear and be replaced by a blank screen with lines identified by code letters A to W.

Next, type in, line-by-line, the weather data (from the Weather Library or your own source) for the city that you are adding. Type <ctrl-A> to enter all 23 lines of weather data. Type in each line of data (followed by a carriage return) exactly as it appears in printed form in the Weather Library. One or more blanks must separate the numbers. Omit the last line which includes the city name, latitude, tower height at the wind speed sensor, and elevation. When you have finished entering the weather data, proofread the data! CIRACTY does not check whether your numbers make sense. To correct mistakes, type the letter corresponding to the line that needs to be changed and press carriage return. Now re-enter the entire line and press carriage return. Type <ctrl-Q> when you are finished. This will write the new information onto the appropriate files on CIRA disk A. You may repeat this procedure for each weather file that you want to add (as long as the total number of cities does not exceed 12). Exit the Add mode by typing <ctrl-D> for Done and you will end up at the list of cities once again.

If, instead of adding or deleting a weather file, you want to correct mistakes or make changes to the current list of cities and weather files on CIRA disk A, type "E" to edit a weather file. Next, type in the code letter of the city you wish to edit and press carriage return (type <ctrl-N> to edit none and go back to the list of cities). A new line will appear at the bottom of the screen with the information on the city that you are editing (Code Letter, City Name, Weather File, Latitude, and Elevation). To change an entry, type over the old information and press carriage return to position the cursor at the next entry. Repeat this procedure for each item you want to change. Press carriage return to skip over an entry that you do not want to change. After you are finished editing the latitude data, the screen will clear and the current weather data will appear on the screen for editing. Type <ctrl-A> if you want to change all 23 lines of data, type <ctrl-Q> if you want to change none, or type the letters corresponding to the line(s) that you want to edit and press carriage return. You must enter the weather data following the format shown in the Weather Library. When finished editing, type <ctrl-Q> to quit and write the new data onto the appropriate files. A backup weather file, <Weather FILE>.BAK, will be created automatically for each city that you edit. Once you are finished editing, deleting and adding cities, type "Q" to quit the program and return to CP/M. You should now be ready to run CIRA with the new weather information. (We recommend that you copy any new or modified weather files onto the original CIRA disk "C" that we supplied you and erase any obsolete weather files from your working disk "A". To enable writing on the original CIRA disk "C" you may have to place a piece of opaque tape over the write notch (remove it when finished).

Create Your Own Weather File

A user can create a weather file for a city using hourly data from TMY tapes, National Weather Service 1440 series tapes, from long-term averages, or from any other filtering methods, as long as the format described below is respected. Except for the degree-day coefficients, there are 12 monthly values (January-December) for each parameter. The data is arranged in 23 lines, labelled A-W. For derivations and explanations of symbols, see the engineering section in this manual.

Line A

This is the monthly average specific infiltration ($m^3/hr\text{-}cm^2$) due to the stack effect under reference conditions. To calculate hourly values of Q/L due to the stack effect we use the following equation:

$$\frac{Q}{L} = 0.7425\left(\frac{\Delta T}{T}\right)^{0.5} \text{; and} \qquad (1)$$

$$\Delta T = |T - T_o| \qquad (2)$$

where:

Q/L is the specific infiltration due to the stack effect [$m^3/hr\text{-}cm^2$];

T is the inside temperature [K]; and

T_o is the outside temperature [K].

We calculate Q/L on an hour-by-hour basis, using an inside temperature of 20°C when the outside temperature is less than 20°C. When the outside temperature is greater than 25°C we use an inside temperature of 25°C. For periods when outside temperatures are between 20°C and 25°C we set $\Delta T = 0$, since the temperature in many houses "floats" under these mild temperature conditions. The 12 average monthly values are calculated by adding all hourly values and dividing by the number of hours in the month. Note that T is the absolute inside temperature, i.e. °C + 273.

Line B

This is the monthly average specific infiltration ($m^3/hr\text{-}cm^2$) due to the wind effect under reference conditions. To calculate monthly values of Q/L due to the wind effect we use the following equation:

$$\frac{Q}{L} = 0.0442 \left(\frac{V}{(0.1\ H_w)^{.15}} \right) \quad (3)$$

where:

Q/L is the specific infiltration due to the wind effect [$m^3/hr\text{-}cm^2$];

V is the monthly average windspeed [m/s]; and

H_w is the height of the windspeed sensor above grade [m].

The monthly average windspeed is the arithmetic mean of all hourly values.

Lines C through F

These lines contain values of the variable-base degree-day coefficients, μ, ν, and λ, the last in units of ^oF. Line C lists the values for day-time heating (8 a.m. - 8 p.m.); line D the night-time heating values; line E the day-time cooling values; line F the night-time cooling values. To find the coefficients μ, ν and λ, we first calculate heating and cooling degree-days and degree-nights to a number of bases (40, 45, 50, 55, 60, 65, and 70^oF for heating and 60, 65, 70, 75, 80, 85, 90^oF for cooling) using the equations:

$$DD_{T_{bm}} = \sum_{n=1}^{d} \frac{1}{12} [DH_{T_{bm}}]; \text{ and} \quad (4)$$

$$DH_{T_{bm}} = \sum_{i=i^*}^{i^*+12} [I(T_{bm} - T_{o_i})]_+ \quad (5)$$

where:

T_{bm} is the base temperature for mode m [^oF];

T_{o_i} is the hourly outside temperature [^oF];

i is an hourly index starting at either 8 a.m. or 8 p.m.;

d is the number of days in the month [day];

m is the degree-day mode [heating day, heating night, cooling day, and cooling night];

I is a seasonal index (1 for heating, -1 for cooling);

$[X]_+$ is equal to X when X is greater than zero, else it is zero;

$DD_{T_{bm}}$ is the number of monthly degree-days at base b and mode m [°F-"day" or °F-"night"]; and

$DH_{T_{bm}}$ is the number of daily ($i^* = 8$ a.m.) or nightly ($i^* = 8$ p.m.) degree-hours at base b and mode m [°F].

Once the degree-days are calculated from this equation, we have a table of monthly heating and cooling degree-days for day and night and for seven base temperatures, as shown in the example below.

Table 1: Monthly Degree-days (°F-day) for Washington, DC (from TRY tape)

Mode	T_b	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Heating day	40	101	26	7	0	0	0	0	0	0	0	3	35
	45	167	64	26	2	0	0	0	0	0	2	15	71
	50	240	114	67	13	0	0	0	0	0	9	40	125
	55	316	172	122	36	2	0	0	0	1	24	77	189
	60	393	237	185	66	8	1	0	0	5	55	128	261
	65	470	307	255	103	23	5	0	0	14	106	196	338
	70	548	377	330	152	50	14	0	7	31	176	268	415
Heating night	40	155	53	23	3	0	0	0	0	0	2	18	59
	45	227	104	68	16	0	0	0	0	0	13	42	108
	50	302	163	133	42	4	0	0	0	1	35	80	169
	55	377	228	204	75	13	0	0	0	8	77	134	240
	60	452	297	279	119	33	3	0	0	18	134	201	317
	65	528	367	356	172	70	11	1	4	34	206	275	395
	70	606	437	434	236	126	32	10	28	60	283	350	472
Cooling day	60	0	0	10	101	188	298	361	299	215	35	10	0
	65	0	0	2	63	125	228	284	222	150	8	2	0
	70	0	0	0	36	74	162	206	151	91	1	0	0
	75	0	0	0	18	37	103	132	88	46	0	0	0
	80	0	0	0	8	15	55	69	41	18	0	0	0
	85	0	0	0	2	3	20	27	14	3	0	0	0
	90	0	0	0	0	0	3	6	2	0	0	0	0
Cooling night	60	1	0	0	37	72	180	220	170	134	5	1	0
	65	0	0	0	15	32	114	144	97	75	0	0	0
	70	0	0	0	4	9	59	76	44	27	0	0	0
	75	0	0	0	0	2	20	30	13	5	0	0	0
	80	0	0	0	0	0	4	8	2	0	0	0	0
	85	0	0	0	0	0	0	1	0	0	0	0	0
	90	0	0	0	0	0	0	0	0	0	0	0	0

Since T_b will normally not correspond to one of the table columns above, we need an interpolation method to produce degree-days at values of T_b not shown in the table. We define a function such that:

$$\hat{DD}_{T_{bm}} = f(\overline{T}_o, T_{bm}) \times d \qquad (6)$$

where:

- $\overline{T}_o$ is the average monthly day-time or night-time outside temperature [^oF];
- T_{bm} is the base temperature for mode m [^oF];
- $\hat{DD}_{T_{bm}}$ are the predicted monthly degree-days (or -nights) at base b and mode m [^oF-day]; and
- d is the number of days in the month [day].

The function we use is:

$$f(\overline{T}_o, T_{bm}) = \frac{1}{2}\left\{ [I(\Delta T)]_+ + \mu[\lambda - |\Delta T|]_+^{v} \right\} \qquad (7)$$

where:

$$\Delta T = T_{bm} - \overline{T}_o; \text{ and}$$

- I is a seasonal index (1 for heating, -1 for cooling);
- μ, v are dimensionless empirical degree-day coefficients (one set for each combination of heating/cooling & day/night);
- λ is an empirical degree-day temperature (one for each combination of heating/cooling & day/night)[^oF];
- $[X]_+$ is equal to X when X is greater than zero, else it is zero;
- T_{bm} is the base temperature for mode m [^oF]; and
- $\overline{T}_o$ is the average monthly outside day/night temperature [^oF].

We now find the set of μ, v, λ that minimizes the root-mean-square error of the actual monthly degree-days versus the predicted monthly degree-days for each base temperature. To do so, we try a series of values of λ (from 10 to 35 at intervals of 0.5) and do ordinary least-square regressions to find the best μ and v for each λ.

For a given λ,

$$\hat{DD}_{T_{bm}}' = \frac{d}{2}\left\{ [I(\Delta T)]_+ + \mu[\lambda - |\Delta T|]_+^{v} \right\} \qquad (8)$$

Rearranging equation (8),

$$(2\hat{DD}_{T_{bm}}/d) - [I(\Delta T)]_+ = \mu[\lambda - |\Delta T|]_+^{v} \qquad (9)$$

Since this equation is of the form $y = \mu x^{v}$, we find μ and v by doing an ordinary least-squares regression on the equation $Y = a + bX$, where:

$$X = \ln[\lambda - |\Delta T|]_+ \text{ ; and} \qquad (10)$$

$$Y = \ln\left\{(2DD_{T_{bm}}/d) - [I(\Delta T)]_+\right\} \qquad (11)$$

We exclude points where $[\lambda - |\Delta T|]_+ < 2$. There is a maximum of 12 values of X for each base temperature, one for each permitted value of $[\lambda - |\Delta T|]_+$. For each λ, the best values of μ and v are obtained from the regression coefficients a, b, using:

$$\mu = e^{a}\text{; and} \qquad (12)$$

$$v = b \qquad (13)$$

Using this set of λ, μ, and v we calculate the predicted monthly degree-days for each base temperature and degree-day mode. The RMS error is calculated from the difference of actual vs. predicted monthly degree-days for each $DD_{T_{bm}}$ greater than zero.

$$E_{rms} = \left(\frac{1}{N}\sum(\hat{DD}_{T_{bm}} - DD_{T_{bm}})^2\right)^{0.5} \qquad (14)$$

where:

N = (12 x # of bases) - # of occurences where $DD_{T_{bm}} = 0$; and

E_{rms} is the root-mean-square error of actual vs. predicted degree-days [°F-day per year].

We store the values of λ, μ, v and E_{rms}, and try another value of λ. When all values of λ have been used, we find the set of λ, μ, and v which gives the lowest value of E_{rms}. Below we present a table of actual and predicted degree-days for the sample city.

Table 2: Actual vs. Predicted Degree-Days for Washington, DC

Degree-day mode = Heating-day

a = actual p = predicted

$\mu = .0042548$ $\nu = 2.32165$ $\lambda = 18.0$ $E_{rms} = 7.349$

T_b	January		February		March		April		May		June	
	a	p	a	p	a	p	a	p	a	p	a	p
40	101	107	26	32	7	12	0	0	0	0	0	0
45	167	169	64	64	26	32	2	0	0	0	0	0
50	240	239	114	113	67	66	13	4	0	0	0	0
55	316	316	172	171	122	118	36	16	2	0	0	0
60	393	394	237	237	185	181	66	38	8	5	1	0
65	470	471	307	307	255	253	103	76	23	19	5	1
70	548	549	377	377	330	330	152	130	50	44	14	8

T_b	July		August		September		October		November		December	
	a	p	a	p	a	p	a	p	a	p	a	p
40	0	0	0	0	0	0	0	0	3	4	35	34
45	0	0	0	0	0	0	2	2	15	16	71	70
50	0	0	0	0	0	0	9	12	40	39	125	123
55	0	0	0	0	1	0	24	32	77	78	189	187
60	0	0	0	0	5	2	55	66	128	132	261	261
65	0	0	0	1	14	10	106	118	196	196	338	338
70	0	2	7	10	31	29	176	181	268	269	415	415

Typical values of E_{rms} are between 3 and 12 degree-days per year, which is a measure of the error incurred by our approximation method.

Line G

The 12 values in this line are the average monthly day-time (8 a.m. - 8 p.m.) outside temperatures ($^{\circ}F$).

Line H

This is the average monthly night-time (8 p.m. - 8 a.m.) outside temperatures ($^{\circ}F$).

Line I

This line contains the average monthly wet bulb temperatures (^{o}F).

Lines J - U

Lines J through U contain the solar flux coefficients, A_0, A_1, A_2, A_3, and A_4. The rows correspond to the twelve months of the year, beginning with January, while the columns correspond to the coefficients. The solar flux coefficients are derived from cloud cover data using the Boeing - DOE 2 method of estimating solar radiation on surfaces of various orientations. The Boeing method is used to calculate total solar radiation from cloud cover information, while the DOE 2 method is used to calculate the direct/diffuse split. You may re-derive these coefficients for your own solar data following the method described below. To calculate the solar flux at any azimuth angle we take the solar fluxes (in Btu/ft^2-day) on five vertical surfaces, North, Northeast, East, Southeast, and South, and fit them to a cosine expansion:

$$S(z) = A_o + A_1\cos(z) + A_2\cos(2z) + A_3\cos(3z) + A_4\cos(4z)$$

where:

S(z) is the average monthly total solar flux on a vertical surface azimuth z assuming a ground reflectance of 0.2.

z is the azimuth of the vertical surface (North = 0; East = 90^o; etc.)

Setting the angle z to the angle for which we know the flux, for example North and Northeast, we obtain:

$$\text{Flux on North} = N = A_o + A_1 + A_2 + A_3 + A_4$$
$$\text{Flux on Northeast} = NE = A_o + 0.7071\ A_1 - 0.7071\ A_3 - A_4$$

and so on. Solving these equations for the coefficients A_i:

$$A_o = 0.125\ (S + N + 2E + 2NE + 2SE)$$
$$A_1 = 0.25\ (N - S) + 0.3536\ (NE - SE)$$
$$A_2 = 0.25\ (N + S - 2E)$$
$$A_3 = 0.25\ (N - S) - 0.3536\ (NE - SE)$$
$$A_4 = 0.125\ (S + N + 2E - 2NE - 2SE)$$

Line V

Line V is the average monthly horizontal total solar flux (Btu/ft^2-day)

Line W

Line 23 is the average monthly diffuse solar flux (Btu/ft^2-day).

Line X

Line X contains the name of the city (and state abbreviation), the latitude, tower height of the wind recording instrument, and the altitude of the weather measurement site. In the case of TRY tapes the actual year that the data represents is listed. This line should not be typed into the weather file on disk; it is provided for information purposes only (e.g. the user will find the latitude and altitude information useful when using the CIRACTY program to add a new weather file to CIRA).

Table of Contents

TMY Cities

California Climate Zones

Other Cities

TEST REFERENCE YEAR CITIES

ALBUQUTR.CTY

```
.187  .170  .147  .101  .062  .052  .049  .042  .057  .099  .156  .178
.138  .186  .196  .196  .213  .184  .189  .133  .166  .159  .125  .119
.15133E-01  1.96279 16.5
.27699E-07  5.42948 30.0
.12467E-02  2.73463 18.0
.20107E-12  8.47870 35.0
37.2  43.7  50.7  62.1  71.3  82.6  83.4  80.2  76.3  61.9  48.4  40.5
30.4  35.2  40.4  50.7  59.3  70.5  71.0  69.5  64.5  51.5  38.8  34.4
28.0  31.7  34.1  42.4  47.1  56.5  59.8  61.5  51.0  44.7  34.9  32.3
  721.4   -643.3    116.3       .2     18.9
  748.9   -519.4     39.4    -16.4     24.1
  999.5   -566.3    -48.1    -16.8     15.5
 1048.2   -290.1   -131.7    -10.9    -10.1
 1189.9   -115.0   -227.7    -62.0    -23.7
 1137.9    -48.5   -300.7    -48.2    -38.0
 1098.0    -87.3   -245.0    -62.3    -27.9
 1082.1   -270.6   -183.7    -16.3    -18.0
 1070.3   -512.0   -121.9    -21.9      3.4
  932.8   -637.5     15.9     -1.3     19.6
  794.6   -714.1    109.5     -6.3     26.1
  580.4   -497.0    105.3     -5.3     14.2
 944. 1098. 1700. 1837. 2251. 2534. 2404. 2122. 1994. 1441. 1080.  742.
 265.  370.  473.  893.  976.  624.  705.  762.  478.  412.  226.  274.
CIRA 1.0 LOC=TRY ALBUQUERQUE,NM, LAT=35.1, TWHT=48, YEAR=1959, ALT=5311
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ATLANTTR.CTY

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.207  .222  .237  .196  .131  .162  .155  .143  .168  .171  .174  .2
.12416E-04  3.72485 31.0
.21194       .97051 13.0
.18421E-10  7.22536 35.0
.38630E-14  9.38156 35.0
49.7  50.2  53.0  64.1  74.6  78.9  78.5  80.8  72.9  66.7  57.3  45.7
43.5  43.7  46.6  54.7  66.1  69.0  71.1  72.5  65.3  58.3  49.7  40.1
42.3  42.9  44.2  51.8  64.3  67.4  70.6  72.4  64.7  57.8  48.3  38.1
  516.5   -386.6     62.9      1.4     11.0
  572.7   -336.4     28.1      4.5      8.4
  777.0   -311.4    -19.5     -1.9      4.2
  951.6   -258.2   -115.6      5.1    -12.2
 1003.6   -124.4   -139.8      7.7    -12.6
 1090.7    -39.8   -179.2    -16.3    -20.7
 1000.1    -93.5   -120.4      5.8    -13.3
  979.3   -192.9   -149.9    -10.6    -13.3
  826.7   -286.7    -62.0     -1.5     -1.5
  715.9   -428.3     11.2     -2.5     11.6
  576.6   -430.3     64.9     -2.4     15.6
  509.7   -409.4     81.2      3.4      7.9
 674.  818. 1188. 1620. 1688. 1874. 1637. 1704. 1331. 1084.  789.  659.
 306.  434.  730.  866. 1095. 1136. 1190.  904.  752.  443.  324.  282.
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BIRMINTR.CTY

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 .177  .183  .193  .151  .115  .137  .108  .104  .159  .113  .092  .101
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 .20778E-06  4.68165 35.0
 .50849E-11  7.52007 35.0
 .42564E-02  2.63752 10.0
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 41.4  40.5  45.7  59.0  64.0  68.5  71.8  71.9  68.3  54.3  50.1  41.2
   565.3   -438.8     72.9      -.4      13.0
   616.0   -374.4     27.3     -4.3      13.3
   724.4   -262.1    -10.3     -4.4       5.5
   923.3   -240.0   -115.2     13.1     -11.7
  1049.0   -130.4   -177.9       .3     -19.0
  1038.7    -48.9   -169.5     -9.0     -19.0
  1017.6    -72.5   -146.0    -14.8     -17.1
  1000.4   -185.8   -131.9    -12.4     -10.7
   863.2   -291.6    -65.3    -10.5        .7
   778.6   -514.3     25.1      2.7      12.2
   508.9   -349.3     52.1     10.2       3.4
   523.9   -418.3     81.8      5.9       5.6
 749.  901. 1099. 1562. 1858. 1814. 1726. 1675. 1374. 1214.  681.  674.
 304.  418.  761.  874. 1014. 1080. 1114. 1022.  791.  406.  350.  292.
CIRA 1.0 LOC=TRY BIRMINGHAM,AL, LAT=33.6, TWHT=20, YEAR=1965, ALT=620
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BISMARTR.CTY

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 .213  .23  .198  .298  .25  .213  .207  .194  .2  .201  .206  .205
 .78902E-01  1.48932 16.0
 .18690E-01  1.85214 16.0
 .74207E-02  2.22022 17.5
 .26266E-07  5.23770 35.0
  7.1  19.6  23.7  43.2  59.0  74.5  78.6  78.4  64.3  48.3  29.6  14.5
  3.5  14.1  16.2  35.9  48.4  61.6  64.2  61.8  50.5  39.2  25.6   9.6
  4.4  15.3  18.3  34.7  47.2  59.9  61.9  59.2  49.6  38.0  26.2  11.1
   313.8   -239.7     59.7      4.9       -.6
   518.2   -398.3     66.2      3.3       8.1
   665.6   -401.4     14.9     10.8       4.3
   890.3   -298.3    -38.8    -22.5       5.5
  1061.6   -257.3    -91.2     23.5     -11.0
  1223.8   -237.7   -200.0     -4.2     -19.3
  1199.9   -272.3   -183.8     -4.8     -17.0
  1074.6   -414.3   -130.1     -6.9      -8.8
   789.6   -433.9    -14.6      1.9       5.3
   588.5   -423.3     52.5     -8.6      13.6
   327.6   -244.2     56.4      7.1      -1.4
   355.8   -329.3     89.9     -5.5       7.0
 341.  627.  935. 1328. 1609. 2183. 2130. 1878. 1174.  778.  369.  361.
 231.  300.  445.  876. 1152.  927.  912.  644.  509.  322.  241.  182.
CIRA 1.0 LOC=TRY BISMARC,ND, LAT=46.8, TWHT=20, YEAR=1970, ALT=1647
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BOISE-TR.CTY

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.192  .190  .156  .132  .086  .075  .065  .064  .071  .134  .160  .195
.178  .159  .212  .186  .201  .184  .166  .168  .152  .166  .172  .172
.90748E-02  2.04930 19.5
.79950E-04  3.35502 24.5
.66494E-05  3.94852 30.0
.14893E-05  4.26211 31.5
34.3  35.6  47.4  55.5  68.8  71.3  80.9  79.4  72.6  54.5  45.0  32.4
30.3  30.4  38.1  42.8  55.2  58.7  66.2  66.0  59.8  42.9  40.0  29.7
29.5  29.9  35.7  39.5  47.8  51.4  55.4  55.0  53.1  40.5  37.8  29.3
  355.8   -257.8     61.1     -4.8      7.4
  472.3   -297.1     46.5      1.4      4.9
  767.3   -429.5     -6.9    -13.5     11.4
 1022.1   -373.7    -86.8    -15.0     -1.6
 1161.1   -267.6   -163.8     -7.1    -17.3
 1187.8   -212.0   -192.5      9.1    -19.3
 1212.8   -279.5   -277.7      2.9    -29.0
 1127.9   -363.1   -161.1    -19.8    -12.7
  942.6   -539.0    -34.2     10.5       .8
  703.2   -512.9     43.9     20.1       .9
  387.4   -283.9     61.2      9.3     -2.4
  320.5   -247.8     67.8     -1.6      2.2
415.  588. 1157. 1662. 2031. 2163. 2502. 2005. 1526.  937.  461.  367.
267.  376.  473.  807.  958.  976.  534.  733.  501.  359.  279.  232.
CIRA 1.0 LOC=TRY BOISE,ID, LAT=43.5, TWHT=20, YEAR=1966, ALT=2838
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BOSTONTR.CTY

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.200  .200  .184  .131  .097  .051  .036  .032  .071  .113  .152  .189
.274  .333  .329  .337  .321  .28  .283  .28  .278  .307  .304  .279
.31231E-01  1.76814 13.5
.51399E-06  4.72496 26.5
.52726E-02  2.30213 15.5
.95133E-03  2.89359 14.0
30.9  30.7  37.3  53.2  60.9  72.1  73.1  77.9  66.4  57.0  46.6  34.5
27.7  28.3  32.9  46.8  55.0  64.7  67.9  70.1  60.4  51.3  43.6  32.1
25.7  26.9  31.4  44.1  50.7  61.4  63.9  65.9  58.3  48.8  41.9  30.2
  466.3   -413.2     92.5      8.5      2.3
  496.8   -346.5     54.5     -5.4     11.6
  705.1   -374.9     -4.7      1.9      8.2
  958.7   -366.4    -93.3      -.3     -8.7
 1059.5   -239.3   -154.4     12.6    -17.9
 1068.9   -159.9   -162.8     -7.6    -12.1
 1033.4   -169.0   -117.6       .1    -11.9
 1046.1   -331.6   -123.3     -2.8     -7.2
  792.1   -410.5    -21.6     -1.8      4.8
  639.1   -470.1     53.4      3.0     10.7
  411.7   -319.5     73.5      1.2      4.1
  375.9   -317.5     80.3    -10.9     12.6
522.  631. 1036. 1612. 1806. 1906. 1684. 1810. 1258.  881.  490.  427.
232.  329.  514.  700.  924.  980. 1117.  824.  523.  329.  271.  217.
CIRA 1.0 LOC=TRY BOSTON,MA, LAT=42.4, TWHT=22, YEAR=1969, ALT=15
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BROWNSTR.CTY

```
 .063  .062  .048  .034  .052  .062  .065  .070  .053  .041  .055  .067
 .222  .258  .294  .281  .287  .248  .207  .179  .174  .174  .249  .199
 .18841E-05  4.03372 35.0
 .33325E-01  1.78378 13.5
 .46763E-10  6.87174 35.0
 .22564E-11  7.53528 35.0
 66.6  66.6  73.6  79.5  84.5  86.7  86.7  87.6  84.1  79.7  70.2  67.5
 59.3  60.0  65.7  71.4  76.4  77.3  78.6  78.7  77.5  68.9  64.8  59.0
 58.1  58.7  63.7  69.5  73.9  74.2  76.2  76.8  76.5  67.2  62.8  58.9
   566.7  -365.5     43.7     -3.1     14.1
   677.7  -320.5      8.5     12.0      4.0
   860.5  -336.4    -66.8     17.2     -5.1
   928.1  -180.9   -132.1     18.9    -16.6
  1010.5   -44.2   -201.5     17.9    -24.5
  1071.6    45.5   -212.3     12.8    -22.3
  1066.4    20.0   -185.5      1.0    -20.4
  1038.2  -104.5   -201.6     -6.5    -26.5
   901.6  -211.3    -84.7    -15.1     -4.5
   865.9  -453.3    -30.6     -4.9     13.4
   583.8  -307.9     26.0    -11.7     16.0
   610.4  -476.4     66.9     19.1      6.0
 836.  990. 1450. 1600. 1895. 2009. 1876. 1839. 1409. 1425.  847.  878.
 383.  628.  717.  955.  955. 1017. 1113.  980.  978.  551.  492.  307.
CIRA 1.0 LOC=TRY BROWNSVILLE,TX, LAT=25.9, TWHT=56, YEAR=1955, ALT=19
```

BUFFALTR.CTY

```
 .205  .216  .188  .142  .117  .058  .036  .034  .082  .133  .166  .194
 .288  .264  .291  .299  .247  .239  .242  .198  .223  .247  .247  .248
 .37589E-06  4.51093 35.0
 .11633E-08  6.07758 35.0
 .27674E-01  1.86982 11.0
 .83578E-03  2.80129 15.5
 28.3  24.4  35.1  49.6  57.0  69.7  74.9  74.2  63.1  52.3  41.4  32.9
 26.0  20.8  31.2  42.7  49.3  61.1  66.2  65.6  55.9  45.8  39.1  30.9
 25.2  20.5  30.1  41.2  47.7  58.1  62.4  62.9  53.6  43.0  37.4  30.5
   299.6  -185.2     44.9     -2.9      4.3
   411.2  -214.2     37.0     -4.7      7.1
   619.9  -295.1      5.5     10.6      -.4
   879.8  -266.4    -61.1    -11.2     -2.5
  1031.8  -192.5   -109.8     -6.5     -7.5
  1095.4  -154.8   -127.6     -1.3     -9.8
  1117.4  -185.6   -149.4      2.8    -16.0
   977.6  -225.9    -77.1    -24.3      -.1
   749.0  -290.9    -18.7     -7.1      4.7
   544.6  -330.9     31.3     13.0      2.3
   316.2  -182.7     40.6     -1.8      3.7
   286.2  -200.9     52.9      4.3     -2.5
 361.  532.  865. 1357. 1624. 1762. 1832. 1507. 1083.  714.  388.  334.
 277.  407.  563.  868. 1121. 1210. 1120. 1057.  726.  420.  305.  237.
CIRA 1.0 LOC=TRY BUFFALO,NY, LAT=42.8, TWHT=20, YEAR=1974, ALT=705
```

BURLINTR.CTY

```
 .231  .224  .195  .165  .121  .064  .050  .049  .103  .141  .164  .209
 .207  .187  .206  .198  .201  .166  .194  .177  .178  .22  .223  .208
 .20760E-06  4.69889 35.0
 .25886E-01  1.76838 15.0
 .83651E-05  4.11314 23.0
 .93821E-09  6.62007 28.0
 17.1  22.0  33.5  45.7  56.8  71.1  76.0  72.5  60.7  51.2  42.8  26.1
 14.9  16.0  28.3  36.7  46.5  59.7  63.9  62.5  51.6  43.9  38.6  23.5
 14.7  17.1  27.7  35.9  45.4  59.4  61.6  61.8  52.1  42.9  37.9  23.0
   328.6   -254.1     63.9      5.9     -2.4
   476.4   -335.7     53.5      8.4      2.3
   614.6   -313.7      8.2      8.3      2.8
   838.8   -246.8    -43.2     -7.3     -.6
  1001.4   -191.2   -102.1     -8.7     -8.1
  1062.2   -162.9   -136.9    -12.1     -9.3
  1058.1   -213.5   -137.5       .6    -11.2
   911.2   -254.4    -74.0    -15.5     -4.7
   707.0   -321.3    -26.2     -2.3      2.9
   538.4   -356.4     42.2     11.1      3.1
   338.4   -239.5     53.6      1.3      3.1
   267.5   -190.9     47.5      3.3     -.0
 376.  586.  854. 1241. 1552. 1786. 1826. 1448. 1068.  699.  394.  300.
 232.  325.  521.  903. 1080. 1057.  975.  878.  559.  374.  261.  216.
CIRA 1.0 LOC=TRY BURLINGTON,VT, LAT=44.5, TWHT=20, YEAR=1966, ALT=332
```

CHARLETR.CTY

```
 .141  .117  .083  .054  .040  .038  .041  .041  .020  .065  .107  .142
 .189  .212  .231  .211  .187  .197  .153  .171  .149  .165  .179  .177
 .26490E-05  3.97953 35.0
 .10009      1.29352 14.0
 .39749E-05  4.80163 17.0
 .56032E-08  5.92408 26.0
 51.0  57.0  65.5  72.0  78.9  80.3  83.4  83.4  77.3  69.4  60.6  50.6
 43.2  47.0  54.3  60.7  67.7  69.3  74.7  74.5  70.5  57.7  48.2  42.6
 42.5  47.2  53.4  59.6  66.5  67.6  74.7  74.1  71.1  58.5  49.4  42.1
   591.4   -453.9     76.1      1.4     13.3
   646.2   -368.1     22.4     -2.5     12.5
   867.6   -364.8    -40.5       .9      1.0
   969.6   -245.4   -120.5      3.6    -13.1
  1048.7   -114.0   -164.2    -13.3    -18.5
  1106.1    -25.9   -183.1    -24.4    -20.7
  1126.8    -54.8   -164.9    -23.6    -19.0
  1026.7   -165.9   -156.2    -24.5    -15.8
   805.2   -245.0    -33.1      6.8     -2.2
   818.4   -529.6     21.8      6.2     13.4
   668.9   -548.8     80.2     -4.2     20.4
   531.0   -405.8     72.9      7.7      7.7
 791.  912. 1388. 1658. 1848. 1930. 1866. 1752. 1196. 1283.  952.  680.
 331.  487.  721.  906. 1060. 1150. 1254.  994.  909.  449.  270.  323.
CIRA 1.0 LOC=TRY CHARLESTON,SC, LAT=32.9, TWHT=77, YEAR=1955, ALT=41
```

CHEYENTR.CTY

```
.209  .192  .175  .153  .105  .075  .056  .068  .109  .137  .184  .205
.258  .317  .284  .305  .257  .222  .19  .21  .196  .201  .24  .271
.26789E-05  4.12783 32.5
.64417E-01  1.52280 11.0
.16191E-02  2.56395 19.5
.16225E-18 12.46708 35.0
27.7  36.6  41.7  49.4  62.6  71.3  77.4  72.4  62.3  54.2  39.1  31.4
21.3  27.7  32.7  37.7  48.1  57.5  62.3  57.8  47.8  41.1  30.3  22.3
19.2  24.3  29.3  34.1  42.5  49.9  54.2  50.8  42.1  38.4  27.8  21.0
  504.8   -432.1      98.4     -9.7     14.9
  672.5   -529.8      71.5      1.3     15.3
  778.0   -402.3       5.5     -3.7      8.5
 1009.5   -310.3    -100.8    -23.6     -4.2
 1132.7   -198.7    -162.9    -46.4    -11.1
 1126.5   -135.5    -206.4    -47.6    -19.1
 1142.6   -137.8    -177.8    -67.5    -15.9
 1050.4   -289.5    -134.4    -40.2     -5.0
  951.0   -507.7     -51.2    -17.5      9.9
  671.4   -471.3      43.8      -.4     11.2
  562.3   -482.4      95.9      8.3      4.3
  515.5   -493.1     118.5      6.3      3.1
 594.  872. 1151. 1644. 2016. 2222. 2101. 1887. 1573.  961.  682.  572.
 260.  319.  601.  867.  991.  828.  971.  797.  501.  352.  267.  207.
CIRA 1.0 LOC=TRY CHEYENNE,WY, LAT=41.2, TWHT=33, YEAR=1974, ALT=6126
```

CHICAGTR.CTY

```
.209  .204  .172  .120  .100  .051  .040  .034  .080  .112  .164  .194
.16  .22  .247  .266  .218  .237  .186  .17  .206  .209  .208  .197
.46144E-01  1.56465 16.5
.42829E-08  5.75200 35.0
.12869E-01  2.13400 13.5
.96384E-06  4.98415 19.5
27.0  29.9  40.2  55.1  59.8  71.6  80.2  76.3  66.1  57.8  42.9  33.0
23.7  25.2  36.6  48.1  53.7  62.6  70.9  67.4  56.7  49.5  39.0  30.4
23.7  25.0  34.8  44.9  51.0  58.8  65.9  64.0  53.7  47.2  37.9  30.0
  400.4   -318.8      71.6      5.1      2.4
  521.3   -353.7      49.6      5.5      6.7
  658.8   -291.7       4.9     -6.5      5.8
  905.1   -291.0     -63.8    -17.3       .5
 1049.0   -161.8    -113.0    -25.6    -10.1
 1099.8   -154.3    -160.4     -8.9    -13.6
 1097.8   -177.9    -186.2    -26.8    -15.6
 1007.5   -254.1     -95.3    -16.9     -4.0
  856.2   -409.9     -36.7    -14.7      7.3
  598.0   -409.8      44.8     -5.9     11.2
  427.5   -322.7      67.8     -8.3     11.9
  307.1   -211.3      52.3     -4.6      6.4
 467.  676.  940. 1465. 1621. 1937. 2050. 1605. 1359.  847.  530.  363.
 254.  360.  615.  832. 1166. 1050.  872. 1001.  587.  342.  274.  253.
CIRA 1.0 LOC=TRY CHICAGO,IL, LAT=41.8, TWHT=20, YEAR=1974, ALT=607
```

CINCINTR.CTY

```
 .202  .173  .159  .102  .064  .036  .044  .043  .048  .115  .155  .171
 .172  .164  .198  .198  .179  .164  .138  .115  .156  .166  .186  .218
 .59500E-05  3.90179 32.0
 .15513E-02  2.52323 20.0
 .49190E-11  7.66569 35.0
 .29052E-02  2.65484 13.0
 29.5  40.4  46.1  59.9  69.1  76.9  81.4  79.6  71.0  56.7  46.2  40.5
 26.5  36.4  38.8  51.9  58.9  69.0  71.4  68.7  63.2  49.8  41.2  37.3
 25.8  35.2  36.8  49.9  56.7  66.1  67.6  65.0  60.4  46.8  39.1  35.3
   385.2   -267.1     56.5      3.7      2.7
   462.6   -248.8     30.9      5.5      2.1
   758.6   -354.4     -1.0    -12.7     10.8
   892.8   -234.9    -68.9    -12.1     -3.8
  1066.1   -168.9   -134.8    -13.5    -13.3
  1059.9   -101.8   -138.9    -15.7    -12.0
  1088.8   -124.8   -176.7    -28.7    -15.9
  1011.7   -288.0   -129.0      7.7    -11.9
   812.9   -300.2    -25.5      1.1      1.1
   590.6   -341.7     25.4     -5.4     11.7
   463.3   -349.6     66.9      2.5      6.6
   402.4   -317.6     80.3    -13.2     12.8
 467.  602. 1125. 1406. 1724. 1750. 1928. 1776. 1200.  853.  589.  496.
 298.  427.  641.  928. 1121. 1173. 1012.  848.  815.  434.  291.  256.
CIRA 1.0 LOC=TRY CINCINNATI,OH, LAT=39.1, TWHT=64, YEAR=1957, ALT=761
```

CLEVELTR.CTY

```
 .206  .203  .185  .129  .091  .068  .031  .042  .072  .120  .168  .204
 .266  .229  .244  .227  .188  .207  .163  .162  .179  .221  .215  .242
 .61404E-05  4.10076 27.0
 .63420E-01  1.47355 13.5
 .62678E-10  6.94951 35.0
 .54045E-03  3.12088 15.0
 27.1  29.4  36.5  53.2  64.3  68.9  76.4  78.1  67.1  55.2  41.3  28.6
 24.8  26.7  31.7  46.0  54.1  61.6  68.2  66.1  59.1  48.3  39.2  27.2
 23.2  25.1  29.1  43.4  51.7  59.3  65.7  64.2  57.8  46.8  36.9  25.1
   311.6   -194.1     45.7      2.7       .2
   485.8   -297.8     44.1     10.0      -.8
   693.2   -363.3      -.4      6.5      5.7
   876.4   -299.7    -78.2      9.6     -8.0
  1014.6   -202.7   -143.4    -14.0    -14.6
  1028.6   -140.4   -134.9      3.0    -12.8
  1044.5   -179.2   -137.8      8.0    -13.8
   993.3   -306.2   -139.2     -2.9     -9.0
   742.4   -300.5    -22.7      2.9      1.7
   526.2   -300.6     30.8      -.6      7.3
   337.1   -201.3     45.0     -3.1      5.2
   261.7   -144.9     36.3     -1.6      1.9
 378.  622. 1009. 1418. 1789. 1707. 1764. 1743. 1097.  720.  422.  318.
 285.  398.  534.  764.  889. 1095. 1057.  730.  693.  425.  313.  270.
CIRA 1.0 LOC=TRY CLEVELAND,OH, LAT=41.4, TWHT=20, YEAR=1969, ALT=777
```

DETROITR.CTY

```
 .218  .213  .173  .125  .107  .053  .042  .047  .056  .113  .164  .201
 .229  .26  .234  .241  .222  .19  .18  .183  .168  .199  .229  .248
 .12361     1.27722 13.5
 .13646E-01 2.01184 14.5
 .38496E-06 4.97992 24.5
 .66457E-03 3.00635 16.5
 22.9  26.4  41.1  56.1  60.1  72.9  77.3  77.4  70.5  58.2  44.2  30.4
 20.5  21.6  33.4  46.0  51.5  63.0  66.5  67.5  60.4  49.3  38.7  27.2
 20.1  20.9  32.7  44.1  49.6  61.0  64.1  65.8  59.9  48.4  37.5  26.5
   390.3  -304.6     73.8    -2.9     6.3
   595.4  -443.6     59.7    -6.0    15.1
   746.6  -375.3     -1.4   -14.6    12.1
   969.7  -340.0    -82.8    -5.9    -6.2
  1048.8  -178.4   -115.9   -23.4    -9.9
  1107.6  -152.1   -152.5   -11.0   -13.7
  1156.8  -175.5   -181.4   -26.9   -16.4
  1045.0  -301.0   -117.9     -.7   -10.1
   829.0  -366.1    -24.9    -9.5     4.4
   610.3  -401.3     38.4   -13.4    17.3
   398.6  -269.8     53.2     3.8     2.9
   291.9  -191.6     49.4    -2.7     3.2
 462.  771. 1094. 1571. 1662. 1887. 2039. 1704. 1271.  855.  484.  346.
 259.  319.  572.  809. 1121. 1104. 1013.  921.  674.  368.  312.  257.
CIRA 1.0 LOC=TRY DETROIT,MI, LAT=42.2, TWHT=20, YEAR=1968, ALT=619
```

DODGECTR.CTY

```
 .205  .193  .160  .113  .086  .059  .060  .047  .077  .098  .157  .188
 .256  .308  .32  .294  .294  .303  .255  .224  .284  .268  .271  .224
 .96044E-02 1.90322 24.5
 .14953E-03 3.17816 23.5
 .40688E-05 4.07902 30.0
 .51507E-02 2.36394 15.0
 29.3  34.4  46.9  59.1  67.5  83.7  83.4  81.4  73.2  62.6  46.6  36.3
 23.3  27.4  36.1  47.1  54.7  70.0  70.6  69.0  62.0  51.6  38.5  30.7
 23.3  27.5  34.4  44.9  52.4  64.4  64.3  64.4  56.0  48.8  37.1  30.8
   550.8  -411.2     78.0    -1.9    11.5
   633.4  -424.3     39.8     2.0    13.5
   873.2  -399.6    -24.1   -11.1     9.1
  1005.5  -322.3   -111.8     2.0    -9.3
  1118.2  -181.2   -198.7   -10.0   -22.1
  1138.9  -117.7   -224.6    -8.9   -23.8
  1104.7  -150.4   -197.0     6.7   -21.2
  1053.9  -248.9   -137.2   -14.9    -9.8
   907.9  -421.9    -68.6    -3.7      .8
   767.7  -554.0     33.4     5.4     9.5
   605.8  -499.5     84.3     3.8    11.6
   471.3  -387.4     86.8     1.5     6.1
 680.  865. 1320. 1701. 2024. 2231. 2034. 1839. 1561. 1175.  795.  571.
 354.  395.  699.  839.  942.  913.  974.  944.  567.  321.  281.  269.
CIRA 1.0 LOC=TRY DODGE CITY,KS, LAT=37.5, TWHT=20, YEAR=1971, ALT=2582
```

ELPASOTR.CTY

```
 .156  .133  .079  .058  .057  .059  .068  .047  .045  .070  .114  .164
 .157  .185  .196  .246  .21  .207  .19  .176  .146  .138  .155  .178
 .44246E-01  1.57558 16.5
 .35029E-07  5.19172 35.0
 .26820E-03  3.07560 20.5
 .13766E-01  2.27680 11.0
 49.3  54.7  67.5  73.0  78.9  85.5  87.9  83.0  78.3  71.6  58.8  44.9
 35.0  43.1  54.1  60.6  65.6  73.9  77.9  72.6  67.8  57.1  47.4  37.2
 30.9  36.1  43.7  46.1  49.4  59.3  65.3  62.7  59.6  48.7  41.5  34.8
   808.9   -721.4    116.6      -.6     22.4
   802.9   -554.1     41.7      -.5     18.0
   960.2   -424.2    -49.3    -31.8     15.3
  1069.4   -252.1   -175.7    -24.7    -14.7
  1103.2   -107.2   -238.7    -16.6    -28.9
  1072.0    -20.4   -257.9     -7.1    -30.3
  1064.5    -73.6   -188.8      -.0    -19.8
  1006.2   -190.4   -169.5    -28.8    -15.0
   975.0   -433.0   -116.5     -2.1     -1.5
   906.1   -602.3      4.0      -.5     17.4
   677.2   -492.2     61.3      6.9     11.4
   637.2   -551.0     98.9      5.2     12.6
1118. 1216. 1629. 1960. 2179. 2205. 2012. 1947. 1813. 1499.  953.  847.
 254.  414.  681.  844.  865.  796. 1024.  820.  527.  388.  376.  263.
CIRA 1.0 LOC=TRY ELPASO,TX, LAT=31.8, TWHT=20, YEAR=1967, ALT=3918
```

FORTWOTR.CTY

```
 .137  .143  .112  .066  .035  .058  .067  .072  .056  .056  .094  .132
 .217  .255  .247  .222  .157  .2  .149  .167  .164  .199  .236  .207
 .31873E-05  3.99340 35.0
 .95574E-06  4.35224 33.0
 .46116E-02  2.36034 16.0
 .14153E-01  2.17736 11.0
 51.6  49.6  56.7  68.0  76.9  85.3  87.8  89.0  80.2  75.0  62.3  52.5
 45.0  43.1  50.5  60.8  68.2  75.2  78.1  79.0  70.0  64.0  52.7  44.5
 42.9  41.5  47.3  57.7  66.4  71.5  73.0  73.3  64.8  59.0  49.1  42.3
   608.1   -493.5     77.6     18.4      4.0
   689.2   -452.7     26.6     12.4      8.1
   846.2   -364.2    -30.2     17.4     -3.4
   932.1   -254.7    -95.8     25.2    -14.3
  1016.5   -111.8   -165.0      1.1    -16.3
  1092.3    -87.4   -195.0     34.4    -19.7
  1106.3    -52.7   -204.6    -25.7    -23.5
  1028.1   -202.0   -177.0    -10.4    -18.9
   955.0   -387.6    -97.1     -8.8       .3
   802.6   -532.2     -2.2     26.2       .7
   711.7   -602.7     86.1      8.7     14.9
   566.9   -458.8     84.4      9.5      7.1
 794. 1014. 1318. 1549. 1755. 2018. 1998. 1899. 1650. 1276. 1004.  732.
 300.  405.  740.  935. 1034. 1053. 1045.  853.  651.  372.  263.  302.
CIRA 1.0 LOC=TRY FORT WORTH,TX, LAT=32.9, TWHT=22, YEAR=1975, ALT=544
```

FRESNOTR.CTY

```
.154  .136  .114  .087  .072  .066  .074  .069  .068  .083  .115  .156
.112  .121  .13   .123  .167  .156  .143  .122  .111  .109  .1  .118
.22988E-08  5.89443 35.0
.24038E-04  4.01133 18.5
.10416E-03  3.28385 24.5
.87971E-09  6.17778 35.0
48.1  54.4  60.8  67.9  76.5  83.3  88.6  87.1  83.6  71.0  60.3  48.2
41.6  43.2  45.5  53.4  60.2  65.6  70.0  68.2  64.6  53.0  47.1  39.8
43.1  45.5  47.1  53.2  56.7  60.3  63.2  63.0  62.0  52.6  48.7  41.7
  388.5   -222.9     41.6      4.4      2.2
  657.5   -451.8     41.8      -.6     15.3
  917.2   -465.5    -43.3    -11.6      9.6
 1014.9   -295.2   -110.8    -31.1     -1.6
 1097.4   -172.3   -240.7    -13.8    -26.0
 1130.3    -99.0   -296.6     -3.7    -35.1
 1097.1   -140.2   -298.2     -2.6    -35.0
 1095.0   -338.2   -250.3      6.9    -26.8
 1029.8   -557.1   -117.1     -2.7       .3
  885.1   -678.1     32.0      7.6     16.7
  677.1   -582.8     97.4      9.4      9.6
  462.4   -348.2     69.9      8.9      2.4
482.  916. 1480. 1766. 2162. 2413. 2394. 2239. 1889. 1378.  898.  556.
368.  379.  573.  853.  730.  616.  507.  470.  358.  279.  269.  311.
CIRA 1.0 LOC=TRY FRESNO,CA, LAT=36.8, TWHT=42, YEAR=1951, ALT=328
```

GREATFTR.CTY

```
.218  .213  .185  .159  .116  .075  .063  .071  .093  .134  .175  .193
.295  .436  .417  .269  .239  .317  .24  .249  .286  .352  .409  .464
.24461E-01  1.71242 21.5
.24349E-02  2.52008 18.0
.42569E-02  2.31899 20.0
.84535E-02  2.07078 17.5
22.9  25.9  37.6  46.6  58.0  70.4  75.2  71.3  64.9  52.3  40.8  31.7
19.5  20.8  29.5  36.8  47.7  57.8  62.7  59.5  52.5  44.7  34.7  27.9
18.4  19.7  27.7  34.0  44.1  50.9  54.8  52.3  46.2  39.0  31.5  23.8
  407.5   -392.6    101.9      7.3     -2.0
  450.3   -341.4     71.3     -4.1      8.0
  626.2   -371.7     21.7      3.7      5.8
  902.3   -384.9    -48.1     -4.7       .7
 1028.6   -240.6    -91.2      6.2     -7.4
 1151.2   -213.1   -159.2    -33.3    -11.9
 1165.1   -281.8   -182.2     -7.6    -19.6
  971.1   -341.2    -99.1     -8.1     -7.9
  779.9   -448.7     -4.7      1.0      1.8
  544.2   -395.2     53.5      1.6      8.5
  439.2   -407.8    100.8     -2.5      6.2
  301.4   -271.0     77.4      -.8       .4
411.  550.  866. 1439. 1598. 2050. 2100. 1616. 1194.  711.  471.  308.
180.  287.  442.  688. 1083.  938.  808.  723.  462.  314.  198.  170.
CIRA 1.0 LOC=TRY GREAT FALLS,MT, LAT=47.5, TWHT=23, YEAR=1956, ALT=3664
```

HOUSTOTR.CTY

```
.136  .120  .081  .035  .030  .042  .065  .054  .042  .055  .064  .111
.246  .242  .251  .275  .224  .181  .157  .162  .159  .197  .196  .225
.11615E-05  4.20592 35.0
.10336E-01  2.09018 16.0
.20455E-01  1.90747 11.5
.11948E-02  2.56898 13.5
50.8  55.9  65.2  73.5  78.5  83.7  87.4  85.0  83.3  73.6  68.1  56.9
45.1  48.5  56.0  66.0  71.6  74.0  78.1  77.1  73.1  63.1  59.1  49.6
44.5  48.0  54.5  64.4  69.8  72.1  76.0  75.2  71.1  62.0  58.7  49.2
  480.6   -284.4     40.3     -6.3     13.0
  664.0   -379.0     21.7      1.7     11.8
  842.6   -341.1    -39.2     29.4     -7.7
  879.3   -181.0    -79.9      4.8     -8.3
  944.5    -71.3   -120.0      5.9    -10.5
 1089.3     16.1   -207.9     -8.7    -24.6
 1084.9     -4.6   -176.0    -29.8    -21.4
  983.7   -113.9   -132.0    -20.8    -13.9
  903.0   -308.1    -93.5    -18.0       .2
  797.6   -444.6     -6.9      7.6      9.3
  595.3   -410.8     46.1      5.4     11.6
  499.1   -341.9     53.0     10.3      4.4
655.  982. 1305. 1394. 1538. 1968. 1861. 1578. 1559. 1246.  845.  658.
395.  493.  783. 1020. 1128. 1044. 1156. 1112.  719.  530.  363.  353.
CIRA 1.0 LOC=TRY HOUSTON,TX, LAT=29.7, TWHT=20, YEAR=1966, ALT=50
```

INDIANTR.CTY

```
.205  .203  .165  .122  .067  .053  .041  .038  .044  .126  .168  .194
.23  .236  .263  .239  .197  .192  .169  .158  .184  .173  .197  .224
.12088E-04  3.54172 35.0
.18538E-02  2.52330 19.0
.61127E-04  3.53785 21.5
.65939E-02  2.34056 13.5
28.6  30.1  42.8  54.3  71.5  73.1  78.9  77.5  72.1  54.4  41.3  32.1
24.0  25.3  36.6  47.2  59.8  62.7  69.8  68.1  64.8  47.8  38.7  30.3
24.2  25.4  35.4  45.1  56.8  60.1  67.1  66.9  63.5  46.7  37.4  29.3
  476.6   -390.6     80.8      8.3      2.8
  522.6   -351.9     51.3     -1.2      9.9
  722.6   -326.3     -7.3      7.0      3.2
  931.5   -273.2    -76.0    -21.8       .2
 1087.5   -177.0   -160.4    -26.7    -14.2
 1137.8   -109.1   -147.5    -19.9    -11.9
 1092.3   -137.1   -141.4    -19.0    -12.1
  987.3   -251.4   -110.8    -15.4     -4.8
  782.2   -287.7    -25.8      6.1      -.1
  580.9   -330.0     22.2     -4.5      9.6
  369.1   -209.0     44.2     -4.7      6.1
  313.6   -196.5     47.9     -8.9      9.4
566.  703. 1036. 1516. 1893. 1837. 1801. 1649. 1158.  819.  469.  384.
270.  356.  656.  879. 1005. 1270. 1168.  917.  792.  436.  353.  282.
CIRA 1.0 LOC=TRY INDIANAPOLIS,IN, LAT=39.9, TWHT=20, YEAR=1972, ALT=792
```

JACKFLTR.CTY

```
 .104  .099  .080  .045  .046  .033  .044  .047  .039  .042  .066  .109
 .196  .208  .22  .213  .185  .182  .173  .161  .208  .19  .16  .16
 .33281E-06  4.54620 35.0
 .90849E-04  3.33641 23.0
 .96204E-05  4.61879 16.0
 .15330E-12  8.36108 35.0
 59.2  60.0  65.4  75.5  82.9  80.9  84.0  84.6  81.9  74.0  67.0  59.1
 51.0  53.5  57.7  65.4  70.3  73.1  75.5  76.4  76.1  65.4  58.6  50.1
 49.7  51.7  55.9  62.8  67.4  71.2  73.5  74.6  73.7  64.2  58.1  50.4
   634.7   -520.9     80.4      -.3     16.4
   606.5   -336.3     18.6       .9      9.7
   812.2   -317.1    -38.5     13.7     -1.2
   941.4   -239.3   -127.2     10.6    -12.8
  1090.8    -84.1   -243.1    -12.0    -28.7
  1039.3      4.8   -165.4    -21.9    -19.0
  1080.6    -21.6   -176.2    -25.0    -21.9
   992.1   -133.5   -141.0    -38.2    -11.7
   876.2   -253.9    -70.0     -3.7     -5.9
   759.1   -412.2      1.5     -3.6     13.0
   584.1   -409.3     50.0      6.3     10.9
   544.3   -412.1     72.4     -1.2     13.4
 901.  896. 1243. 1688. 2108. 1818. 1870. 1725. 1376. 1186.  825.  737.
 267.  466.  764.  851.  879. 1106. 1144. 1013.  891.  531.  355.  318.
CIRA 1.0 LOC=TRY JACKSONVILLE,FL, LAT=30.5, TWHT=21, YEAR=1965, ALT=24
```

JACKMSTR.CTY

```
 .145  .153  .096  .046  .050  .055  .049  .050  .049  .075  .085  .128
 .197  .204  .242  .226  .166  .148  .149  .143  .168  .169  .155  .221
 .45346E-01  1.57878 16.5
 .38402E-04  3.48865 27.5
 .66350E-11  7.56395 35.0
 .14876E-06  5.19280 23.0
 49.2  49.0  61.6  72.6  81.3  84.8  85.2  85.3  83.1  68.8  64.9  52.6
 42.6  40.6  50.8  62.5  67.2  73.4  75.3  75.5  70.7  55.3  53.7  45.8
 41.0  39.9  50.4  61.0  65.3  71.3  73.9  74.1  68.8  56.0  54.0  45.7
   518.4   -360.0     61.4     -2.8     11.6
   654.0   -403.5     26.8    -12.9     19.6
   824.7   -347.5    -35.8       .0      3.2
   924.8   -219.4   -109.3     -3.3     -8.3
  1026.7   -108.7   -187.9     -9.3    -20.3
  1051.0    -11.3   -197.8    -27.2    -22.8
  1004.6    -55.6   -172.1    -19.0    -17.1
   992.0   -163.6   -133.1    -15.5    -13.1
   891.2   -327.9    -91.9    -10.7      -.5
   785.9   -510.1     10.9      9.2     11.5
   581.3   -434.7     58.5      9.8      7.6
   468.1   -332.0     59.8     11.1       .8
 698.  963. 1334. 1569. 1909. 1953. 1839. 1665. 1546. 1247.  816.  602.
 353.  417.  689.  909.  938.  984.  993. 1029.  669.  406.  313.  328.
CIRA 1.0 LOC=TRY JACKSON,MS, LAT=32.3, TWHT=20, YEAR=1964, ALT=310
```

KANSASTR.CTY

```
 .199  .191  .138  .095  .074  .051  .054  .052  .049  .087  .158  .195
 .2  .197  .251  .242  .201  .207  .192  .204  .178  .206  .194  .227
 .18604E-01  1.73708 21.0
 .16026E-05  4.06492 35.0
 .15380E-09  6.71953 35.0
 .32214E-02  2.50093 14.5
 30.4  34.7  50.9  61.7  67.3  81.7  83.9  81.0  74.2  63.8  45.2  32.9
 26.3  29.6  42.5  52.2  58.2  72.8  75.3  74.1  64.1  55.0  39.9  28.7
 26.6  27.5  39.9  48.3  54.3  68.0  69.9  70.1  61.2  52.4  38.7  28.1
   453.6   -353.9     71.1      8.1      3.3
   572.9   -402.9     60.2      7.7      3.8
   854.4   -464.2    -13.0      8.6      3.3
   982.0   -325.8   -101.1      2.4     -9.7
  1043.5   -162.9   -159.5    -28.3    -12.8
  1126.8   -133.3   -188.9     -2.4    -18.2
  1107.5   -163.5   -167.8      8.3    -15.8
   981.5   -263.7   -131.5      9.3    -14.0
   904.7   -428.2    -54.2     -6.9      4.9
   686.1   -466.8     36.3      1.9     12.0
   455.6   -325.1     61.9     -7.6      1.7
   421.6   -332.7     74.6      -.8      6.9
 542.  772. 1296. 1642. 1815. 2044. 1936. 1664. 1495.  985.  576.  499.
 285.  366.  575.  816.  959. 1036. 1071.  851.  596.  380.  320.  266.
CIRA 1.0 LOC=TRY KANSAS,MO, LAT=39.1, TWHT=22, YEAR=1968, ALT=742
```

LAKECHTR.CTY

```
 .140  .121  .084  .038  .030  .045  .063  .049  .039  .059  .069  .111
 .212  .202  .195  .243  .195  .141  .118  .12  .127  .16  .165  .188
 .51608E-06  4.42972 35.0
 .83592E-07  4.93422 35.0
 .10260E-01  2.12887 12.5
 .13460E-01  1.98944 10.0
 49.5  55.7  64.1  73.0  78.5  84.1  86.9  84.4  82.1  72.6  67.1  56.5
 44.9  48.3  54.8  64.7  71.1  73.4  78.1  76.5  72.2  61.3  57.8  50.4
 44.6  48.0  53.9  63.8  69.8  72.0  76.5  75.0  72.0  61.5  58.1  50.5
   441.5   -255.0     41.1     -3.5      9.2
   655.3   -392.3     29.2      8.3      5.7
   817.8   -324.9    -46.2     14.8     -1.8
   939.1   -208.4   -101.7     10.2    -11.2
   970.8    -73.7   -136.8       .9    -13.2
  1075.6     -3.3   -208.3     -2.8    -22.3
  1077.2    -20.0   -177.4    -21.0    -19.5
   986.6   -120.7   -136.5    -30.6    -12.2
   901.3   -298.6    -91.0     -7.8     -2.3
   787.0   -444.8     -2.5      7.5     10.4
   616.2   -451.9     53.3      8.6     10.5
   451.0   -298.2     45.3     16.5     -1.1
 602.  973. 1272. 1522. 1623. 2013. 1871. 1641. 1496. 1240.  883.  582.
 385.  464.  736. 1017. 1100. 1010. 1139. 1067.  773.  519.  330.  345.
CIRA 1.0 LOC=TRY LAKE CHARLES,LA, LAT=30.1, TWHT=22, YEAR=1966, ALT=9
```

LOSANGTR.CTY

```
 .116  .097  .111  .091  .080  .054  .040  .032  .049  .066  .093  .102
 .155  .165  .2  .188  .163  .162  .16  .156  .15  .137  .146  .125
 .37345E-02  2.60941 10.5
 .37858E-21 13.85732 35.0
 .15493E-03  4.03836 10.0
 .35948E-02  2.04498 10.0
 57.5  60.8  58.5  62.8  64.2  69.0  70.0  70.9  69.4  67.8  61.9  60.8
 51.0  55.3  52.9  55.7  58.2  62.0  63.4  64.8  63.2  59.7  55.3  53.6
 47.6  53.3  50.7  52.7  57.0  60.7  62.5  63.4  61.1  57.9  53.1  50.2
   678.9   -558.4     93.1     -5.8     21.1
   664.6   -405.8     29.6     13.9      5.5
   914.2   -457.2    -48.3     -.3       5.6
  1001.7   -340.5   -149.7     31.8    -17.1
   947.9   -179.0   -150.5     43.8    -19.7
   968.0   -112.5   -165.7     41.7    -17.5
   912.3   -185.6   -173.6     90.1    -19.2
   922.0   -292.3   -144.7     55.8    -18.5
   874.7   -439.2    -59.7     81.0    -24.5
   847.7   -597.2     24.1     40.3     -2.7
   653.2   -520.6     75.7     14.7      7.5
   577.0   -438.9     77.1      7.5      8.2
 896.  936. 1508. 1824. 1722. 1844. 1789. 1807. 1445. 1303.  886.  718.
 310.  476.  583.  724.  903.  932.  781.  692.  633.  404.  316.  353.
CIRA 1.0 LOC=TRY LOS ANGELES,CA, LAT=33.9, TWHT=20, YEAR=1973, ALT=97
```

LUBBOCTR.CTY

```
 .170  .162  .124  .087  .064  .058  .048  .050  .048  .085  .139  .152
 .244  .293  .307  .306  .244  .256  .229  .187  .21  .229  .262  .277
 .11842E-02  2.53060 28.0
 .11834E-07  5.48351 35.0
 .13192E-03  3.20461 23.5
 .13927      1.08062 10.5
 43.6  47.1  57.3  70.3  75.2  81.6  83.9  84.3  78.0  67.3  53.3  50.1
 34.3  33.0  43.3  54.0  62.1  68.0  73.2  71.3  66.1  52.8  39.9  36.8
 34.3  32.4  39.1  47.2  57.8  62.1  67.2  65.9  63.6  51.3  37.4  35.1
   638.2   -520.2     87.5      2.5     12.4
   841.4   -625.4     52.2     11.2     15.2
   970.9   -475.1    -55.0     -3.9      5.2
  1083.7   -321.8   -160.6      1.6    -13.3
  1086.5   -104.1   -199.7    -32.4    -22.9
  1124.2    -41.7   -246.1    -24.3    -30.2
  1133.1    -75.1   -207.9    -20.2    -25.8
  1100.6   -243.6   -222.7    -13.0    -23.4
   959.7   -439.3   -115.1     11.2    -10.2
   908.4   -636.9     23.8      2.1     16.6
   804.5   -712.1    105.2     12.9     14.7
   658.4   -570.5    105.0       .9     16.8
 853. 1246. 1615. 1965. 2036. 2269. 2072. 2107. 1749. 1450. 1122.  838.
 300.  378.  622.  825.  950.  873. 1056.  753.  505.  376.  251.  282.
CIRA 1.0 LOC=TRY LUBBOCK,TX, LAT=33.7, TWHT=68, YEAR=1955, ALT=3243
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MADISOTR.CTY

```
.222  .222  .189  .132  .112  .066  .051  .052  .094  .123  .176  .206
.186  .203  .226  .243  .217  .19  .179  .163  .182  .179  .186  .164
.24621E-05  4.09151 33.0
.12656E-01  2.05762 15.5
.26436E-02  2.61919 15.5
.96131E-04  3.47081 19.5
21.3  23.3  36.0  53.5  58.9  70.7  79.5  73.1  63.9  56.0  40.1  28.8
18.0  16.6  29.9  43.7  49.4  58.1  66.6  60.7  51.3  45.8  34.6  25.5
18.2  18.5  30.8  42.8  49.2  57.5  64.6  61.3  51.4  45.2  34.7  26.1
  402.5   -335.3     80.4      4.5       .9
  547.8   -394.4     63.4      1.6      8.2
  619.3   -281.0     10.7     -6.1      6.9
  897.4   -286.4    -60.0     -1.5     -4.1
  994.0   -190.6    -86.0     -5.0     -7.2
 1095.4   -138.3   -153.8    -23.2    -12.6
 1081.7   -165.2   -153.3    -23.1     -8.6
  958.3   -245.3    -77.4    -12.4     -4.4
  828.8   -400.0    -37.5    -17.1      6.6
  558.7   -359.6     42.0     -4.3     10.5
  394.3   -301.3     63.3      -.8      6.2
  305.6   -234.3     57.8      6.0     -1.7
459.  705.  870. 1390. 1535. 1841. 1839. 1479. 1295.  761.  472.  344.
238.  347.  583.  876. 1131. 1086. 1023.  997.  555.  380.  255.  220.
CIRA 1.0 LOC=TRY MADISON,WI, LAT=43.1, TWHT=21, YEAR=1974, ALT=858
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MEMPHITR.CTY

```
.160  .167  .118  .057  .045  .060  .052  .047  .049  .087  .099  .152
.195  .195  .238  .221  .161  .166  .123  .14  .137  .135  .14  .209
.73137E-06  4.35121 35.0
.16155E-06  4.75956 35.0
.24581E-01  1.76352 14.0
.44160E-06  5.05638 22.0
45.4  44.5  56.6  68.3  77.3  84.2  84.7  82.9  78.6  65.2  59.8  45.8
37.7  36.6  47.3  59.9  67.2  74.1  75.3  73.9  68.0  53.3  50.6  41.3
37.3  36.8  46.0  57.8  64.6  70.7  74.0  72.5  66.2  53.0  51.1  39.9
  600.7   -488.9     84.0     -4.8     18.9
  660.8   -460.8     40.2     -3.0     16.3
  807.6   -389.2    -34.3     -5.8      5.5
  904.6   -250.8   -107.6     -2.1     -7.0
 1041.3   -110.1   -173.9    -30.2    -18.7
 1074.9    -32.0   -213.5    -40.1    -24.6
 1045.4    -75.5   -201.7    -35.6    -23.1
  984.5   -215.2   -141.6     -5.2    -12.3
  872.1   -364.0    -74.4     -9.1      1.2
  802.6   -551.0     19.0    -10.7     22.6
  583.7   -466.2     70.6      9.4      7.1
  434.3   -326.0     62.3     13.5      -.9
772.  952. 1327. 1548. 1834. 1996. 1967. 1733. 1526. 1253.  781.  535.
295.  352.  557.  813.  992.  943.  905.  893.  599.  349.  281.  288.
CIRA 1.0 LOC=TRY MEMPHIS,TN, LAT=35.1, TWHT=22, YEAR=1964, ALT=258
```

MIAMI-TR.CTY

```
 .034  .050  .023  .025  .032  .052  .067  .073  .062  .034  .018  .017
 .182  .184  .191  .23  .165  .132  .181  .165  .186  .226  .177  .211
 .18896      1.14036 11.0
 .50481E-01  1.52619 12.0
 .90920E-02  2.07920 10.5
 .10507E-10  9.04093 17.5
 69.8  69.4  76.7  78.7  80.4  83.2  84.9  85.8  84.4  79.3  77.4  74.2
 65.0  62.9  71.1  73.3  74.9  77.9  79.8  80.3  78.9  74.5  72.2  69.5
 62.8  60.7  67.9  69.3  70.9  74.9  76.1  76.7  75.6  71.3  69.1  66.5
   532.0   -281.9    33.0    -2.3    10.3
   744.0   -388.2     2.1   -17.0    20.0
   884.6   -276.2   -62.7   -22.9     6.2
   994.1   -143.9  -147.1   -22.0   -14.7
  1023.4    -15.7  -172.1   -12.3   -21.6
  1048.6     49.2  -156.5    -8.4   -17.0
  1070.6     36.6  -160.2   -21.6   -20.1
   997.6    -96.3  -150.1   -10.6   -17.3
   908.2   -227.1   -83.9   -12.8    -4.1
   778.6   -326.2   -16.1    -2.8     8.3
   622.7   -365.1    31.9   -10.8    20.2
   521.0   -342.6    49.8    -1.7    13.0
 744. 1184. 1436. 1682. 1774. 1788. 1783. 1717. 1474. 1193.  927.  740.
 482.  539.  853. 1039. 1090. 1179. 1213. 1079.  949.  716.  458.  368.
CIRA 1.0 LOC=TRY MIAMI,FL, LAT=25.8, TWHT=23, YEAR=1964, ALT=9
```

MINNEATR.CTY

```
 .251  .230  .208  .145  .094  .048  .048  .040  .082  .133  .191  .226
 .199  .214  .207  .276  .245  .213  .199  .184  .201  .223  .244  .208
 .41247E-01  1.67952 17.0
 .35577E-01  1.72035 14.5
 .15290E-01  1.97222 15.5
 .53837E-02  2.32001 14.5
  8.2  18.8  28.8  50.0  62.3  76.3  81.3  77.4  65.7  52.8  34.3  19.4
  4.7  13.8  23.9  42.1  54.7  67.0  70.1  66.6  57.3  46.3  31.0  17.1
  5.8  14.8  23.3  40.0  52.3  63.3  66.4  63.7  56.0  45.3  29.9  16.4
   398.0   -342.5    85.5     1.0     2.5
   560.3   -438.0    74.9    -6.4    14.7
   773.0   -486.0    17.5     3.1     5.9
   921.7   -329.5   -65.6   -14.8      .7
  1009.8   -242.0   -99.3    12.6    -8.8
  1146.4   -184.4  -162.6    -6.5   -18.2
  1160.6   -224.1  -186.3    -5.8   -17.5
  1023.4   -340.5  -127.7    -2.6    -6.7
   786.3   -411.2   -17.1     8.7      .8
   590.9   -422.8    53.2   -10.2    16.7
   349.9   -251.4    56.6     5.6     -.6
   314.6   -256.8    69.2    -1.2     1.9
 438.  712. 1142. 1448. 1617. 1943. 2023. 1733. 1187.  817.  408.  343.
 224.  299.  442.  786. 1029. 1054.  938.  753.  549.  325.  265.  207.
CIRA 1.0 LOC=TRY MINNEAPOLIS,MN, LAT=44.9, TWHT=21, YEAR=1970, ALT=834
```

NASHVITR.CTY

```
.157  .164  .126  .078  .054  .046  .042  .038  .031  .084  .135  .158
.208  .203  .218  .225  .172  .174  .156  .137  .144  .173  .196  .217
.26389E-05  4.02766 35.0
.19966E-02  2.40836 21.0
.24075E-02  2.69726 14.0
.58010E-03  3.16848 13.0
44.7  44.2  54.9  65.5  73.6  78.9  82.1  81.9  80.5  64.1  51.1  44.3
38.3  37.4  46.2  55.0  61.4  66.3  71.5  71.8  70.8  55.4  45.7  40.5
37.8  36.5  44.0  53.0  61.5  64.2  70.3  70.5  69.2  55.0  45.2  39.0
  479.0   -360.0      62.7     10.4       2.9
  580.8   -390.2      43.8      7.8       7.6
  788.9   -371.9     -14.9      4.3       4.9
  964.9   -279.5    -103.3      6.1     -11.0
 1039.9   -133.9    -180.8    -19.7     -19.5
 1129.4    -65.6    -197.5    -23.5     -22.1
 1042.9   -103.1    -182.4    -14.7     -18.9
 1016.3   -245.8    -159.0     -9.2     -12.1
  837.7   -310.5     -55.4     -9.1       -.5
  630.6   -325.3       7.0     -3.8       9.5
  434.8   -260.3      39.1      2.5       5.1
  380.5   -272.6      57.4     -2.9       8.2
593.  819. 1218. 1611. 1884. 1990. 1892. 1832. 1358.  911.  562.  475.
301.  373.  642.  886.  928. 1093.  970.  829.  719.  504.  367.  273.
CIRA 1.0 LOC=TRY NASHVILLE,TN, LAT=36.1, TWHT=25, YEAR=1972, ALT=590
```

NEWORLTR.CTY

```
.140  .137  .092  .045  .029  .054  .046  .052  .036  .035  .068  .122
.191  .231  .215  .207  .177  .149  .128  .137  .16  .201  .193  .196
.22967E-07  5.27749 35.0
.17547E-02  2.65066 16.0
.15799E-02  2.69718 14.0
.19840E-13  8.80071 35.0
51.0  50.5  61.3  73.1  79.0  84.6  83.1  84.6  81.4  72.3  66.4  55.2
45.6  45.6  55.4  64.7  71.1  77.1  77.3  77.2  76.0  66.2  59.3  49.4
43.6  42.4  52.2  62.2  68.8  73.9  75.0  74.1  73.7  62.7  57.5  47.7
  568.2   -374.0      44.7     -1.4      14.0
  681.4   -427.0      31.6      7.7       9.2
  800.6   -337.2     -42.2       .7       2.6
  954.2   -211.9    -123.2      8.2     -13.5
  970.2    -86.9    -166.1      2.3     -19.3
 1014.5     11.6    -195.9    -20.9     -22.9
 1017.0     16.1    -159.3    -57.7     -19.5
  949.9   -143.1    -173.4    -24.8     -21.6
  848.1   -235.4     -67.5    -26.9       4.4
  740.2   -414.9       2.2     11.4       6.7
  566.9   -390.3      46.6       .8      12.6
  494.5   -348.5      60.3     -7.6      14.9
760. 1038. 1332. 1610. 1785. 1924. 1779. 1781. 1366. 1175.  810.  672.
390.  442.  644.  962.  960.  947. 1086.  812.  849.  507.  346.  325.
CIRA 1.0 LOC=TRY NEW ORLEANS,LA, LAT=30.0, TWHT=53, YEAR=1958, ALT=4
```

NEWYORTR.CTY

```
 .178  .180  .164  .123  .078  .041  .027  .025  .038  .089  .155  .169
 .26  .276  .298  .231  .212  .19  .175  .177  .203  .24  .245  .225
 .10319E-01  2.17841 14.5
 .23905E-10  7.10849 35.0
 .10670E-01  2.17981 12.5
 .11383E-02  3.34710 10.0
 38.5  38.1  44.3  55.9  66.2  72.9  79.3  77.6  71.2  61.8  45.6  40.6
 35.2  34.1  39.4  49.2  58.1  65.9  72.6  70.6  65.0  56.3  41.8  37.4
 33.0  32.3  37.5  46.1  54.0  62.5  67.5  66.9  60.8  53.2  38.6  35.0
   443.8    -354.3     79.2     -4.4     10.2
   575.5    -413.1     57.1     -1.6     12.8
   742.4    -376.2    -18.7      8.2      3.4
   966.2    -306.4    -96.6     -7.7     -4.7
  1053.8    -210.7   -141.1      4.8     -9.3
  1054.1    -149.7   -142.3      6.2    -13.1
  1074.8    -157.8   -146.8     -5.5    -15.7
  1003.2    -278.8   -111.1      7.2     -9.5
   847.9    -372.2    -32.8    -15.5      8.3
   577.8    -371.3     30.3     10.7      2.9
   478.2    -371.0     77.8     -9.2     13.2
   391.4    -317.8     76.4      1.1      3.9
 527.  767. 1083. 1572. 1770. 1803. 1795. 1652. 1318.  795.  592.  453.
 271.  342.  556.  841. 1027. 1084. 1092.  927.  671.  380.  288.  244.
CIRA 1.0 LOC=TRY NEW YORK,NY, LAT=40.8, TWHT=62, YEAR=1951, ALT=16
```

OKLAHOTR.CTY

```
 .173  .158  .139  .100  .052  .042  .057  .071  .056  .085  .155  .160
 .313  .313  .318  .356  .279  .252  .227  .222  .258  .282  .258  .296
 .37285E-04  3.34696 35.0
 .18919E-01  1.75596 18.5
 .34972E-06  4.51851 35.0
 .20407        .91293 10.0
 40.5  44.8  51.4  61.0  71.9  78.7  86.1  89.3  77.6  65.9  46.7  43.5
 34.0  37.5  42.5  52.5  62.8  71.2  75.8  78.0  67.3  56.6  39.6  37.4
 32.0  36.9  39.5  48.6  60.4  68.9  72.8  71.7  63.6  54.5  39.1  35.0
   574.3    -464.9     82.1     16.1      2.8
   612.0    -395.5     46.5      7.3      6.9
   822.3    -355.8    -31.7     -4.7      4.7
   971.6    -300.9   -117.2      8.5    -11.8
  1045.1    -157.2   -175.9      9.0    -19.5
  1044.6    -106.0   -162.9     24.9    -15.4
  1079.3    -126.7   -210.3     14.8    -23.4
   980.5    -246.0   -180.4     -2.1    -18.5
   888.5    -403.6    -75.4      6.5     -3.3
   701.7    -444.7     15.7      3.4      8.0
   587.3    -463.7     72.0       .5     14.4
   542.5    -444.3     87.8      9.5      5.2
 720.  856. 1271. 1687. 1847. 1829. 2026. 1847. 1537. 1083.  783.  669.
 308.  426.  682.  811.  975. 1087.  928.  682.  569.  390.  294.  297.
CIRA 1.0 LOC=TRY OKLAHOMA CITY,OK, LAT=35.4, TWHT=70, YEAR=1951, ALT=1285
```

OMAHA-TR.CTY

```
.226  .200  .149  .136  .083  .046  .049  .044  .071  .113  .168  .202
.207  .179  .264  .238  .247  .23  .178  .173  .168  .22  .218  .2
.39522E-05  3.94365 35.0
.18450E-01  1.97030 14.5
.30184E-02  2.58874 16.0
.98911E-02  2.25638 12.0
20.8  32.3  49.0  53.6  68.3  77.6  83.7  77.0  68.7  60.0  43.4  31.6
15.8  24.2  39.0  43.9  55.5  67.7  74.7  65.3  57.8  46.9  35.4  24.2
16.4  24.9  37.7  41.7  52.4  65.0  71.7  64.8  57.5  46.4  35.0  24.7
  473.3   -395.4     88.9     -6.1     11.7
  619.9   -463.1     63.2      5.7      9.2
  756.9   -384.0     -3.6    -11.1     11.2
  910.7   -266.6    -72.9    -11.8      -.8
 1099.5   -246.5   -172.5      9.2    -16.9
 1156.0   -160.9   -171.0      9.9    -16.2
 1123.0   -207.1   -198.6     14.0    -21.3
 1030.3   -311.8   -140.6       .2    -11.4
  848.0   -397.1    -43.5     16.1     -3.7
  729.6   -533.3     44.0     -1.5     16.0
  511.6   -414.7     88.1     -8.3     13.5
  419.3   -360.6     90.3     -4.2      6.5
556.  813. 1143. 1429. 1977. 1967. 2074. 1779. 1319. 1043.  639.  478.
260.  341.  566.  893.  893. 1141.  887.  788.  634.  334.  281.  230.
CIRA 1.0 LOC=TRY OMAHA,NE, LAT=41.3, TWHT=20, YEAR=1966, ALT=977
```

PHILADTR.CTY

```
.198  .193  .170  .107  .064  .036  .030  .036  .052  .103  .153  .189
.248  .272  .266  .233  .225  .192  .17  .169  .171  .178  .199  .249
.31596E-04  3.59334 25.5
.12031E-01  1.99765 15.5
.31507E-01  1.80435 11.5
.67048E-15 10.11939 34.5
31.7  34.1  43.1  60.2  70.1  77.6  78.2  79.9  71.6  60.2  47.4  34.8
28.0  30.0  35.5  50.3  59.4  68.4  70.9  69.9  62.0  50.5  41.4  31.9
26.2  28.0  33.5  48.1  55.4  65.3  69.3  68.7  60.8  49.5  39.9  30.1
  463.5   -373.3     76.8     -7.7     15.1
  511.2   -312.1     41.6     -6.6     12.3
  799.0   -434.0    -17.2      5.1      4.4
  962.0   -310.6    -92.3      2.0     -7.2
 1084.7   -218.6   -177.4      7.3    -14.7
 1065.3   -154.2   -136.8     17.3    -11.3
 1000.7   -126.9   -114.8     -8.3    -11.7
 1011.9   -293.5   -124.3      1.1     -9.6
  847.1   -404.5    -25.4     -1.1      6.1
  665.8   -458.3     37.3      -.6     14.1
  462.6   -344.4     73.5     -8.1     11.3
  413.1   -333.6     77.3     -3.3      8.6
550.  671. 1213. 1565. 1927. 1816. 1585. 1745. 1369.  944.  578.  486.
265.  399.  524.  851.  918. 1129. 1145.  850.  630.  364.  305.  252.
CIRA 1.0 LOC=TRY PHILADELPHIA,PA, LAT=39.9, TWHT=20, YEAR=1969, ALT=5
```

PHOENITR.CTY

```
.126  .108  .083  .065  .076  .083  .119  .091  .069  .068  .092  .124
.086  .101  .114  .114  .112  .108  .107  .096  .074  .086  .076  .083
.86677E-07  5.00288 33.5
.19452E-05  4.53889 23.5
.59541E-01  1.50920 15.0
.30423E-01  1.81361 12.0
57.7  61.9  68.4  75.0  86.1  93.6  99.9  93.4  91.7  80.2  65.5  57.2
43.4  48.9  53.0  61.0  69.5  74.6  85.6  81.4  74.1  62.5  50.7  45.3
41.6  46.1  46.1  53.4  57.2  59.3  71.1  71.0  66.8  57.2  49.9  44.6
  691.8   -597.1    104.1     12.4      8.9
  761.6   -515.6     40.4    -13.7     25.0
  962.2   -487.9    -54.5     -4.6      7.4
 1056.8   -261.8   -142.2    -24.6    -11.1
 1143.7   -151.6   -275.6      5.3    -32.5
 1154.8    -44.5   -325.9     -2.1    -41.7
 1118.2    -89.8   -255.0    -14.9    -31.0
 1024.0   -255.8   -209.5      5.5    -22.6
 1031.1   -518.3   -144.1     -3.3     -3.3
  890.0   -612.7     12.1     -1.1     17.2
  737.6   -620.4     88.0     -7.4     25.1
  604.7   -503.7    100.6     -9.4     18.9
 920. 1127. 1623. 1843. 2325. 2554. 2361. 2083. 2012. 1444. 1045.  794.
 285.  411.  576.  913.  755.  610.  786.  633.  349.  358.  263.  293.
CIRA 1.0 LOC=TRY PHOENIX,AZ, LAT=33.4, TWHT=29, YEAR=1951, ALT=1108
```

PITTSBTR.CTY

```
.210  .184  .170  .118  .079  .042  .038  .048  .059  .131  .160  .181
.229  .212  .247  .239  .211  .205  .174  .149  .167  .152  .216  .256
.31869E-04  3.44355 31.0
.59949E-02  2.26867 16.5
.23395E-01  1.85228 14.0
.79274E-11  7.49455 35.0
26.4  37.1  42.5  56.4  66.4  74.9  76.9  75.9  69.1  53.5  45.0  37.5
23.8  32.1  35.9  47.6  55.5  65.7  67.1  64.2  60.2  46.1  39.7  33.9
23.2  31.9  34.5  46.5  53.6  63.2  64.0  61.8  58.5  45.1  38.5  32.8
  342.3   -200.7     44.4      1.5      2.9
  456.5   -267.1     40.4     11.0      -.9
  725.4   -356.3     -2.1      2.4      2.8
  911.4   -249.3    -67.6     -8.0     -3.7
 1071.6   -190.9   -135.7    -15.8    -10.5
 1147.3   -128.6   -148.6    -14.9    -15.3
 1148.6   -171.2   -157.2      1.1    -14.1
 1032.7   -231.3   -119.0    -25.0     -7.9
  805.2   -324.6    -17.6      -.8      2.9
  583.4   -345.4     24.6     -2.6     10.1
  423.8   -294.1     57.0     -1.2      7.2
  384.6   -301.1     71.4      7.0     -1.4
 418.  600. 1055. 1414. 1792. 1895. 1927. 1671. 1211.  819.  531.  445.
 330.  400.  591.  950. 1070. 1241. 1167. 1000.  759.  418.  310.  258.
CIRA 1.0 LOC=TRY PITTSBURGH,PA, LAT=40.5, TWHT=20, YEAR=1957, ALT=1151
```

PORTMETR.CTY

```
 .222  .216  .188  .163  .111  .072  .051  .056  .092  .141  .178  .203
 .191  .182  .176  .177  .169  .162  .163  .164  .163  .182  .188  .142
 .84298E-02  2.17145 15.0
 .18876E-01  1.94113 13.5
 .91899E-02  2.07079 16.0
 .14205E-01  2.10365 12.0
 22.9  25.4  37.5  47.0  60.9  70.3  73.9  71.9  63.7  52.0  40.1  30.9
 17.5  19.9  29.7  36.3  49.4  57.3  60.3  60.5  53.4  43.3  34.0  24.9
 18.1  19.8  28.8  36.2  48.3  56.9  59.7  60.5  54.3  43.4  33.8  25.9
   429.7    -365.4      81.7      -3.7      10.4
   585.4    -452.2      68.1       4.5       9.5
   739.2    -415.9       -.4       2.1       5.8
   953.1    -341.2     -77.9     -20.9      -1.8
  1067.5    -237.7    -127.1      -7.4     -11.5
  1163.0    -179.0    -165.3      -4.7     -16.7
  1148.1    -198.5    -168.5     -13.6     -13.5
   991.4    -277.3     -85.1        .7      -5.0
   823.3    -428.6     -23.8      15.0      -1.9
   611.4    -440.1      52.1      -5.9      14.0
   433.3    -347.0      73.5      -4.2      10.7
   371.5    -327.3      85.4       1.0       2.2
 480.  733. 1081. 1540. 1791. 1987. 1961. 1562. 1266.  836.  512.  406.
 233.  316.  494.  764. 1001. 1101. 1047.  985.  567.  329.  256.  205.
CIRA 1.0 LOC=TRY PORTLAND,ME, LAT=43.7, TWHT=20, YEAR=1965, ALT=43
```

PORTORTR.CTY

```
 .184  .163  .154  .131  .118  .072  .062  .067  .082  .112  .147  .174
 .252  .2  .191  .183  .156  .162  .159  .155  .13  .115  .193  .221
 .48907E-01  1.61415 11.5
 .42870E-02  2.40549 13.0
 .16079E-01  1.90493 15.5
 .10885E-01  1.95770 14.5
 36.3  44.2  47.0  53.9  57.1  68.2  75.1  69.3  66.2  58.0  48.8  40.5
 34.3  40.4  40.8  46.9  50.1  57.9  62.2  60.2  56.7  51.2  44.9  37.1
 33.5  39.3  40.5  46.0  48.9  54.8  58.0  56.8  54.6  51.3  44.0  36.5
   214.3    -108.8      25.6       3.7      -1.7
   407.7    -262.9      40.0       7.9        .6
   569.6    -287.2      15.0      22.0      -5.7
   822.9    -241.1     -20.1      -3.1      -1.8
   997.0    -203.2     -55.1       2.0      -2.0
  1153.7    -237.2    -177.3      28.9     -17.3
  1185.8    -306.8    -221.5      32.2     -24.0
   984.6    -356.4     -91.4      55.1     -18.9
   748.8    -410.1      -8.5      40.7      -9.6
   482.4    -310.2      39.0      25.2      -8.0
   307.3    -202.2      44.3       3.4        .4
   260.2    -193.8      54.7      -1.2        .5
 257.  511.  780. 1166. 1462. 2023. 2247. 1570. 1096.  625.  366.  293.
 239.  316.  523.  959. 1246.  962.  709.  860.  556.  369.  259.  203.
CIRA 1.0 LOC=TRY PORTLAND,OR, LAT=45.6, TWHT=20, YEAR=1960, ALT=21
```

RALEIGTR.CTY

```
 .164  .155  .153  .095  .044  .042  .028  .038  .043  .089  .125  .154
 .21  .21  .201  .211  .159  .165  .142  .138  .137  .163  .166  .168
 .44431E-02  2.24749 21.0
 .27270E-09  6.47907 35.0
 .12952E-01  2.16097 12.5
 .29948E-02  2.57356 12.0
 43.8  45.9  48.1  63.1  77.0  76.0  78.9  81.2  76.5  64.2  56.0  48.6
 36.1  38.5  40.1  52.5  64.8  66.1  69.9  70.3  65.9  51.8  46.0  38.8
 34.9  37.3  39.7  50.8  63.3  65.2  69.9  69.9  66.0  51.8  44.8  38.4
   584.9   -492.6     93.8     10.7      5.5
   628.4   -432.1     46.5      3.4      9.1
   786.9   -378.9    -12.2      4.4      4.2
   948.7   -251.1   -103.6     -9.9     -4.5
  1055.8   -167.2   -180.3     -3.2    -19.1
  1037.2    -92.2   -163.4      4.0    -13.0
  1034.2   -125.2   -141.2     10.5    -12.4
   983.2   -248.8   -130.4      6.5    -12.2
   883.0   -351.5    -60.7      9.3      -.7
   776.0   -536.7     35.1     -6.4     19.5
   585.5   -462.5     68.4     15.0      4.2
   535.9   -442.6     93.0     -6.0     14.5
 752.  897. 1232. 1570. 1926. 1839. 1778. 1755. 1410. 1207.  766.  673.
 282.  368.  623.  901.  936. 1065. 1120.  872.  746.  371.  298.  283.
CIRA 1.0 LOC=TRY RALEIGH,NC, LAT=35.8, TWHT=20, YEAR=1965, ALT=434
```

RICHMOTR.CTY

```
 .185  .181  .158  .095  .061  .038  .032  .038  .055  .088  .144  .184
 .173  .205  .193  .182  .158  .145  .126  .117  .116  .136  .144  .163
 .15002E-03  3.03983 27.5
 .25249E-03  3.03931 22.0
 .21015E-01  1.97197 12.5
 .92578E-15  9.95955 35.0
 36.8  39.1  47.5  64.2  72.6  79.9  81.1  79.0  72.8  63.5  51.1  38.1
 31.3  33.8  37.0  52.3  58.9  69.7  72.1  68.8  61.8  52.6  41.9  32.2
 30.4  32.3  36.3  51.6  58.4  68.7  72.0  69.3  63.2  53.7  42.2  31.5
   471.4   -360.6     73.3     -6.8     13.4
   519.8   -300.8     38.4    -17.3     17.1
   855.5   -439.0    -24.7    -17.6     12.6
   985.3   -285.6   -108.9    -10.9     -5.4
  1077.7   -178.4   -204.9    -12.0    -20.3
  1110.0    -95.4   -160.3    -10.8    -16.9
  1059.9   -109.4   -139.6    -18.4    -14.4
  1004.5   -257.8   -135.9     -7.2    -10.9
   860.0   -327.1    -46.3    -12.9      4.2
   683.1   -459.8     28.6     18.1      7.7
   540.4   -408.5     72.8     -5.7     14.8
   493.3   -424.7     94.9       .5      7.7
 585.  713. 1381. 1643. 2007. 1861. 1755. 1744. 1351.  979.  690.  600.
 294.  413.  551.  873.  847. 1185. 1161.  867.  756.  399.  322.  248.
CIRA 1.0 LOC=TRY RICHMOND,VA, LAT=37.5, TWHT=20, YEAR=1969, ALT=164
```

SACRAMTR.CTY

```
 .168  .148  .132  .088  .083  .077  .077  .070  .073  .082  .116  .152
 .122  .194  .164  .154  .19  .182  .15  .143  .136  .118  .076  .061
 .23428E-10  7.19697 35.0
 .58761E-02  2.40502 11.5
 .47583E-04  3.50662 25.0
 .38872E-11  7.60496 35.0
 43.8  49.0  55.2  68.6  69.7  80.1  83.0  82.2  77.2  65.9  58.3  47.5
 36.8  44.2  45.1  51.9  53.4  59.8  61.8  62.7  59.5  55.9  48.8  42.7
 37.9  44.4  46.1  52.6  53.3  58.1  60.5  61.2  59.3  56.3  50.3  43.8
   575.1   -503.3     95.9     23.3     -3.4
   518.7   -303.6     25.5      4.5      5.2
   820.7   -393.9    -22.5     -1.1      3.5
  1057.8   -382.9   -145.9     -4.3    -12.3
  1096.1   -197.2   -207.5     -2.1    -22.3
  1138.8   -124.6   -299.7     -4.5    -34.4
  1145.5   -185.8   -297.0      9.0    -34.6
  1073.6   -355.4   -231.8     -6.5    -21.6
  1004.2   -564.1   -102.6      4.3     -1.5
   715.3   -509.0     30.4     27.9     -2.3
   607.3   -519.8     91.7     23.6     -1.9
   402.2   -306.9     64.9     17.0     -5.5
 685.  693. 1245. 1917. 2035. 2434. 2437. 2202. 1808. 1040.  761.  468.
 264.  402.  626.  667.  842.  562.  544.  422.  348.  352.  277.  277.
CIRA 1.0 LOC=TRY SACRAMENTO,CA, LAT=38.5, TWHT=20, YEAR=1962, ALT=17
```

SALTLATR.CTY

```
 .198  .189  .183  .132  .090  .064  .062  .059  .073  .117  .180  .207
 .126  .179  .186  .2  .185  .163  .188  .22  .165  .155  .162  .174
 .48828E-03  2.79707 26.0
 .11811E-07  5.46293 35.0
 .35935E-07  5.26991 33.5
 .58882E-12  8.24228 35.0
 33.1  36.9  38.8  54.1  66.1  75.8  84.6  84.0  74.6  59.7  39.0  28.7
 26.6  29.7  31.8  44.9  52.7  61.4  67.9  67.1  58.3  46.1  32.8  23.9
 27.1  29.0  30.8  41.0  45.8  53.7  56.3  56.2  51.0  43.5  31.9  23.8
   502.3   -428.9     91.4     -1.9     10.4
   553.4   -363.9     50.3      3.8      6.4
   775.3   -380.4      2.8    -12.9     11.0
  1003.8   -325.8    -70.6      4.8     -4.3
  1151.4   -236.5   -167.6    -11.6    -16.5
  1231.3   -154.0   -218.3    -15.6    -25.0
  1238.9   -215.5   -281.7    -21.9    -30.1
  1140.5   -396.0   -202.2    -23.1    -17.3
  1045.0   -591.2    -71.7     -3.7      4.1
   781.0   -589.7     52.7      7.0     13.5
   496.8   -387.5     75.5     -4.1     12.1
   368.7   -273.7     66.1      8.4     -3.1
 596.  725. 1143. 1596. 2083. 2262. 2557. 2264. 1796. 1110.  616.  429.
 253.  394.  624.  966.  976. 1031.  659.  513.  444.  341.  292.  274.
CIRA 1.0 LOC=TRY SALT LAKE CITY,UT, LAT=40.8, TWHT=58, YEAR=1948, ALT=4222
```

SANANTTR.CTY

```
 .127  .130  .110  .042  .043  .061  .065  .059  .052  .034  .069  .129
 .181  .229  .207  .219  .212  .19  .178  .182  .158  .177  .188  .202
 .11021E-05  4.37410 32.5
 .21324E-02  2.44214 20.0
 .16265E-08  6.29033 30.0
 .18717E-12  8.41525 35.0
 53.4  54.1  58.4  73.7  77.4  87.5  87.8  86.3  84.3  76.9  65.7  53.1
 46.4  46.0  50.6  64.1  68.2  77.3  78.5  77.9  72.4  69.1  59.0  46.5
 45.6  44.0  48.9  61.6  65.4  71.6  74.0  74.9  69.3  67.3  57.1  46.2
   522.9   -333.6     48.1        .7      9.5
   712.2   -465.9     30.4      15.4      6.4
   796.3   -312.2    -50.0      28.3     -8.7
   909.3   -227.1   -107.4      28.0    -13.5
  1004.3   -107.9   -177.1      30.1    -19.7
  1015.5    -25.6   -210.9      23.0    -23.0
  1021.0    -56.0   -201.6      18.5    -21.1
   951.9   -159.2   -130.9      13.4    -14.6
   951.7   -352.5   -131.1     -14.3     -6.6
   721.8   -344.5      -.5      18.0     -2.5
   537.4   -335.8     36.6       8.3      5.1
   496.0   -358.2     60.5       1.3     10.2
 725. 1102. 1255. 1532. 1827. 2029. 1983. 1658. 1739. 1094.  760.  673.
 389.  419.  726.  925.  990.  894.  934. 1003.  598.  629.  390.  317.
CIRA 1.0 LOC=TRY SAN ANTONIO,TX, LAT=29.5, TWHT=33, YEAR=1960, ALT=788
```

SANDIETR.CTY

```
 .105  .097  .096  .078  .073  .042  .016  .014  .016  .048  .079  .105
 .143  .12  .155  .164  .16  .168  .157  .163  .149  .148  .109  .114
 .59014E-15  9.95148 35.0
 .24671E-15  9.93506 35.0
 .99049E-02  1.93192 11.0
 .21587E-23 15.11182 35.0
 59.2  62.2  60.9  64.6  64.3  68.7  72.7  71.2  71.3  68.5  65.7  60.4
 53.9  53.5  56.3  58.2  60.5  64.0  68.2  67.2  67.3  63.7  57.8  52.0
 50.3  48.6  53.1  54.1  56.0  60.6  64.1  63.2  63.9  59.5  53.7  48.1
   598.0   -440.5     70.4       7.0      8.5
   845.3   -612.9     44.4       7.2     16.4
   870.7   -364.4    -26.5       9.0       .6
   993.8   -373.0   -171.9      57.9    -21.1
   925.2   -153.1   -128.6      39.5    -14.9
   907.5   -101.2   -197.9      56.6    -19.8
   898.6   -149.1   -183.7      64.4    -16.4
   871.0   -308.3   -128.8     105.6    -21.7
   857.5   -421.0    -65.1      84.9    -22.4
   741.2   -453.1     18.0      46.5     -9.2
   719.4   -587.5     78.4      14.6      9.4
   707.9   -634.0    115.4       8.3     12.8
 803. 1282. 1357. 1992. 1676. 1906. 1920. 1676. 1515. 1130. 1010.  928.
 362.  383.  784.  587.  976.  716.  716.  708.  619.  512.  296.  261.
CIRA 1.0 LOC=TRY SAN DIEGO,CA, LAT=32.4, TWHT=20, YEAR=1974, ALT=13
```

SANFRATR.CTY

```
 .141  .137  .125  .116  .116  .095  .081  .077  .086  .087  .120  .142
 .169  .181  .206  .228  .303  .288  .298  .26  .238  .179  .167  .171
 .32489E-14  9.56358 35.0
 .16372E-04  4.69905 11.0
 .18154E-01  1.94023 11.0
 .10000E-30 20.00000 35.0
 50.5  52.7  55.0  57.8  58.6  63.1  65.2  65.7  64.3  64.4  56.6  50.6
 46.2  46.6  50.1  50.3  50.6  54.6  57.3  57.5  56.5  56.3  50.7  46.5
 45.0  45.1  49.1  49.1  50.0  54.0  56.6  57.2  56.4  54.9  50.0  45.2
   513.3    -408.8      80.0     14.8      -.4
   689.5    -507.6      61.8     -1.3      15.3
   770.4    -345.8      -4.0      4.3       2.8
  1014.9    -343.7    -143.7      1.4     -11.9
  1026.7    -228.9    -217.6     17.7     -25.1
   990.7    -154.9    -221.0     36.9     -24.1
   989.0    -198.9    -214.6     53.9     -23.3
   927.8    -329.4    -161.2     42.7     -19.4
   909.8    -579.1     -65.8     96.6     -29.0
   750.1    -527.3      25.7     11.8       9.6
   593.4    -476.0      82.8     -4.6      15.0
   497.2    -430.9      90.3      9.1       3.8
 632.  940. 1132. 1794. 2113. 2087. 2028. 1870. 1630. 1123.  774.  587.
 301.  364.  698.  705.  611.  641.  654.  525.  372.  350.  296.  246.
CIRA 1.0 LOC=TRY SAN FRANCISCO,CA, LAT=37.6, TWHT=20, YEAR=1974, ALT=8
```

SEATTLTR.CTY

```
 .174  .167  .162  .141  .128  .091  .066  .086  .101  .125  .157  .170
 .174  .23  .235  .243  .214  .2  .181  .2  .188  .197  .226  .174
 .18265E-11  7.85844 35.0
 .26889E-02  2.70390 11.5
 .13446E-01  1.90105 16.5
 .17763E-09  6.69741 34.0
 39.7  42.9  44.7  51.7  55.2  63.3  72.1  65.0  60.7  54.8  45.8  41.2
 37.4  39.4  40.0  44.5  48.1  54.2  60.3  57.9  53.8  50.0  42.4  38.6
 36.1  38.1  39.7  44.8  48.1  53.0  57.2  56.1  53.6  49.4  41.1  37.6
   230.2    -158.2      42.1     -1.9       2.1
   385.2    -263.8      44.6      -.8       6.4
   510.2    -260.2      18.1     13.7      -1.2
   782.5    -254.0     -24.3      -.4       -.7
   939.3    -216.6     -54.3      5.1      -5.4
  1042.3    -223.5    -143.5     21.6     -11.0
  1120.8    -285.3    -186.4     10.2     -15.3
   849.7    -280.3     -62.6     36.6     -14.2
   656.7    -361.3      -5.3     29.6      -8.2
   434.5    -259.9      32.2      9.3        .2
   295.8    -227.5      53.9      2.7        .7
   218.1    -158.4      43.3      1.9      -1.1
 261.  478.  682. 1124. 1409. 1769. 2041. 1274.  945.  552.  336.  238.
 196.  275.  471.  851. 1100.  929.  745.  841.  479.  358.  205.  178.
CIRA 1.0 LOC=TRY SEATTLE,WA, LAT=47.5, TWHT=20, YEAR=1960, ALT=400
```

STLOUITR.CTY

```
 .196  .187  .146  .109  .064  .054  .047  .046  .044  .107  .168  .195
 .225  .234  .251  .233  .181  .193  .177  .15  .179  .182  .194  .216
 .19326E-04  3.44825 35.0
 .55427E-02  2.11712 20.5
 .14603E-06  5.13147 28.0
 .78070E-04  3.56617 19.5
 32.8  36.6  50.1  59.2  73.3  79.9  82.1  81.1  75.5  58.6  42.2  32.2
 26.6  29.4  41.0  50.7  60.9  66.8  73.0  71.0  67.7  51.5  38.3  28.7
 27.1  29.8  40.2  49.3  59.0  63.5  69.5  69.7  67.2  50.9  38.6  29.2
   523.4   -450.2     91.4      9.2      3.2
   564.3   -380.5     50.2       .8      7.4
   794.7   -389.3     -7.5     -3.1      5.3
   957.3   -249.7    -84.7    -29.6       .1
  1076.3   -162.1   -157.7    -25.3    -13.2
  1142.0    -98.8   -187.4    -16.1    -17.4
  1090.5    -96.7   -149.7    -35.5    -13.5
  1008.1   -235.8   -119.9    -15.8     -7.5
   806.1   -304.2    -30.3     -7.2      6.2
   582.9   -321.7     19.0     -9.3     12.1
   386.4   -213.2     35.6     -2.3      7.3
   357.2   -248.6     55.6       .4      4.0
 639.  773. 1203. 1536. 1877. 1982. 1765. 1686. 1258.  843.  485.  432.
 251.  367.  621.  946. 1026. 1110. 1184.  956.  761.  441.  367.  279.
CIRA 1.0 LOC=TRY ST LOUIS,MO, LAT=38.4, TWHT=20, YEAR=1972, ALT=535
```

TAMPA-TR.CTY

```
 .075  .063  .039  .038  .049  .048  .051  .042  .032  .034  .052  .060
 .185  .189  .181  .201  .184  .187  .138  .129  .168  .183  .192  .201
 .59175E-08  5.63287 35.0
 .28346E-01  1.91336 11.0
 .40602E-01  1.65564 10.0
 .76316E-11  7.18278 35.0
 65.2  67.7  74.0  75.4  84.5  84.3  84.9  83.3  81.5  76.0  69.9  66.5
 56.9  59.3  64.5  65.9  73.5  76.3  77.0  76.2  75.4  67.4  62.0  59.9
 56.0  58.6  62.9  64.1  70.7  74.2  75.0  75.1  74.1  65.8  61.0  58.5
   593.9   -442.4     59.6      5.3     11.1
   721.1   -439.6     18.9      -.5     14.1
   879.1   -381.7    -72.1     11.1     -3.7
   959.6   -200.2   -174.0     -1.0    -20.6
  1017.6    -38.4   -237.2    -14.8    -32.0
  1059.5     22.4   -147.5    -11.3    -15.6
  1039.3     21.9   -157.3    -40.7    -20.6
   968.8    -73.4   -126.7    -43.7    -14.4
   841.2   -205.9    -62.2     -9.4     -4.6
   791.5   -409.1    -16.5     -9.9     15.3
   588.4   -375.9     42.4      1.1     13.8
   520.7   -365.8     58.9      5.7      8.2
 856. 1144. 1537. 1775. 2046. 1767. 1830. 1574. 1299. 1269.  848.  721.
 315.  443.  617.  793.  795. 1225. 1138. 1117.  944.  543.  411.  346.
CIRA 1.0 LOC=TRY TAMPA,FL, LAT=28.0, TWHT=56, YEAR=1953, ALT=19
```

TULSA-TR.CTY

```
 .183   .171   .117   .094   .054   .042   .054   .053   .038   .071   .115   .174
 .182   .218   .247   .253   .232   .209   .192   .192   .192   .187   .244   .225
 .33348E-01  1.73404 15.5
 .13076E-05  4.34524 29.0
 .34786E-01  1.72751 12.5
 .16926E-15 10.49006 35.0
 36.8   42.5   57.2   61.6   72.9   81.2   85.5   84.8   74.9   69.4   56.5   40.7
 31.2   35.5   50.0   53.3   61.7   71.7   76.0   73.3   67.8   58.9   49.7   34.2
 31.4   35.3   48.8   51.3   58.8   69.1   73.3   70.9   67.2   58.5   48.1   34.1
   513.9    -381.0      71.9       3.4       7.4
   582.6    -380.6      42.8       5.6       6.6
   783.0    -321.4     -17.1      -1.0       3.6
   991.6    -276.8    -101.7      -5.8      -8.3
  1070.8    -180.2    -194.3       6.4     -22.1
  1117.3     -89.8    -194.1       1.6     -20.5
  1159.9    -137.5    -195.9       9.3     -19.1
  1058.0    -271.6    -204.1      -7.4     -21.3
   842.9    -281.5     -35.6       4.5        .6
   787.4    -522.3      26.5      -4.3      18.5
   548.7    -411.8      64.8      18.8        .0
   553.4    -487.2     103.3        .4      10.2
 654.   808.  1157.  1648.  1988.  1980.  2070.  2033.  1241.  1173.   700.   685.
 334.   392.   735.   930.   892.  1079.  1112.   670.   898.   419.   334.   248.
CIRA 1.0 LOC=TRY TULSA,OK, LAT=36.2, TWHT=23, YEAR=1973, ALT=650
```

WASHINTR.CTY

```
 .190   .166   .150   .095   .058   .050   .048   .040   .039   .108   .134   .164
 .144   .145   .177   .186   .18   .171   .161   .158   .158   .167   .163   .186
 .42548E-02  2.32165 18.0
 .53077E-08  5.69351 35.0
 .37750E-01  1.73471 13.5
 .78132E-01  1.39315 11.0
 34.6   43.1   48.7   62.3   71.6   79.8   83.3   79.3   74.1   58.7   52.1   43.2
 30.9   38.8   42.0   54.5   62.5   71.8   74.2   71.0   67.8   51.7   46.7   39.5
 29.5   37.5   39.2   51.0   58.3   68.2   67.2   65.3   64.7   49.5   44.7   37.4
   425.0    -305.7      64.3       4.6       3.5
   494.7    -314.2      37.1       6.8       4.5
   768.8    -369.6      -7.8      -6.9       7.2
   947.3    -310.6    -106.0      14.5      -9.1
  1015.4    -207.2    -162.5      -1.9     -14.1
  1058.2    -113.9    -174.1     -12.3     -16.6
  1108.8    -138.7    -182.2     -16.5     -19.0
   995.2    -265.4    -132.1      -3.6      -9.3
   783.5    -334.5     -20.8      25.3      -5.2
   652.0    -399.4      28.2      -4.7      14.7
   480.7    -372.0      71.7      -2.2       8.5
   434.1    -356.7      80.8      -1.7       7.8
 514.   662.  1162.  1576.  1866.  1909.  1974.  1744.  1202.   930.   620.   515.
 312.   361.   611.   806.   852.   991.  1021.   837.   725.   439.   277.   250.
CIRA 1.0 LOC=TRY WASHINGTON,DC, LAT=38.9, TWHT=93, YEAR=1957, ALT=14
```

TYPICAL METEOROLOGICAL YEAR

CITIES

AKRON-TM.CTY

```
 .211  .203  .178  .133  .090  .058  .035  .034  .069  .114  .161  .193
 .269  .215  .251  .216  .2  .166  .162  .16  .182  .192  .232  .232
 .13362E-04  3.78172 28.0
 .10207E-08  6.13454 35.0
 .10167E-06  5.29117 26.0
 .53126E-02  2.40996 13.0
 26.8  30.4  39.3  53.3  63.8  73.8  77.6  74.1  67.5  57.5  44.1  32.1
 22.8  25.1  34.0  44.4  53.6  62.1  67.8  65.1  57.3  50.0  39.7  30.0
 22.8  24.7  33.5  41.9  52.2  59.8  65.6  63.5  57.5  48.9  38.1  28.8
   340.6   -249.3     63.3    -18.7     13.3
   479.3   -290.4     45.7    -32.0     23.0
   614.4   -268.6     -1.7    -31.7     13.2
   849.1   -212.6    -87.7    -64.2      1.0
   938.8   -136.3   -142.8    -54.9    -15.8
   999.6    -81.8   -166.7    -61.9    -21.4
  1000.8   -101.9   -170.3    -66.9    -20.1
   855.5   -208.4    -96.3    -60.0     -1.1
   709.5   -305.4    -13.1    -38.6     12.9
   608.6   -361.6     47.8    -43.7     26.5
   391.6   -261.0     61.5    -22.0     15.4
   260.3   -181.2     51.6    -19.6     13.1
  431.  664.  927. 1403. 1708. 1876. 1872. 1553. 1175.  909.  522.  326.
  236.  354.  513.  722.  789.  864.  824.  687.  542.  414.  296.  203.
CIRA 1.0 LOC=AKRON,OH, LAT=40.9, TWHT=20, ALT=1208
```

ALLENTTM.CTY

```
 .208  .202  .172  .126  .083  .041  .040  .035  .067  .114  .150  .196
 .277  .239  .252  .266  .187  .185  .149  .153  .17  .183  .241  .213
 .14652E-01  1.85607 19.0
 .13425E-01  1.91671 15.0
 .28877E-03  3.27698 16.5
 .98297E-16 10.57377 35.0
 28.0  31.4  42.6  55.6  65.3  74.7  77.2  76.7  69.2  59.4  47.5  32.5
 23.9  25.9  34.6  46.1  56.4  63.6  65.5  66.6  59.3  48.3  41.6  29.3
 22.9  26.0  34.6  45.6  55.3  61.9  64.5  66.2  59.4  49.6  40.6  28.5
   414.2   -320.0     83.3    -29.2     20.5
   530.3   -317.8     54.9    -39.2     25.0
   680.4   -303.4     -2.7    -45.1     17.9
   799.8   -225.3    -77.5    -40.6      2.8
   914.7   -150.9   -130.3    -39.5    -12.8
   972.8    -96.9   -162.7    -44.6    -21.9
   940.4   -118.5   -156.8    -48.2    -19.0
   842.0   -221.0   -106.1    -45.3     -2.9
   732.5   -314.7    -24.7    -34.8     11.2
   627.0   -395.3     47.8    -36.6     25.3
   423.0   -293.8     69.4    -30.0     21.8
   340.5   -256.0     70.4    -23.1     17.2
  533.  737. 1060. 1363. 1664. 1839. 1783. 1542. 1215.  946.  558.  424.
  257.  399.  532.  681.  796.  830.  775.  645.  542.  386.  299.  237.
CIRA 1.0 LOC=ALLENTOWN,PA, LAT=40.7, TWHT=20, ALT=387
```

ALPENATM.CTY

```
 .226  .227  .203  .163  .125  .073  .056  .049  .097  .133  .176  .213
 .142  .142  .167  .172  .171  .161  .13  .11  .11  .133  .159  .148
 .41407E-07  5.12810 35.0
 .11440E-08  6.12012 35.0
 .17250E-02  2.56847 18.0
 .62795E-03  3.01560 16.5
 20.5  20.9  30.8  46.2  57.0  68.7  73.9  72.6  61.7  53.0  39.7  25.3
 16.4  15.1  25.3  37.0  44.8  58.1  61.8  63.1  52.1  45.5  35.4  22.9
 16.6  16.1  24.4  37.0  43.7  56.8  59.8  62.4  52.6  45.1  34.4  22.0
   299.5   -204.8     58.5    -40.2     26.7
   460.4   -276.9     47.2    -47.3     26.0
   703.3   -299.4      -.9    -88.2     29.6
   842.3   -200.2    -77.4   -109.8      8.2
  1062.2    -87.3   -161.8   -154.3    -18.7
  1042.0    -42.4   -154.8   -120.8    -26.2
  1083.0    -51.6   -178.7   -162.0    -23.7
   922.8   -166.7   -105.4   -132.2      1.2
   770.1   -272.3    -34.9    -83.4     19.1
   558.8   -287.4     20.7    -46.6     22.5
   346.5   -225.7     38.7    -16.6     15.7
   209.7   -130.9     33.2    -21.2     15.8
 363.  589. 1030. 1362. 1845. 1832. 1972. 1568. 1153.  731.  394.  242.
 230.  335.  533.  669.  786.  860.  769.  696.  617.  433.  265.  183.
CIRA 1.0 LOC=ALPENA,MI, LAT=45.0, TWHT=33, ALT=689
```

ANNETTTM.CTY

```
 .196  .184  .173  .161  .140  .124  .101  .102  .125  .150  .173  .180
 .204  .205  .194  .194  .187  .131  .148  .15  .168  .22  .216  .24
 .34505E-02  2.63269 10.5
 .93183E-03  3.14832 10.0
 .10000E-30 20.00000 35.0
 .10000E-30 20.00000 35.0
 31.1  36.2  41.1  45.2  51.2  55.1  60.0  59.9  54.7  47.6  39.6  37.0
 30.5  34.4  37.0  40.1  46.2  50.1  55.0  55.3  50.5  44.9  38.6  36.4
 29.0  33.0  36.0  39.2  44.7  49.0  53.7  54.7  49.6  43.3  37.4  35.0
   158.2   -122.4     42.1     -6.7      1.9
   307.6   -209.6     55.8    -19.5     12.0
   566.3   -339.6     46.5    -24.5     14.7
   775.6   -323.6    -23.1    -38.6     10.0
   960.0   -287.5    -86.2    -12.3    -13.7
   903.4   -206.6    -79.7    -16.6     -9.2
   861.9   -208.1    -75.7    -16.1     -9.9
   747.4   -255.7    -42.9    -29.0       .9
   586.3   -304.6     26.8    -19.1      8.7
   336.6   -197.8     41.3    -16.0     10.5
   172.1   -125.5     38.8     -5.7      2.6
   120.1    -96.6     35.1     -5.7      1.2
 167.  361.  740. 1183. 1514. 1448. 1332. 1147.  811.  421.  187.  122.
 125.  245.  419.  595.  786.  839.  806.  626.  477.  295.  141.   93.
CIRA 1.0 LOC=ANNETTE,AK, LAT=55.0, TWHT=53, ALT=110
```

APALACTM.CTY

```
 .116  .121  .077  .028  .036  .056  .061  .061  .046  .045  .079  .107
 .145  .2  .168  .153  .142  .116  .107  .089  .117  .135  .118  .128
 .28141E-01  1.80650 13.0
 .36022E-05  4.31679 24.0
 .45207E-02  2.54450 11.0
 .78835E-03  3.05288 12.0
 56.1  56.2  64.0  72.5  79.3  83.4  84.2  85.1  82.7  74.7  64.0  59.9
 50.0  48.9  57.3  65.5  70.4  78.0  79.1  78.7  75.9  64.9  55.9  50.4
 48.9  47.8  56.1  63.5  68.4  74.5  76.4  76.4  70.9  63.1  54.4  49.6
   591.2   -433.8     75.4      5.3      6.5
   723.1   -468.9     38.6     -5.6     18.1
   804.9   -363.7    -50.8     -1.3      4.8
   970.7   -281.3   -178.8     13.0    -15.8
   983.3   -111.0   -219.5     19.9    -27.1
   909.6     17.6   -189.7    -25.1    -24.4
   876.5    -25.1   -191.6    -14.7    -23.9
   876.2   -113.7   -166.3    -43.9    -11.8
   849.6   -293.2    -96.1    -19.5       .9
   832.8   -514.8     15.5     -2.9     15.4
   678.5   -528.9     81.3     16.0      5.0
   585.1   -482.4     92.0      6.4      7.1
 863. 1183. 1457. 1979. 2133. 1915. 1873. 1784. 1556. 1442. 1046.  832.
 352.  416.  544.  628.  736.  776.  708.  700.  618.  448.  327.  278.
CIRA 1.0 LOC=APALACHICOLA,FL, LAT=29.7, TWHT=50, ALT=19
```

ASHVILTM.CTY

```
 .164  .176  .156  .100  .072  .046  .038  .032  .068  .106  .149  .166
 .155  .222  .222  .201  .102  .129  .076  .121  .14  .137  .181  .194
 .15142E-03  3.24060 23.5
 .21077E-01  1.89671 10.5
 .93145E-02  2.14693 13.5
 .76378E-20 13.15287 35.0
 45.3  41.9  47.5  62.0  71.5  75.0  77.7  75.6  68.3  60.4  50.1  43.8
 36.5  32.8  38.7  51.0  57.7  63.1  66.1  65.5  59.0  50.0  39.6  36.7
 37.9  33.0  37.8  50.9  58.4  64.6  67.4  66.7  60.6  51.5  41.4  37.6
   511.2   -392.7     84.2    -36.9     29.2
   629.6   -403.2     52.8    -39.6     28.4
   782.2   -363.2    -26.0    -42.0     15.8
   911.3   -228.5   -113.3    -50.3     -5.6
   932.7    -86.3   -172.8    -58.5    -22.5
   937.0    -28.9   -175.0    -49.0    -22.9
   899.6    -42.2   -171.8    -64.7    -22.6
   810.6   -199.2   -102.3    -26.2     -5.0
   740.3   -290.5    -36.3    -49.2     14.3
   700.7   -434.7     42.3    -47.9     28.9
   584.9   -460.2     92.5    -41.7     31.9
   485.0   -394.9     97.2    -34.3     25.1
 710.  963. 1340. 1686. 1825. 1829. 1773. 1582. 1354. 1147.  846.  654.
 276.  381.  510.  715.  752.  831.  757.  658.  530.  388.  273.  250.
CIRA 1.0 LOC=ASHVILLE,NC, LAT=35.4, TWHT=20, ALT=2140
```

ATLANTIM.CTY

```
 .166  .158  .127  .069  .053  .032  .034  .031  .035  .076  .121  .153
 .197  .274  .2  .213  .154  .153  .165  .154  .182  .165  .213  .239
 .27781E-04  3.64163 26.0
 .90825E-02  2.12367 14.5
 .30498E-09  6.75431 30.0
 .65676E-21 13.90900 35.0
 43.7  46.4  54.8  68.8  74.2  78.6  81.6  81.3  76.5  66.2  55.8  47.4
 37.4  39.8  46.4  58.6  63.3  69.1  72.2  71.8  68.4  56.5  47.1  40.4
 36.3  38.3  44.9  54.9  61.4  66.9  70.7  69.7  67.2  54.6  46.3  39.3
   500.3   -353.3      67.8    -32.8      26.1
   605.7   -371.8      45.2    -26.2      21.3
   769.3   -328.1     -35.1    -39.2      13.7
   892.2   -212.0    -126.5    -48.2      -4.7
   987.2    -75.7    -198.7    -59.7     -25.2
   945.0    -13.8    -189.3    -43.2     -27.5
   913.1    -32.8    -191.3    -58.4     -26.1
   895.1   -177.2    -150.0    -42.2     -13.3
   763.9   -266.9     -48.3    -46.7      11.7
   737.9   -445.2      41.5    -61.1      34.9
   598.2   -452.2      87.0    -37.3      27.9
   500.0   -387.0      87.1    -38.8      30.5
 696.  928. 1325. 1661. 1978. 1890. 1883. 1783. 1347. 1254.  885.  689.
 308.  403.  544.  697.  767.  805.  717.  669.  608.  406.  300.  273.
CIRA 1.0 LOC=ATLANTA,GA, LAT=33.7, TWHT=20, ALT=1010
```

AUGUSTIM.CTY

```
 .146  .144  .115  .066  .047  .042  .045  .045  .038  .079  .110  .138
 .176  .17  .193  .158  .14  .13  .128  .107  .128  .153  .154  .133
 .41745E-03  2.87065 25.0
 .12135E-01  1.87877 19.0
 .64866E-10  6.86421 35.0
 .21279E-16 10.98656 35.0
 49.4  50.6  57.9  70.5  77.5  82.3  84.4  84.8  77.8  68.0  60.5  51.9
 41.9  39.9  47.5  58.2  64.7  70.2  72.6  72.4  68.0  54.5  46.4  42.3
 41.5  40.7  46.1  57.8  63.5  69.3  72.4  72.2  66.5  55.2  47.7  43.3
   512.9   -357.5      71.9    -25.9      21.4
   643.0   -413.7      47.3    -27.8      23.0
   784.8   -330.7     -31.4    -46.9      17.2
   897.9   -190.8    -123.9    -58.9      -7.0
   988.5    -64.0    -188.0    -62.0     -24.7
   959.9      6.7    -189.4    -59.3     -28.0
   912.1    -31.4    -173.3    -51.3     -23.0
   843.1   -155.9    -129.5    -42.2      -9.7
   759.7   -248.3     -49.0    -52.6      12.5
   728.5   -433.7      35.1    -49.0      29.4
   616.2   -448.4      81.0    -55.5      39.4
   496.5   -406.7      95.3    -41.0      30.9
 718.  998. 1340. 1664. 1913. 1893. 1814. 1666. 1373. 1221.  921.  699.
 335.  382.  568.  725.  838.  841.  798.  683.  622.  418.  312.  233.
CIRA 1.0 LOC=AUGUSTA,GA, LAT=33.3, TWHT=25, ALT=136
```

BALTIMTM.CTY

```
 .194  .186  .157  .126  .072  .050  .040  .039  .049  .099  .141  .183
 .209  .26  .255  .191  .184  .182  .168  .169  .134  .187  .196  .225
 .18814E-04  3.42001 35.0
 .31731E-05  3.94080 35.0
 .72131E-08  5.76498 32.5
 .10082E-07  5.51811 35.0
 32.8  35.3  44.5  53.0  63.9  73.8  78.0  75.8  71.0  60.0  49.0  36.2
 29.7  32.0  41.5  48.8  59.6  70.3  74.5  73.1  67.4  53.7  44.9  34.1
 27.9  30.6  37.0  44.3  53.6  63.6  69.0  67.5  61.8  51.2  42.1  31.6
   250.9   -187.0     26.4      -.1      2.7
   422.4   -218.7    -19.5    -21.1     13.6
   624.1   -215.0    -83.9    -26.2      2.2
   782.0    -96.5   -162.7    -48.8     -9.7
   965.8     16.7   -212.3    -59.3    -21.0
  1130.6    117.6   -254.3    -73.8    -27.8
  1066.8     53.5   -237.1    -56.9    -22.8
   822.6    -53.1   -193.1    -47.5    -17.3
   758.4   -181.4   -135.5    -38.4     -5.1
   527.2   -253.6    -52.1    -15.9     10.3
   345.0   -208.4      8.5     -5.7      7.7
   198.0   -148.2     24.8       .4      1.9
 284.  509.  832. 1091. 1371. 1586. 1511. 1163. 1003.  637.  392.  220.
 143.  280.  476.  698.  894. 1015.  989.  708.  630.  338.  240.  122.
CIRA 1.0 LOC=BALTIMORE,MD, LAT=39.2, TWHT=20, ALT=148
```

BARBERTM.CTY

```
 .023  .019  .012  .016  .018  .029  .031  .036  .031  .030  .016  .016
 .184  .207  .232  .21  .185  .168  .176  .171  .156  .139  .187  .178
 .10000E-30 20.00000 35.0
 .15516E-09  6.24891 35.0
 .46743E-31 22.14866 26.5
 .21820E-04  3.84432 14.0
 75.6  74.6  75.6  77.3  78.4  80.6  81.1  81.7  81.2  80.8  78.1  76.5
 67.7  67.9  68.6  70.5  72.3  74.0  74.3  75.2  74.9  73.6  72.8  70.0
 66.8  64.9  66.0  67.3  67.9  69.9  70.3  71.0  70.9  70.2  69.8  66.9
   702.8   -448.7     62.0    -48.1     40.0
   797.1   -395.0     -2.9    -55.2     34.5
   899.0   -237.8    -96.8    -65.9     12.9
   929.3    -53.8   -177.0    -71.6    -18.3
   971.8    110.9   -211.7    -72.8    -36.5
   994.7    185.5   -211.0    -60.9    -34.5
   969.4    165.6   -229.3    -70.7    -39.5
   919.7     20.4   -236.7    -71.3    -35.5
   886.9   -169.4   -151.0    -80.8     -1.6
   806.5   -340.6    -41.8    -71.6     30.2
   712.5   -424.0     44.6    -66.8     45.3
   687.2   -483.5     79.0    -57.6     46.5
 1234. 1465. 1714. 1843. 1981. 2028. 2029. 1991. 1810. 1568. 1298. 1200.
  410.  516.  740.  824.  859.  843.  773.  671.  642.  501.  404.  337.
CIRA 1.0 LOC=BARBERS POINT,HI, LAT=21.3, TWHT=20
```

BETHELTM.CTY

```
 .254  .255  .232  .218  .169  .127  .115  .129  .152  .200  .231  .255
 .312  .36  .346  .267  .253  .229  .209  .241  .222  .304  .26  .287
 .29483E-02  2.60338 13.5
 .36220E-05  4.53698 17.5
 .10000E-30 20.00000 35.0
 .10000E-30 20.00000 35.0
  5.7   6.0  17.8  24.5  44.7  55.7  57.6  54.0  48.9  31.1  16.7   5.1
  5.5   3.7  13.4  18.9  35.3  46.9  50.6  48.3  42.1  27.6  15.4   4.3
  4.5   4.2  14.4  20.4  36.1  47.4  50.9  48.9  43.1  28.0  15.3   4.0
    94.1    -74.1      28.0     -5.7      1.6
   346.7   -315.4      96.4    -24.4     13.6
   617.9   -434.9      68.1    -19.0     11.0
   800.9   -387.1      -9.3    -17.3     -1.0
  1002.3   -301.4     -74.5    -32.7     -4.2
  1022.4   -256.2     -81.3     -7.1     -8.0
   792.8   -217.5     -59.8     16.7     -8.1
   642.8   -249.8     -17.8      7.5     -4.7
   564.9   -289.9      25.7    -20.3      7.6
   324.4   -229.0      57.9    -13.6      8.5
   138.6   -116.0      41.6     -8.9      3.2
    55.4    -47.4      19.4     -2.8      -.4
  93.  336.  746. 1127. 1490. 1547. 1154.  899.  724.  367.  134.   51.
  77.  185.  372.  570.  838.  921.  779.  603.  473.  248.  100.   43.
CIRA 1.0 LOC=BETHEL,AK, LAT=60.7, TWHT=20, ALT=125
```

BIGDELTM.CTY

```
 .275  .261  .243  .204  .142  .097  .086  .101  .156  .209  .250  .277
 .279  .26  .197  .153  .173  .144  .139  .127  .153  .173  .236  .231
 .38463E-01  1.66353 14.5
 .14657E-02  2.78699 15.0
 .32754E-03  3.09172 20.0
 .10000E-30 20.00000 35.0
 -3.9   3.8  15.1  32.0  52.9  62.6  64.8  61.2  47.9  27.7   9.6  -5.8
 -5.5  -1.4   3.9  22.2  41.5  51.9  54.2  51.1  38.9  23.5   5.1  -6.7
 -5.4    .1   7.4  23.0  40.3  49.1  52.5  49.6  38.8  23.3   6.3  -6.8
    48.8    -38.9      12.4     -3.7      2.6
   268.1   -212.1      57.1    -36.6     25.2
   668.5   -426.9      59.3   -100.6     42.6
   900.7   -358.1     -23.0   -103.7     12.0
  1196.0   -237.9    -101.8   -142.9    -10.0
  1240.9   -141.1    -114.8   -127.9    -17.6
  1114.9   -221.8     -82.4    -87.7     -5.9
   926.5   -292.0     -45.6   -107.6      5.6
   647.7   -329.6      24.9    -81.7     23.1
   178.6   -124.2      27.0    -22.5     10.3
    10.0     -7.6       2.9     -1.6      1.0
     8.3     -4.6       1.8      -.9       .6
  43.  249.  753. 1183. 1683. 1777. 1618. 1260.  795.  189.    9.    9.
  37.  171.  369.  592.  831.  949.  875.  652.  438.  112.    8.    9.
CIRA 1.0 LOC=BIG DELTA,AK, LAT=64.0, TWHT=29, ALT=1268
```

BILLINTM.CTY

```
 .212  .205  .187  .160  .106  .074  .053  .056  .092  .126  .177  .216
 .325  .279  .272  .255  .244  .212  .203  .216  .218  .246  .253  .304
 .11480E-01  1.93096 21.5
 .11730E-01  2.02913 14.5
 .43850E-01  1.69346 14.0
 .88903E-10  6.77801 35.0
 25.7  29.5  37.5  46.9  61.9  70.1  79.9  78.7  64.8  55.9  39.1  23.7
 21.1  24.5  28.7  37.3  51.0  57.3  65.9  65.4  53.4  46.6  34.8  20.2
 19.0  23.6  27.4  35.2  46.5  53.3  58.5  56.2  49.4  40.5  30.5  18.5
   436.0   -401.4   116.7   -34.2    21.1
   574.9   -434.0    91.2   -43.9    27.4
   773.1   -418.5    15.0   -58.8    24.6
   917.2   -305.2   -75.8   -66.6     6.6
  1025.5   -201.0  -155.0   -69.0   -13.9
  1183.6   -135.7  -230.4   -98.2   -28.9
  1195.6   -200.3  -232.3   -87.2   -30.7
  1093.0   -360.3  -145.8   -97.7    -2.6
   891.2   -500.8    -5.0   -58.1    22.9
   711.6   -538.0    86.6   -54.3    35.5
   472.3   -415.4   106.9   -37.6    27.4
   389.5   -377.4   114.6   -29.1    17.8
 497.  757. 1142. 1505. 1862. 2280. 2332. 2063. 1470. 1005.  566.  421.
 197.  311.  489.  682.  726.  731.  653.  534.  442.  313.  215.  163.
CIRA 1.0 LOC=BILLINGS,MT, LAT=45.8, TWHT=25, ALT=3567
```

BIRMINTM.CTY

```
 .152  .143  .109  .076  .047  .042  .049  .041  .049  .067  .112  .152
 .187  .171  .2  .213  .179  .123  .138  .115  .141  .141  .156  .194
 .73889E-01  1.46200 15.0
 .37055E-03  2.82880 26.0
 .10213E-01  2.16961 13.0
 .12621E-01  2.10463 10.5
 46.7  49.9  58.2  67.1  76.6  81.1  84.8  82.6  78.5  68.4  58.6  47.9
 41.1  42.7  49.5  57.1  64.2  70.0  74.8  72.3  66.4  56.9  48.6  40.7
 40.0  40.3  47.6  53.6  63.1  67.9  71.5  71.3  64.7  56.3  47.3  40.2
   505.7   -362.9    74.0   -23.8    18.6
   613.9   -356.7    39.5   -35.4    25.2
   748.4   -315.8   -36.4   -27.4     8.1
   861.0   -214.6  -119.9   -47.8    -2.4
   975.7    -78.3  -186.5   -57.0   -21.2
   945.1    -12.0  -185.7   -43.7   -26.1
   912.6    -37.8  -174.0   -45.0   -22.8
   838.9   -166.1  -130.4   -38.8    -9.3
   801.0   -290.6   -61.8   -54.5    13.3
   732.5   -437.7    33.2   -48.7    30.8
   571.2   -418.9    78.7   -30.4    24.2
   466.3   -369.9    83.6   -27.7    21.9
 710.  940. 1277. 1633. 1913. 1864. 1796. 1660. 1481. 1217.  841.  642.
 312.  428.  547.  652.  810.  832.  804.  662.  562.  418.  313.  244.
CIRA 1.0 LOC=BIRMINGHAM,AL, LAT=33.6, TWHT=20, ALT=620
```

BOISE-TM.CTY

```
 .196  .178  .167  .141  .093  .069  .065  .063  .072  .122  .168  .195
 .207  .207  .228  .234  .198  .215  .188  .164  .194  .15  .159  .181
 .46016E-04  3.56732 23.5
 .18374E-06  5.02900 28.0
 .46114E-02  2.20044 19.5
 .19873E-10  7.27091 35.0
 32.9  40.4  44.4  52.4  64.5  73.8  82.8  81.0  71.2  57.9  43.6  33.7
 28.7  33.7  36.6  42.5  52.2  59.3  66.7  63.5  57.7  45.8  37.1  29.0
 28.7  31.9  34.4  38.3  45.2  53.4  55.3  54.2  50.6  43.0  36.9  29.5
   413.7   -358.4    100.9    -18.3     13.0
   650.4   -497.5     97.8    -59.0     41.2
   811.3   -415.7      3.9    -77.7     37.9
  1070.7   -389.4   -125.4    -40.1     -8.4
  1191.3   -246.1   -226.3    -45.8    -27.4
  1266.3   -116.9   -283.8    -95.1    -37.5
  1281.2   -193.5   -294.3    -92.9    -35.8
  1143.7   -386.7   -185.8    -76.7    -11.0
   992.8   -522.2    -39.3    -75.3     25.2
   775.8   -573.4     79.5    -71.4     45.2
   477.5   -404.4    104.9    -24.5     16.2
   376.8   -333.2     96.7    -24.7     19.2
 495.  878. 1259. 1854. 2243. 2505. 2636. 2229. 1714. 1138.  606.  436.
 225.  322.  515.  662.  722.  711.  589.  499.  455.  315.  242.  202.
CIRA 1.0 LOC=BOISE,ID, LAT=43.6, TWHT=20, ALT=2838
```

BUFFALTM.CTY

```
 .208  .207  .188  .142  .110  .054  .036  .038  .079  .121  .167  .198
 .338  .305  .291  .298  .236  .211  .225  .209  .188  .244  .246  .252
 .51927E-06  4.43119 35.0
 .16857E-02  2.58359 18.0
 .13089E-02  2.84946 15.0
 .19192E-03  3.44367 16.0
 26.6  27.6  35.3  49.7  58.5  70.8  76.9  73.0  66.3  54.5  41.5  31.2
 24.5  24.2  31.0  42.6  50.2  61.5  66.9  64.5  57.7  48.9  39.0  28.4
 23.4  23.2  29.9  41.1  47.8  58.4  63.7  61.9  56.0  46.7  37.2  27.2
   273.7   -171.0     46.2    -18.8     12.7
   395.9   -201.7     33.4    -27.6     17.6
   604.3   -277.0     12.0    -20.4      8.7
   772.1   -212.3    -61.7    -56.0      5.8
   927.4   -160.0   -125.4    -55.0    -10.4
   986.5   -101.4   -148.8    -59.9    -17.4
   946.8   -152.9   -150.7    -34.9    -19.6
   839.6   -217.6    -86.7    -59.1      -.7
   742.2   -304.4    -10.9    -37.0     12.7
   504.5   -280.3     39.3    -30.3     19.1
   271.7   -162.5     40.6    -15.8     10.7
   217.9   -138.5     39.0    -11.7      7.9
 342.  527.  890. 1279. 1678. 1799. 1768. 1485. 1177.  723.  347.  267.
 241.  366.  528.  673.  785.  879.  763.  673.  624.  400.  245.  195.
CIRA 1.0 LOC=BUFFALO,NY, LAT=42.9, TWHT=20, ALT=705
```

BURLIATM.CTY

```
 .218  .206  .175  .114  .089  .041  .037  .041  .064  .112  .156  .197
 .24  .221  .257  .26  .215  .167  .172  .162  .18  .169  .222  .239
 .91851E-02  2.03009 20.0
 .12934E-07  5.44058 35.0
 .14951E-09  6.68454 35.0
 .94841E-11  7.42485 35.0
 23.2  29.3  41.5  58.0  64.2  76.2  79.4  78.8  71.1  58.9  45.6  33.1
 18.9  23.7  33.4  48.4  54.3  67.1  69.5  69.0  60.9  48.7  39.2  28.1
 18.5  24.4  33.4  47.1  51.2  66.4  66.2  67.1  59.6  48.8  40.3  28.4
   500.5   -381.2     73.9    -37.0     31.9
   623.8   -395.8     59.6    -93.9     53.6
   765.2   -332.2    -32.3    -58.1     18.8
   940.9   -178.8   -115.3   -125.8     10.5
  1064.9    -52.4   -177.4   -126.9    -22.0
  1138.9     12.1   -202.6   -150.1    -33.2
  1163.1       .8   -223.1   -174.3    -34.6
  1058.4   -169.9   -170.8   -125.4      2.9
   865.1   -303.1    -55.7   -118.8     23.3
   730.0   -404.5     37.6   -129.4     60.5
   514.0   -352.5     67.3    -69.9     45.2
   350.8   -268.0     72.6    -53.0     36.0
 585.  871. 1149. 1579. 1858. 2116. 2194. 1865. 1450. 1096.  659.  431.
 288.  356.  544.  737.  853.  887.  807.  726.  570.  410.  307.  212.
CIRA 1.0 LOC=BURLINGTON,IA, LAT=40.8, TWHT=33, ALT=692
```

BURLVTTM.CTY

```
 .229  .220  .205  .166  .113  .061  .036  .050  .087  .134  .173  .207
 .173  .242  .173  .193  .186  .14  .17  .142  .195  .18  .221  .209
 .11451E-03  3.22259 24.5
 .54612E-04  3.45199 24.5
 .11567E-02  2.75798 18.0
 .95278E-02  2.15087 15.0
 18.7  22.4  28.4  43.5  56.3  67.8  72.5  69.8  60.8  50.9  39.8  26.1
 16.1  19.3  25.2  37.8  52.0  61.9  67.8  64.8  56.7  47.8  37.6  24.6
 14.9  18.2  23.5  35.3  48.0  58.0  63.1  59.6  54.4  44.6  36.1  23.3
   191.9   -140.7     21.4     -2.5      4.0
   356.2   -174.1    -14.2    -22.2     12.8
   565.4   -190.7    -74.9    -37.2      7.0
   768.5   -137.6   -148.9    -31.5     -9.2
  1016.1     41.6   -228.3    -92.4    -15.0
  1146.6     98.5   -264.7    -84.0    -18.0
  1152.5     65.0   -268.3    -80.5    -19.9
   986.4    -67.8   -233.3    -53.8    -19.4
   701.7   -179.4   -125.7    -40.2       .2
   443.2   -202.3    -33.3    -19.1     12.3
   202.2   -125.9     11.9     -3.2      4.8
   149.8   -108.6     17.1     -1.2      3.5
 202.  409.  710. 1044. 1387. 1603. 1596. 1317.  888.  516.  222.  155.
 119.  261.  430.  664.  899.  978.  985.  807.  569.  331.  150.  100.
CIRA 1.0 LOC=BURLINGTON,VT, LAT=44.5, TWHT=20, ALT=332
```

CAPEHATM.CTY

```
 .147  .148  .128  .080  .035  .025  .039  .034  .019  .050  .102  .142
 .254  .282  .289  .264  .234  .217  .182  .212  .218  .255  .234  .259
 .24292E-02  2.50721 17.5
 .78235E-06  4.57881 27.5
 .54475E-18 12.02067 35.0
 .18984E-03  3.52423 13.0
 48.2  47.5  52.9  62.5  69.5  77.9  81.1  80.6  76.4  68.0  58.5  49.1
 44.2  43.6  49.8  57.6  65.5  72.4  76.3  75.4  71.2  63.3  52.8  45.0
 42.3  42.5  47.4  55.5  61.9  71.0  74.0  73.4  68.9  60.4  51.5  43.8
   543.2   -444.0     83.5      4.4      8.9
   651.6   -457.8     62.7     19.0      1.9
   753.6   -360.0    -13.2    -15.4     14.1
   903.6   -288.8   -116.6    -12.6       .6
   970.7   -141.2   -186.5    -21.4    -19.1
  1007.2    -82.5   -215.9      9.3    -20.3
   936.1   -121.0   -175.5      7.2    -17.8
   856.6   -215.7   -130.8     -1.1    -10.2
   831.4   -381.1    -56.1      1.7      2.1
   715.4   -470.1     37.3     -6.6     16.6
   641.4   -515.1     93.8     -1.2     11.7
   484.8   -440.6    101.1      6.2      3.0
  719.  971. 1274. 1739. 1960. 2049. 1898. 1684. 1503. 1169.  897.  638.
  276.  400.  553.  643.  753.  789.  782.  660.  536.  390.  313.  202.
CIRA 1.0 LOC=CAPE HATTERAS,NC, LAT=35.2, TWHT=32, ALT=7
```

CARIBOTM.CTY

```
 .240  .236  .210  .182  .123  .085  .058  .080  .111  .155  .191  .230
 .238  .248  .226  .23  .219  .207  .175  .172  .209  .207  .216  .245
 .25389E-07  5.28551 35.0
 .68493E-07  5.08052 33.0
 .31091E-02  2.41406 18.0
 .84103E-12  8.13461 35.0
 14.7  15.6  28.5  38.1  54.6  63.2  67.3  63.8  57.0  46.0  33.3  17.9
 10.1  11.2  22.3  33.4! 48.1  57.5  62.0  59.2  52.6  42.1  31.5  15.7
 10.9  12.0  22.4  32.3  45.5  53.2  58.1  55.8  50.8  40.4  29.4  15.4
   206.6   -159.7     26.9     10.4     -2.6
   414.1   -273.4      4.0     18.8     -2.8
   640.2   -285.6    -62.9     12.9     -3.0
   809.8   -212.6   -144.7      4.2     -8.5
   972.7    -85.9   -197.1       .9     -5.4
  1085.3     20.2   -216.1    -28.0      2.0
   983.8    -18.2   -197.1    -25.0      1.0
   875.7   -114.2   -179.7     -9.5     -7.2
   654.0   -205.1   -104.1     -6.9      1.8
   384.0   -206.5    -19.1      7.4      2.8
   177.0   -117.0     12.2      4.5      1.0
   168.0   -135.1     24.4     11.6     -4.3
  202.  436.  758. 1057. 1334. 1513. 1371. 1150.  801.  423.  183.  156.
  137.  261.  496.  677.  874.  989.  900.  773.  558.  280.  132.  109.
CIRA 1.0 LOC=CARIBOU,ME, LAT=46.9, TWHT=31, ALT=624
```

CASPERTM.CTY

```
 .213  .201  .193  .169  .121  .084  .061  .059  .105  .137  .187  .203
 .367  .367  .307  .27  .268  .265  .225  .26  .226  .291  .359  .349
 .38844E-03  2.85517 28.0
 .37299E-08  5.76412 35.0
 .69120E-08  5.69086 34.5
 .13883E-03  3.40289 18.0
 26.7  32.3  35.7  44.3  58.7  71.3  80.9  79.1  63.5  53.4  36.6  30.0
 21.6  24.6  26.8  33.2  44.0  54.5  64.2  63.4  49.0  40.6  30.7  25.4
 20.1  24.0  26.0  31.7  41.8  50.1  54.8  51.7  45.2  36.8  28.5  23.3
   565.4   -560.6    151.4    -49.4     35.6
   746.4   -613.7    107.3    -66.2     43.0
   907.0   -538.1     -1.5    -70.3     27.8
  1037.5   -345.9   -141.3    -75.3     -3.6
  1194.0   -171.4   -251.5    -93.5    -30.9
  1261.5    -81.1   -293.7   -112.9    -43.1
  1260.1   -121.8   -289.2   -137.1    -37.4
  1138.0   -337.6   -191.0   -107.9     -9.4
  1002.9   -513.7    -59.5    -82.9     21.2
   832.9   -660.5     82.1    -49.9     37.2
   605.7   -592.6    148.7    -50.5     38.2
   473.5   -477.6    136.3    -44.9     33.6
 677. 1021. 1447. 1830. 2227. 2505. 2572. 2238. 1695. 1229.  763.  543.
 166.  255.  397.  581.  687.  671.  588.  491.  430.  264.  163.  148.
CIRA 1.0 LOC=CASPER,WY, LAT=42.9, TWHT=20, ALT=5338
```

CHARLOTM.CTY

```
 .168  .158  .131  .080  .051  .030  .039  .037  .038  .083  .130  .158
 .185  .187  .194  .174  .192  .144  .135  .136  .165  .169  .13  .125
 .10587E-04  3.84499 28.5
 .84870E-04  3.41506 21.0
 .11903E-10  7.33489 35.0
 .12611E-02  2.82895 12.0
 43.4  46.1  54.4  66.4  74.8  79.2  82.3  81.6  77.2  66.5  54.9  46.5
 36.0  37.6  44.7  55.3  64.2  69.5  71.2  70.5  67.0  54.1  44.6  39.0
 35.0  36.8  43.1  52.7  62.0  65.8  69.1  68.1  64.4  54.1  44.2  38.2
   551.3   -433.3     92.2    -38.9     31.1
   600.6   -373.0     42.8    -38.3     29.0
   803.7   -361.9    -23.2    -51.8     21.1
   898.2   -217.8   -108.7    -61.4     -2.3
   922.0    -93.5   -162.6    -51.0    -19.8
   980.9    -21.7   -190.4    -66.5    -25.5
   929.8    -57.7   -179.2    -50.2    -24.3
   895.8   -189.2   -137.3    -49.3    -12.1
   811.4   -296.8    -54.4    -48.2     10.8
   737.6   -470.3     50.1    -52.8     34.7
   605.8   -463.9     89.6    -43.9     34.3
   462.4   -385.7     95.8    -33.2     24.3
 766.  901. 1343. 1643. 1821. 1993. 1864. 1768. 1446. 1222.  870.  629.
 279.  380.  558.  716.  763.  817.  763.  663.  606.  393.  300.  224.
CIRA 1.0 LOC=CHARLOTTE,NC, LAT=35.2, TWHT=20, ALT=736
```

CHARSCTM.CTY

```
 .134  .135  .095  .059  .039  .038  .042  .042  .032  .061  .100  .130
 .144  .176  .194  .162  .166  .149  .138  .143  .156  .151  .146  .137
 .37917E-01  1.63332 16.0
 .60462E-04  3.33375 26.5
 .79391E-02  2.16989 14.0
 .29501E-02  2.58879 11.0
 52.9  53.6  61.3  70.0  76.4  79.7  83.5  82.2  79.7  69.3  61.7  54.3
 44.4  43.8  52.1  58.9  65.9  71.0  74.5  74.1  70.2  59.4  50.5  44.4
 44.6  43.6  50.4  59.0  64.1  70.4  73.9  72.8  70.5  59.0  50.6  45.1
   499.5   -397.0     85.5       .9      7.6
   652.8   -451.4     63.8      -.4     11.4
   773.6   -363.4    -13.0    -22.1     16.1
   910.8   -289.9   -121.1     11.6     -8.8
   954.0   -103.5   -162.7    -22.0    -15.0
   902.2    -51.6   -174.4     -1.3    -18.1
   859.5    -63.7   -166.9    -16.6    -18.9
   782.8   -166.9   -101.5    -29.5     -5.8
   759.4   -299.6    -49.0    -21.7     10.8
   688.9   -414.8     36.3    -10.3     18.0
   668.4   -535.4    100.8     -2.9     15.8
   490.9   -416.3    100.8     -1.6      6.4
 714. 1037. 1368. 1755. 1866. 1777. 1736. 1592. 1408. 1137. 1001.  693.
 278.  383.  561.  685.  877.  831.  758.  664.  567.  454.  325.  247.
CIRA 1.0 LOC=CHARLESTON,SC, LAT=32.9 , TWHT=77, ALT=40
```

CHARWVTM.CTY

```
 .185  .187  .150  .108  .077  .052  .044  .036  .043  .106  .134  .166
 .147  .159  .148  .123  .118  .096  .108  .083  .087  .11  .144  .141
 .11570E-05  4.27481 35.0
 .19288E-01  1.80506 16.0
 .21751E-11  7.88447 35.0
 .65202E-12  8.13102 35.0
 35.8  35.9  48.7  59.1  67.7  77.9  82.5  77.3  72.4  61.2  51.9  42.0
 31.0  31.4  40.3  49.2  55.6  64.5  70.7  66.7  63.0  49.3  43.8  37.1
 29.4  29.9  38.1  46.3  53.7  63.1  67.9  66.5  62.7  49.0  42.6  35.8
   388.3   -271.2     62.0    -20.6     15.5
   467.4   -272.2     41.6    -19.2     14.7
   637.2   -267.0     -6.7    -31.5     13.3
   804.4   -214.0    -74.2    -37.3     -2.2
   898.0   -130.7   -137.1    -40.4    -15.3
   969.4    -71.4   -167.4    -44.5    -22.6
   886.3   -104.1   -141.3    -27.2    -18.3
   790.2   -228.8    -81.4    -15.7     -3.5
   734.7   -283.9    -25.1    -45.5     16.6
   640.8   -398.3     51.0    -34.9     25.6
   435.1   -309.0     69.0    -15.2     11.8
   308.5   -210.2     52.1    -14.6     10.6
 504.  657.  989. 1389. 1659. 1843. 1665. 1502. 1265. 1005.  589.  391.
 275.  370.  543.  711.  787.  866.  804.  646.  592.  408.  295.  239.
CIRA 1.0 LOC=CHARLESTON,WV, LAT=38.3, TWHT=32, ALT=939
```

CHERRYTM.CTY

```
 .144  .146  .118  .069  .039  .035  .040  .036  .021  .057  .105  .140
 .159  .187  .143  .16  .168  .197  .114  .092  .164  .106  .134  .129
 .63141E-08  5.68412 35.0
 .23776E-03  2.93210 24.0
 .39164E-02  2.66723 11.0
 .97698E-03  3.28681 10.0
 50.2  49.6  57.0  66.6  74.1  79.9  82.6  81.1  77.9  69.0  57.9  51.4
 41.5  42.0  47.8  57.2  64.6  71.3  74.4  73.8  70.8  60.9  52.1  44.3
 40.0  40.2  46.7  56.6  64.1  69.4  71.8  72.1  70.2  60.0  50.6  44.0
   556.8   -444.6     98.7    -28.9     24.0
   669.3   -439.6     66.0    -41.3     26.6
   864.8   -363.2    -37.7    -68.7     25.2
   935.2   -218.0   -129.7    -68.6     -1.9
   972.8    -88.2   -185.1    -57.8    -22.9
  1010.6    -11.7   -206.0    -60.4    -27.2
   930.6    -40.7   -175.1    -69.8    -22.5
   868.8   -155.9   -130.1    -64.1     -6.4
   789.7   -267.0    -52.3    -65.9     18.0
   691.3   -404.1     36.3    -44.9     30.7
   606.1   -469.5     94.7    -30.4     25.7
   523.2   -443.6    109.1    -38.9     30.7
 783. 1047. 1440. 1730. 1921. 2009. 1866. 1662. 1396. 1125.  893.  723.
 284.  392.  609.  713.  779.  833.  785.  702.  616.  437.  305.  241.
CIRA 1.0 LOC=CHERRY POINT,NC, LAT=34.9, TWHT=20
```

CHEYENTM.CTY

```
 .208  .207  .189  .155  .125  .084  .059  .060  .094  .134  .181  .196
 .289  .312  .334  .286  .198  .241  .212  .214  .229  .254  .28  .273
 .16890E-03  3.03469 28.5
 .22359E-01  1.87641 12.0
 .95676E-01  1.36441 12.5
 .18406E-01  1.82496 12.0
 29.7  29.5  36.8  49.0  56.3  67.1  76.1  74.3  64.7  54.5  40.0  33.7
 21.7  22.6  28.8  37.3  44.6  54.3  61.7  60.1  51.3  42.0  31.8  27.1
 21.0  21.2  25.8  34.8  42.6  50.0  56.3  54.8  47.1  37.7  28.3  23.8
   608.8   -605.0    145.1    -51.6     39.1
   721.4   -557.2     79.6    -62.1     41.2
   907.9   -508.4    -28.4    -84.2     29.0
   979.6   -293.6   -142.2    -97.0      5.2
  1029.6   -105.4   -204.0   -105.6    -18.6
  1114.0    -16.2   -252.1   -127.3    -32.7
  1088.6    -54.7   -240.8   -136.7    -26.0
   999.4   -263.8   -169.2    -90.9     -6.4
   962.1   -477.5    -60.0    -76.1     20.6
   797.3   -605.2     62.9    -68.7     46.3
   670.1   -645.5    138.3    -36.0     31.1
   576.3   -617.5    166.1    -38.9     31.1
 736. 1011. 1474. 1760. 1951. 2182. 2195. 1971. 1685. 1215.  842.  668.
 140.  271.  369.  564.  686.  694.  633.  518.  434.  247.  164.  112.
CIRA 1.0 LOC=CHEYENNE,WY, LAT=41.2, TWHT=33, ALT=6126
```

CHINALTM.CTY

```
 .148  .125  .091  .086  .064  .084  .108  .089  .073  .072  .112  .158
 .089  .128  .224  .151  .181  .255  .162  .123  .178  .111  .1   .052
 .14394E-05  4.48964 26.5
 .15379E-02  2.65942 17.5
 .48191E-02  2.17914 19.5
 .39289E-03  3.05208 19.5
 51.5  58.3  64.6  67.9  83.5  93.2  97.5  91.9  89.4  72.2  59.8  47.9
 39.2  43.7  51.7  53.7  66.5  76.9  83.6  80.8  70.7  57.9  47.5  38.5
 36.6  39.5  45.5  44.4  53.9  58.6  60.6  58.5  57.7  46.2  42.6  34.9
   619.4   -554.0    134.0    -47.4     38.0
   805.8   -597.8     86.7    -62.5     47.2
   934.1   -485.1    -24.0    -63.4     26.9
  1110.7   -326.5   -202.1    -87.3     -6.9
  1196.0   -107.2   -304.4    -91.1    -39.0
  1252.7      8.6   -350.9    -94.7    -54.6
  1182.1    -58.9   -324.1    -81.7    -47.3
  1105.2   -256.6   -248.9    -80.5    -22.3
  1033.0   -478.3    -98.2    -78.6     18.6
   852.6   -610.5     55.3    -63.0     44.5
   693.4   -594.8    124.6    -52.2     41.6
   610.4   -590.3    151.2    -44.5     36.5
 886. 1295. 1686. 2254. 2573. 2755. 2634. 2409. 2010. 1470. 1028.  844.
 225.  333.  482.  527.  607.  614.  558.  466.  419.  293.  244.  175.
CIRA 1.0 LOC=CHINA LAKE,CA, LAT=35.6, TWHT=20, ALT=2265
```

COLORATM.CTY

```
 .193  .190  .179  .142  .103  .071  .055  .059  .083  .117  .174  .187
 .192  .222  .274  .263  .256  .228  .208  .185  .196  .209  .231  .214
 .16955E-02  2.52501 23.0
 .27837E-01  1.93089 11.0
 .54271E-03  2.92411 21.0
 .67083E-13  8.71643 35.0
 36.5  38.1  42.3  52.2  62.3  72.4  76.8  75.6  70.2  58.8  42.6  39.5
 25.3  26.0  29.6  40.3  49.5  57.9  63.9  62.5  55.1  45.9  33.1  27.7
 23.9  25.7  28.1  35.2  44.6  50.0  57.7  57.8  49.3  39.8  30.5  26.3
   688.9   -696.0    161.4    -59.5     45.3
   790.3   -636.1     90.6    -74.8     49.1
   947.4   -530.6    -42.0    -74.2     28.0
  1050.8   -291.1   -179.7   -101.8     -3.3
  1055.6   -106.6   -218.6   -108.5    -20.7
  1128.4    -27.1   -267.4   -102.0    -37.0
  1076.9    -27.5   -245.8   -128.5    -31.2
   998.9   -202.3   -188.8   -116.8     -9.4
   965.1   -446.8    -75.1    -95.1     23.5
   869.7   -670.1     64.2    -61.2     43.8
   720.6   -675.7    136.5    -62.9     49.4
   610.6   -619.7    153.9    -51.5     41.0
 873. 1162. 1580. 1951. 2143. 2343. 2175. 2017. 1778. 1382.  971.  750.
 117.  229.  374.  560.  649.  666.  665.  524.  416.  240.  157.  132.
CIRA 1.0 LOC=COLORADO SPRINGS,CO, LAT=38.8 , TWHT=22, ALT=6145
```

COLUSCTM.CTY

```
 .149  .151  .110  .070  .046  .047  .052  .046  .049  .065  .116  .143
 .137  .168  .156  .171  .139  .134  .128  .108  .135  .127  .151  .117
 .49072E-06  4.48867 35.0
 .41036E-06  4.56041 33.5
 .20441E-01  1.79919 14.5
 .76443E-07  5.74062 20.0
 48.2  49.9  60.0  70.8  77.5  84.0  85.9  84.5  78.4  70.3  58.3  51.2
 40.1  39.7  48.5  58.8  65.5  71.9  74.7  74.3  67.2  58.6  47.1  41.8
 40.3  39.7  47.7  55.3  64.0  69.0  72.2  73.0  65.8  58.5  47.6  42.0
   491.2   -360.1     75.2    -27.4     21.9
   656.8   -420.7     50.5    -49.4     35.3
   802.7   -374.8    -19.4    -36.7     14.3
   915.6   -230.4   -130.9    -53.6     -7.5
   936.1    -78.5   -180.0    -50.9    -22.4
   971.9      3.8   -194.4    -70.5    -27.7
   927.5    -37.7   -179.9    -58.6    -23.5
   876.9   -132.0   -149.5    -76.1    -10.4
   793.8   -297.0    -50.0    -49.2     13.9
   722.3   -411.6     29.0    -54.6     34.3
   607.1   -456.4     86.2    -48.1     38.3
   498.3   -414.1    100.1    -46.5     34.5
 689. 1026. 1366. 1721. 1856. 1965. 1875. 1730. 1438. 1185.  901.  699.
 293.  377.  549.  664.  766.  815.  771.  665.  584.  446.  304.  228.
CIRA 1.0 LOC=COLUMBIA,SC, LAT=34.0, TWHT=36, ALT=213
```

CONCORTM.CTY

```
 .220  .211  .193  .148  .099  .068  .048  .064  .091  .131  .174  .214
 .178  .145  .163  .158  .174  .124  .097  .12  .136  .154  .126  .155
 .59670E-05  4.06471 27.0
 .29802E-03  3.03286 22.0
 .29552E-07  5.24637 35.0
 .68424E-02  2.33558 14.0
 23.8  29.3  35.6  51.3  64.1  73.4  77.1  73.5  64.0  54.9  42.2  26.1
 18.1  18.8  27.7  39.1  50.2  58.6  64.2  60.5  53.5  43.6  34.2  20.5
 18.7  20.8  28.0  39.3  49.0  59.2  63.6  60.9  54.3  44.4  35.1  20.6
   370.5   -302.7     81.0    -16.9     13.0
   532.1   -356.9     62.9    -25.5     20.0
   632.4   -296.5       .1    -41.8     19.5
   760.3   -245.4    -58.9    -45.3      4.6
   930.8   -146.9   -141.6    -62.9    -12.5
   973.6    -66.7   -168.2    -75.5    -18.7
   907.3   -133.0   -137.6    -42.6    -13.4
   787.3   -213.1    -79.4    -54.9      2.4
   679.2   -300.0      -.4    -23.3     10.7
   563.9   -359.7     54.8    -30.4     19.3
   361.4   -270.4     69.8    -17.9     13.0
   281.0   -217.5     63.2    -13.3      9.5
 452.  714.  963. 1294. 1648. 1749. 1649. 1422. 1075.  816.  465.  336.
 221.  358.  478.  606.  756.  821.  777.  622.  568.  369.  243.  198.
CIRA 1.0 LOC=CONCORD,NH, LAT=43.2, TWHT=20, ALT=342
```

DAGGETTM.CTY

```
 .140  .115  .096  .078  .064  .072  .100  .085  .065  .066  .101  .141
 .167  .268  .274  .329  .337  .311  .271  .239  .263  .166  .202  .163
 .19950E-03  3.18150 21.5
 .42355E-02  2.39321 15.0
 .17572E-07  5.38771 35.0
 .22622E-02  2.61266 16.0
 54.6  59.8  63.4  68.6  80.9  87.5  96.3  92.5  87.6  74.1  63.5  52.9
 40.1  47.8  52.1  56.6  65.2  70.9  82.1  78.5  70.5  59.2  48.6  41.5
 39.4  40.2  44.3  45.6  52.4  56.5  63.3  61.3  57.6  51.3  44.1  39.1
   664.7   -592.7     138.0    -49.7      40.4
   806.2   -591.2      80.9    -65.5      49.0
   955.3   -499.4     -32.0    -65.8      29.4
  1112.3   -311.9    -209.3    -89.7      -7.0
  1200.0    -92.5    -312.9    -97.2     -41.4
  1241.5     15.8    -353.6    -87.6     -55.1
  1180.6    -49.9    -327.2    -75.9     -48.7
  1083.8   -242.5    -240.5    -79.8     -21.1
  1032.6   -453.0    -103.5    -85.3      20.5
   876.6   -607.1      48.3    -76.3      48.7
   714.2   -612.9     125.5    -57.0      45.9
   614.0   -569.4     142.5    -51.9      42.6
 964. 1305. 1745. 2266. 2615. 2747. 2638. 2368. 2017. 1518. 1072.  860.
 232.  331.  467.  539.  599.  606.  569.  486.  450.  307.  241.  204.
CIRA 1.0 LOC=DAGGETT,CA, LAT=34.9, TWHT=20, ALT=2003
```

DAYTONTM.CTY

```
 .102  .092  .058  .036  .019  .033  .042  .042  .037  .030  .051  .066
 .204  .191  .199  .205  .228  .155  .169  .154  .211  .198  .187  .169
 .62738E-07  4.97036 35.0
 .37013E-08  5.73786 35.0
 .68223E-12  8.05146 35.0
 .40570E-14 12.39407 15.5
 59.5  62.6  69.8  74.1  77.4  81.5  82.9  83.5  81.3  75.8  69.0  66.1
 51.3  53.5  58.9  64.5  70.9  73.4  75.9  75.2  75.3  67.8  60.5  59.0
 51.7  52.9  57.7  64.0  67.2  71.6  74.9  74.9  73.8  66.0  59.6  58.5
   619.6   -438.3      82.1    -27.2      25.0
   737.1   -413.8      29.8    -35.8      27.1
   915.3   -327.6     -65.0    -70.2      20.6
   989.5   -154.2    -159.5    -80.1      -9.4
   963.9    -17.4    -192.0    -57.4     -27.1
   925.8     59.0    -171.6    -62.4     -27.6
   905.8     37.9    -171.5    -66.4     -26.6
   868.7    -67.6    -159.7    -76.9     -16.9
   813.3   -203.4     -73.5    -78.5      15.3
   749.7   -373.7       6.3    -57.2      31.8
   649.1   -435.3      72.0    -50.5      39.3
   580.4   -431.4      93.0    -34.4      28.9
 939. 1196. 1605. 1890. 1931. 1789. 1755. 1673. 1462. 1280. 1038.  870.
 372.  500.  686.  813.  843.  896.  850.  741.  711.  508.  379.  332.
CIRA 1.0 LOC=DAYTONA,FL, LAT=29.2, TWHT=23, ALT=31
```

DODGECTM.CTY

```
 .203  .186  .164  .116  .066  .053  .050  .055  .066  .103  .157  .191
 .303  .275  .359  .256  .348  .291  .225  .346  .247  .325  .271  .306
 .18227E-02  2.40291 26.5
 .21794       .96401 11.5
 .51991E-02  2.23482 18.5
 .10863E-04  4.20739 18.5
 31.1  39.0  46.0  59.5  71.0  82.0  83.3  85.0  72.0  62.2  46.7  35.7
 24.3  29.1  33.0  47.2  59.3  68.8  70.6  70.6  59.8  51.3  38.4  28.6
 25.5  29.5  32.5  45.8  56.2  64.3  65.5  65.2  58.2  49.7  37.0  27.7
   636.6   -607.4    133.6     10.5      2.9
   754.0   -613.2     80.7      7.3     12.5
   858.8   -523.8      4.1     -2.9     11.5
   987.5   -378.9   -133.2      6.2     -9.2
  1003.6   -191.7   -190.9    -16.3    -17.5
  1067.5   -138.1   -255.2     11.6    -29.7
  1076.6   -150.6   -271.1     -2.0    -27.9
  1012.8   -339.7   -185.8      6.1    -17.0
   972.5   -526.9    -69.4     29.3    -10.9
   831.9   -651.2     58.2     11.5     12.9
   633.4   -558.1    110.2    -13.9     20.6
   567.2   -559.9    141.1     -8.7     12.1
 811. 1092. 1482. 1908. 2074. 2330. 2296. 2113. 1722. 1302.  871.  717.
 212.  293.  438.  572.  674.  611.  568.  509.  481.  295.  233.  178.
CIRA 1.0 LOC=DODGE CITY,KS, LAT=37.8, TWHT=20, ALT=2582
```

DULUTHTM.CTY

```
 .252  .237  .218  .179  .133  .091  .061  .068  .109  .148  .202  .235
 .243  .256  .238  .243  .284  .25  .202  .215  .247  .188  .231  .223
 .13370E-02  2.47901 23.0
 .25386E-01  1.86880 12.0
 .33590E-03  3.25184 16.5
 .10000E-30 20.00000 35.0
  8.8  17.5  25.5  40.3  54.4  64.3  70.3  68.3  59.2  48.8  30.1  16.5
  3.8  10.3  18.9  33.2  44.7  52.8  59.8  57.7  51.5  41.8  27.1  12.7
  4.8  12.3  20.1  32.3  43.6  51.9  59.4  57.8  51.5  40.1  26.7  13.2
   366.3   -314.2     91.8    -28.3     17.4
   519.5   -390.5     79.1    -41.1     28.1
   696.2   -369.8     24.2    -49.9     20.2
   807.0   -295.3    -44.9    -46.1      5.9
   913.8   -196.8   -122.7    -44.5    -11.6
   976.8   -135.9   -146.9    -61.0    -12.3
   993.9   -191.2   -154.1    -50.1    -19.2
   856.5   -274.4    -76.1    -52.7       .5
   673.8   -309.6     -1.6    -50.5     20.0
   532.1   -355.0     60.4    -32.3     21.0
   301.9   -220.1     60.3    -17.4     10.9
   276.0   -247.2     74.8    -26.4     17.7
 414.  667. 1008. 1320. 1556. 1765. 1830. 1508. 1048.  723.  366.  297.
 204.  286.  486.  621.  729.  803.  709.  619.  499.  342.  220.  145.
CIRA 1.0 LOC=DULUTH,MN, LAT=46.8, TWHT=21, ALT=1428
```

FAIRBATM.CTY

```
 .291  .274  .247  .198  .130  .082  .072  .103  .152  .212  .260  .282
 .068  .091  .119  .116  .136  .137  .155  .139  .115  .106  .075  .104
 .47886E-02  2.23121 16.0
 .47309E-01  1.69568 10.5
 .18046E-02  2.68589 14.5
 .10000E-30 20.00000 35.0
-13.5  -3.3  13.5  34.3  55.9  64.9  66.3  60.4  49.1  27.6   3.2  -9.6
-15.9  -6.8   2.6  25.2  43.9  54.8  57.1  52.9  41.3  21.5   1.3  -9.2
-15.5  -6.1   5.7  23.8  42.0  51.7  53.6  50.6  40.7  22.6   1.8 -10.4
    29.0    -22.3       8.8     -1.5        .1
   231.4   -195.9      64.8    -14.3       6.3
   631.4   -478.2      90.8    -32.8      17.9
   926.8   -463.4      -6.9    -40.4       6.7
  1132.8   -318.0     -87.4    -63.7      -2.8
  1159.8   -243.1    -108.3    -45.1      -4.9
  1073.8   -258.7     -90.5    -59.4      -4.0
   786.5   -325.8     -28.0    -12.9      -1.8
   576.3   -338.3      35.4    -10.6       5.9
   312.2   -261.8      69.8    -13.4       7.8
    82.8    -73.6      27.5     -4.6        .8
     2.1     -1.1        .5      -.1       -.0
  28.  220.  712. 1233. 1618. 1692. 1568. 1078.  689.  306.   74.    3.
  25.  156.  349.  616.  886.  948.  841.  619.  438.  187.   57.    2.
CIRA 1.0 LOC=FAIRBANKS,AK, LAT=64.8, TWHT=33, ALT=436
```

FORTWATM.CTY

```
 .218  .201  .182  .126  .087  .042  .042  .041  .063  .113  .160  .192
 .266  .209  .264  .262  .192  .199  .176  .17  .181  .221  .265  .243
 .24901E-06  4.67576 35.0
 .11588E-01  2.12431 14.0
 .18669E-02  2.74912 15.0
 .10686E-01  2.16625 12.5
 24.0  31.2  38.1  54.5  65.7  76.0  77.8  75.9  69.3  58.4  44.5  33.0
 19.5  25.8  31.8  45.7  54.7  64.9  67.4  64.8  58.7  49.3  38.2  30.5
 20.2  26.1  31.2  44.8  53.3  61.5  65.2  63.9  58.3  49.5  37.8  29.3
   387.7   -307.6      69.3     20.9      -9.5
   524.2   -356.1      48.6     30.7      -5.9
   648.2   -337.1        .1     40.7      -7.3
   826.0   -296.0     -59.9     18.9      -1.0
   918.7   -220.4    -140.5     33.2      -7.3
   988.9   -185.5    -159.9     42.2      -6.8
   926.1   -207.6    -145.9     40.0      -6.6
   882.8   -339.3    -101.2     59.9      -9.7
   752.4   -381.9     -16.6     37.6      -1.9
   628.7   -439.1      48.7     40.0      -8.0
   422.3   -316.4      65.6     19.9      -6.3
   297.1   -223.8      55.4     14.1      -7.6
 464.  690.  950. 1382. 1658. 1848. 1745. 1607. 1201.  899.  527.  351.
 254.  383.  551.  741.  798.  900.  805.  678.  590.  401.  294.  223.
CIRA 1.0 LOC=FORT WAYNE,IN, LAT=41.0, TWHT=20, ALT=791
```

FRESNOTM.CTY

```
 .159  .134  .108  .092  .069  .068  .073  .065  .067  .075  .124  .161
 .098  .116  .128  .14  .165  .145  .118  .112  .125  .098  .082  .109
 .12818E-03  3.46934 18.0
 .13274E-01  2.05222 13.0
 .17399E-06  4.77204 34.0
 .39453E-06  4.85038 26.5
 47.2  54.6  61.9  66.4  75.8  84.5  90.3  87.3  81.9  72.0  57.4  46.0
 39.5  44.4  48.9  52.2  60.4  67.7  72.9  70.3  63.9  55.4  46.2  39.2
 40.5  45.4  49.4  50.5  54.2  58.3  62.4  63.3  58.6  52.9  48.0  40.2
   513.3   -392.5     86.7     12.6     -2.3
   690.7   -492.5     66.6     10.4      9.3
   933.8   -524.0    -35.6      4.6     10.2
  1114.7   -419.0   -175.7     20.4    -12.0
  1193.1   -217.5   -281.3     -1.6    -31.4
  1231.1   -119.0   -329.8      8.3    -36.5
  1234.5   -176.5   -336.4     26.4    -34.7
  1148.4   -369.5   -244.8     13.6    -22.1
  1072.4   -576.2    -84.9    -10.8      7.2
   877.7   -684.1     68.4      -.7     20.8
   656.5   -560.1    113.7      4.2      8.2
   448.5   -354.7     83.9      6.6       .3
 669. 1033. 1589. 2116. 2501. 2719. 2703. 2397. 2023. 1453.  910.  571.
 335.  403.  505.  634.  675.  624.  575.  526.  446.  303.  292.  283.
CIRA 1.0 LOC=FRESNO,CA, LAT=36.8, TWHT=42, ALT=328
```

GOODLATM.CTY

```
 .202  .189  .175  .133  .103  .065  .057  .054  .080  .120  .176  .204
 .221  .241  .307  .317  .283  .259  .21  .254  .254  .25  .252  .271
 .17432E-04  3.62966 31.5
 .85047E-04  3.44434 20.5
 .10742E-06  4.90730 35.0
 .19579E-02  2.66125 14.5
 32.0  39.1  43.6  55.9  62.8  76.2  82.3  82.4  70.0  58.8  42.1  31.5
 23.7  26.2  30.4  41.1  49.7  62.4  67.1  67.2  56.3  45.5  32.1  24.2
 24.5  27.3  31.4  37.7  48.3  59.4  62.3  62.7  54.0  45.1  32.0  25.2
   620.8   -617.8    150.8    -38.3     30.4
   744.1   -565.1     77.3    -54.8     39.8
   844.3   -460.2    -22.0    -69.7     28.8
  1027.1   -312.1   -143.7    -84.7       .6
  1047.1   -165.1   -211.7    -57.0    -25.1
  1086.9   -125.6   -242.6    -37.5    -32.9
  1070.6   -143.4   -233.2    -71.2    -27.2
  1024.6   -306.4   -174.6    -59.7    -13.9
   923.4   -485.3    -44.1    -34.6     10.7
   818.0   -602.2     64.8    -52.3     35.6
   616.0   -542.6    113.8    -45.4     35.6
   567.9   -578.1    148.4    -38.0     31.6
 796. 1044. 1399. 1910. 2086. 2341. 2347. 2125. 1640. 1275.  813.  689.
 147.  304.  398.  607.  657.  641.  590.  500.  446.  303.  213.  140.
CIRA 1.0 LOC=GOODLAND,KS, LAT=39.4, TWHT=25, ALT=3654
```

GRANDJTM.CTY

```
 .214  .193  .167  .125  .074  .051  .059  .049  .066  .117  .168  .199
 .12  .111  .153  .253  .24  .209  .197  .222  .183  .153  .14  .106
 .26839E-06  4.64798 35.0
 .14402E-02  2.69877 16.5
 .63843E-04  3.55290 21.0
 .18836E-13  9.11861 35.0
 27.3  36.3  44.6  56.1  69.7  79.2  87.3  83.5  73.1  57.8  45.6  32.4
 20.6  27.8  35.2  45.0  57.0  65.4  72.2  69.8  58.9  47.2  34.1  25.9
 21.6  27.5  32.4  37.3  45.6  51.7  57.3  57.6  50.2  41.1  31.7  26.3
   601.3   -552.4    130.7    -57.4     42.4
   749.1   -561.5     89.6    -68.9     41.0
   916.5   -473.2    -16.2    -80.6     28.2
  1042.6   -316.6   -153.5    -79.6     -3.8
  1185.1   -117.4   -268.9   -118.7    -33.4
  1227.9    -33.2   -300.5   -116.4    -45.4
  1160.6   -118.2   -271.4    -90.2    -37.9
  1060.1   -265.9   -185.6   -103.9     -9.9
   993.4   -478.0    -65.8    -87.1     21.5
   824.6   -596.2     63.1    -68.3     45.9
   679.0   -600.2    123.4    -56.8     43.1
   587.2   -579.4    150.6    -63.7     45.6
 776. 1102. 1519. 1954. 2389. 2581. 2506. 2197. 1816. 1324.  918.  726.
 194.  309.  491.  589.  647.  665.  601.  520.  435.  303.  215.  151.
CIRA 1.0 LOC=GRAND JUNCTION,CO, LAT=39.1, TWHT=22, ALT=4843
```

GRANDRTM.CTY

```
 .213  .214  .187  .139  .090  .053  .046  .047  .083  .117  .168  .208
 .228  .261  .253  .281  .19  .208  .186  .145  .194  .192  .207  .223
 .11551E-01  1.96728 19.5
 .57719E-02  2.18589 17.5
 .10867E-01  2.05447 15.0
 .39011E-01  1.74294 11.5
 25.8  25.5  36.6  51.3  64.7  73.2  78.2  74.2  66.0  56.8  42.0  28.1
 22.7  21.7  31.0  42.6  53.8  62.0  65.5  62.6  55.8  49.2  37.9  24.8
 22.8  21.2  31.2  41.5  52.4  60.3  62.9  62.0  56.4  48.2  36.2  24.2
   301.1   -227.4     58.5    -11.2      8.6
   537.3   -360.2     55.6    -40.4     28.1
   656.4   -293.5     -7.1    -36.9     15.9
   874.9   -274.3    -92.2    -46.6     -1.5
   935.0   -181.7   -137.7    -43.9    -13.6
  1034.6   -107.7   -187.4    -63.5    -22.5
  1019.3   -140.2   -182.2    -67.9    -17.4
   901.6   -263.0   -109.6    -56.7     -1.2
   752.9   -334.4    -12.3    -50.6     18.1
   596.0   -383.2     55.9    -36.7     22.1
   362.3   -268.0     69.1    -23.6     15.9
   258.2   -189.9     54.7    -15.5     11.4
 364.  723.  967. 1466. 1741. 1966. 1970. 1680. 1238.  877.  465.  313.
 207.  329.  524.  654.  725.  794.  738.  616.  546.  370.  243.  195.
CIRA 1.0 LOC=GRAND RAPIDS,MI, LAT=42.9, TWHT=20, ALT=784
```

GREENSTM.CTY

```
 .174  .171  .141  .090  .056  .039  .037  .035  .047  .091  .126  .165
 .186  .187  .199  .191  .154  .15  .139  .139  .125  .127  .152  .155
 .67399E-02  2.11941 19.5
 .13025      1.22564 11.0
 .11057E-01  2.11962 13.5
 .54837E-06  5.05454 19.5
 42.2  43.5  51.9  65.6  71.8  79.5  81.2  80.4  75.1  64.8  55.4  44.3
 33.3  35.4  41.6  53.8  60.9  68.2  70.6  69.8  63.8  52.5  44.5  36.5
 33.1  34.2  40.7  49.7  60.1  66.1  70.1  69.4  62.8  52.4  45.2  36.7
   547.6   -437.8     95.2    -51.6     39.4
   636.0   -394.4     52.1    -39.9     27.7
   798.7   -389.5     -7.1    -43.8     18.3
   932.8   -268.8   -115.9    -55.7     -5.2
   915.7   -106.2   -163.2    -41.2    -20.7
   991.8    -47.6   -200.2    -49.8    -26.0
   940.8    -63.3   -174.8    -54.9    -23.7
   854.0   -197.0   -122.3    -42.4    -11.3
   766.1   -303.6    -39.6    -42.8     11.1
   735.2   -463.4     42.5    -53.5     36.2
   596.5   -452.3     88.8    -50.4     38.2
   493.4   -410.8    100.2    -46.6     34.8
 750.  952. 1349. 1774. 1780. 2007. 1844. 1691. 1373. 1192.  848.  659.
 261.  414.  533.  641.  753.  798.  789.  632.  553.  395.  302.  233.
CIRA 1.0 LOC=GREENSBORO,NC, LAT=36.1, TWHT=20, ALT=897
```

GREENVTM.CTY

```
 .163  .159  .126  .080  .062  .041  .027  .038  .036  .088  .120  .157
 .205  .154  .154  .168  .158  .14  .121  .103  .129  .169  .143  .162
 .56030E-06  4.60950 30.5
 .96555E-02  2.21894 12.5
 .16799E-01  2.08663 11.0
 .15950E-13  9.03130 35.0
 44.9  46.5  55.7  66.0  71.4  80.1  80.4  82.0  76.7  65.3  57.8  46.8
 37.0  37.1  45.7  54.9  59.6  68.6  71.4  71.1  66.4  54.5  46.2  39.4
 36.2  37.0  43.4  52.3  57.0  66.5  70.6  69.4  64.1  52.2  45.4  38.9
   555.3   -436.7     92.1    -37.6     29.7
   622.6   -414.8     56.0    -32.7     24.9
   798.2   -351.4    -27.2    -55.2     21.0
   908.5   -217.6   -126.1    -58.3     -8.0
   950.4    -82.0   -173.4    -63.3    -21.6
   991.0    -30.9   -195.7    -51.6    -26.2
   903.0    -60.5   -159.7    -42.4    -20.5
   897.7   -185.0   -134.4    -53.5     -8.1
   808.9   -303.8    -54.1    -47.7     10.7
   715.6   -451.8     46.9    -46.5     29.2
   613.1   -484.9     95.7    -49.5     37.1
   460.0   -376.2     88.8    -32.2     25.2
 767.  958. 1345. 1694. 1864. 2015. 1775. 1774. 1472. 1191.  910.  621.
 280.  356.  551.  675.  777.  826.  804.  684.  581.  387.  268.  230.
CIRA 1.0 LOC=GREENVILLE,SC, LAT=34.9, TWHT=23, ALT=957
```

GUANTATM.CTY

```
.022  .020  .035  .047  .055  .062  .069  .067  .063  .051  .040  .029
.151  .146  .153  .199  .155  .136  .148  .153  .192  .134  .122  .18
.10000E-30 20.00000 35.0
.10000E-30 20.00000 35.0
.22261E-03  3.72127 12.5
.23163E-05  4.92302 15.0
75.8  76.5  77.7  80.0  81.0  82.3  83.6  83.8  82.1  80.7  78.4  76.2
75.0  75.3  77.4  79.6  81.7  81.1  82.3  82.1  82.6  80.8  79.3  77.1
69.5  70.1  70.9  71.8  74.5  75.8  76.5  76.5  75.8  75.1  73.3  70.1
  717.3  -330.8    -68.5    -44.9     36.9
  805.3  -280.0   -131.8    -43.3     13.3
  927.5  -185.1   -213.5    -16.6    -25.0
 1165.3   -13.7   -328.8    -11.9    -60.7
 1048.2   144.1   -254.0    -22.2    -38.3
 1112.8   235.7   -249.5    -18.5    -27.7
 1099.5   202.4   -260.9    -14.9    -32.8
 1096.4    64.7   -312.0     -8.0    -54.2
  978.7  -103.5   -253.0    -26.4    -40.3
  749.9  -210.4   -134.1    -53.1     10.6
  712.3  -320.1    -76.2    -46.3     39.0
  696.2  -353.4    -52.7    -48.6     46.9
 913. 1084. 1319. 1650. 1519. 1615. 1580. 1568. 1358. 1074.  966.  884.
 486.  567.  768.  986.  929.  949.  937.  903.  846.  565.  471.  445.
CIRA 1.0 LOC=GUANTANAMO BAY, CUBA, LAT=19.9, TWHT=20, ALT=21
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GULKANTM.CTY

```
.272  .262  .227  .193  .157  .114  .092  .121  .156  .207  .251  .273
.076  .109  .132  .123  .169  .138  .213  .159  .125  .148  .081  .061
.27079E-08  6.18433 29.0
.31590E-02  2.50980 13.5
.83001E-10  6.82330 35.0
.10000E-30 20.00000 35.0
-1.8   5.4  24.2  37.6  49.6  59.3  63.7  57.8  48.9  29.5   9.0  -3.6
-6.3  -2.2  12.0  24.8  37.6  47.9  53.4  47.4  38.7  22.9   5.1  -4.8
-4.7    .7  16.1  27.4  36.9  46.3  50.7  46.9  40.1  23.0   5.8  -5.0
   76.6   -64.6     25.2     -3.8       .0
  307.0  -270.0     83.6    -21.9     11.9
  628.4  -463.8     87.6    -25.0     14.6
  936.4  -445.3    -12.5    -60.0     14.2
 1078.9  -322.2    -82.1    -71.5     -2.6
 1081.4  -215.5   -101.3    -73.9     -5.2
 1058.3  -274.6    -91.3    -56.9     -3.5
  853.1  -360.9    -30.7    -51.6      7.4
  611.3  -372.1     45.2    -27.4     12.5
  385.0  -328.2     87.9    -17.8      9.8
  115.8   -97.2     36.5     -5.6       .4
   23.8   -15.9      6.5     -1.0      -.1
  72.  303.  742. 1299. 1605. 1651. 1617. 1233.  778.  399.  111.   25.
  58.  178.  371.  624.  797.  857.  820.  587.  420.  215.   86.   24.
CIRA 1.0 LOC=GULKANA,AK, LAT=62.1, TWHT=30, ALT=1572
```

HELENATM.CTY

```
 .223  .202  .192  .164  .113  .087  .059  .071  .110  .142  .183  .215
 .164  .188  .205  .195  .185  .188  .174  .167  .159  .184  .153  .183
 .29645E-01  1.67887 18.5
 .41284E-07  5.16937 35.0
 .53934E-02  2.19876 20.5
 .44955E-05  3.81800 35.0
 20.6  30.4  33.8  43.0  57.4  63.6  75.0  71.2  58.9  49.7  37.1  23.4
 17.4  25.3  29.9  38.6  50.5  57.2  66.3  62.0  49.7  43.8  33.1  21.5
 16.4  23.5  26.1  34.4  44.6  50.1  53.2  52.0  44.7  38.1  29.9  19.2
   189.1   -150.8     18.9       .1      4.4
   355.8   -199.9     -4.3     -9.7      8.8
   593.8   -225.6    -72.4    -23.9      6.8
   775.1   -139.8   -147.7    -37.4     -6.6
  1113.5     -4.5   -248.1    -71.4    -20.0
  1150.4     78.3   -245.4    -77.7    -17.6
  1345.0    141.6   -338.5   -137.4    -20.6
  1120.9    -61.2   -289.9    -97.7    -18.8
   813.4   -265.4   -150.5    -40.5     -3.3
   532.0   -277.6    -37.0    -18.8      9.7
   252.1   -198.9     26.5      -.4      2.2
   160.0   -130.9     26.8     -1.7      1.6
 178.  393.  721. 1052. 1523. 1596. 1852. 1509. 1033.  601.  254.  158.
  97.  248.  452.  650.  936.  982. 1012.  806.  520.  329.  125.   89.
CIRA 1.0 LOC=HELENA,MT, LAT=46.6, TWHT=20, ALT=3893
```

HILO--TM.CTY

```
 .020  .027  .015  .010  .018  .018  .018  .017  .019  .021  .012  .019
 .13  .159  .154  .128  .149  .16  .111  .117  .111  .146  .145  .153
 .27061E-03  3.77736 10.0
 .10000E-30 20.00000 35.0
 .34424E-04  4.43689 11.0
 .72264E-03  3.38878 11.0
 70.2  68.7  70.7  70.3  71.8  73.0  73.1  73.6  73.1  73.4  72.0  69.2
 72.0  70.4  72.2  72.7  73.9  74.8  76.0  76.4  76.5  75.6  73.8  72.6
 64.7  63.9  65.9  66.7  67.6  68.8  69.8  71.2  70.1  69.8  68.4  66.2
   241.5   -105.4     -7.7    -15.9      6.7
   300.7   -111.3    -29.0    -13.8       .7
   377.0    -45.0    -68.6    -37.2     -3.3
   461.0     38.6    -96.2    -54.2    -12.0
   520.4    101.9   -109.0    -50.1    -19.3
   561.6    137.6   -109.2    -42.5    -15.9
   554.2    129.7   -121.2    -43.4    -19.7
   474.4     52.6   -119.8    -37.8    -20.2
   415.5    -26.6    -94.1    -35.2    -10.8
   281.1    -84.8    -35.8    -17.2       .8
   243.2   -108.1     -9.6    -16.5      6.2
   226.0    -92.8     -4.8    -22.6     10.0
 351.  457.  597.  707.  813.  896.  898.  786.  671.  456.  367.  329.
 187.  225.  347.  478.  511.  527.  493.  415.  363.  218.  175.  184.
CIRA 1.0 LOC=HILO,HI, LAT=19.7, TWHT=57, ALT=27
```

HOMER-TM.CTY

```
 .223  .214  .207  .181  .159  .135  .119  .123  .146  .181  .203  .222
 .127  .14  .139  .127  .114  .164  .102  .102  .126  .112  .148  .134
 .41244E-20 13.26574 35.0
 .21437E-06  5.54834 18.0
 .10000E-30 20.00000 35.0
 .10000E-30 20.00000 35.0
 21.2  25.8  29.7  39.9  47.2  53.5  57.6  56.6  49.7  38.3  28.6  20.9
 19.1  22.0  23.1  32.7  39.6  47.0  50.0  49.7  44.5  34.0  27.2  19.4
 18.4  22.0  24.3  33.4  40.5  45.8  50.1  50.3  43.6  33.5  25.9  18.5
   131.8   -117.1     44.9     -8.1      1.3
   314.8   -265.8     80.4    -21.8     12.4
   610.6   -420.9     75.6    -40.6     23.9
   900.4   -425.9     -9.8    -65.6     16.5
  1047.8   -306.7    -86.6    -70.6      1.2
  1158.4   -275.2   -111.2    -42.1    -10.9
  1047.4   -288.1   -100.5    -46.1     -9.5
   772.5   -307.2    -20.8    -38.3      5.8
   593.0   -326.8     35.2    -37.1     17.0
   409.1   -318.5     79.7    -28.0     17.3
   189.6   -171.2     60.0    -11.5      4.0
    72.6    -62.7     24.9     -4.2       .2
 122.  330.  756. 1303. 1629. 1827. 1664. 1144.  774.  453.  178.   67.
  90.  193.  383.  601.  787.  920.  769.  614.  448.  254.  118.   54.
CIRA 1.0 LOC=HOMER,AK, LAT=59.6, TWHT=67, ALT=63
```

HURON-TM.CTY

```
 .240  .229  .207  .148  .099  .059  .052  .056  .091  .136  .191  .230
 .278  .24  .297  .272  .237  .244  .215  .256  .272  .255  .288  .229
 .34025E-05  3.98214 35.0
 .35128E-01  1.59204 19.0
 .53101E-01  1.55128 16.5
 .10530E-02  2.65512 22.0
 13.3  19.0  28.2  48.8  60.1  68.3  78.0  76.3  63.7  50.9  34.0  16.9
  9.7  14.4  23.8  42.6  54.5  64.2  71.7  69.6  57.7  45.9  30.5  15.4
 10.2  15.6  24.1  39.9  50.5  60.0  64.6  64.5  52.7  42.4  29.7  14.3
   227.1   -191.4     23.9      6.1      1.7
   401.3   -224.7    -13.6    -17.3     12.6
   604.9   -216.1    -87.8    -33.5      6.6
   744.5   -125.5   -149.3    -38.9     -6.4
  1069.9     23.4   -245.8    -88.3    -17.2
  1163.9    132.7   -268.5   -105.7    -15.0
  1242.9    122.2   -320.8   -116.6    -19.8
  1080.8    -44.7   -281.5    -89.0    -21.2
   744.9   -213.3   -137.7    -44.2      1.2
   530.9   -267.0    -43.9    -24.4     10.9
   256.6   -196.0     27.2      1.3      1.0
   167.5   -128.9     21.4     -3.7      3.7
 218.  444.  750. 1003. 1496. 1631. 1738. 1457.  967.  619.  273.  170.
 101.  253.  432.  632.  907.  984.  961.  813.  535.  320.  140.   96.
CIRA 1.0 LOC=HURON,SD, LAT=44.4, TWHT=20, ALT=1281
```

JACKFLTM.CTY

```
 .119  .107  .070  .040  .034  .040  .047  .047  .029  .040  .080  .108
 .198  .217  .206  .206  .173  .198  .184  .161  .197  .205  .198  .143
 .43232E-01  1.62920 15.5
 .18727E-06  4.68795 35.0
 .63834E-02  2.31986 12.5
 .22299E-03  3.44157 12.5
 56.3  59.6  67.9  75.8  80.4  82.5  84.2  84.6  80.7  73.5  64.5  59.2
 47.5  49.7  57.5  64.9  70.7  74.1  75.7  76.3  74.1  64.2  56.7  49.6
 47.7  49.1  55.9  62.2  67.1  71.4  74.2  74.5  73.0  63.3  56.7  51.0
   594.4   -419.0     80.5    -22.4     22.0
   719.5   -425.1     38.8    -29.2     24.0
   884.6   -350.0    -49.3    -44.6     14.0
   988.5   -184.8   -154.7    -73.2     -8.0
   983.5    -26.4   -201.0    -69.3    -27.4
   964.2     46.5   -189.8    -61.7    -31.2
   938.9     19.5   -183.2    -62.8    -26.8
   875.7    -78.6   -153.8    -92.0    -10.3
   790.6   -220.6    -57.9    -53.1     10.0
   724.3   -376.9     17.2    -53.4     30.9
   606.1   -407.4     73.1    -39.3     31.3
   548.6   -397.9     89.8    -30.6     24.8
 874. 1142. 1550. 1895. 1979. 1880. 1805. 1726. 1399. 1220.  947.  801.
 374.  475.  657.  776.  820.  887.  870.  729.  717.  489.  376.  343.
CIRA 1.0 LOC=JACKSONVILLE,FL, LAT=30.5, TWHT=21, ALT=26
```

KNOXVITM.CTY

```
 .174  .169  .138  .084  .055  .038  .035  .036  .039  .089  .141  .163
 .151  .139  .167  .145  .143  .106  .108  .094  .102  .116  .139  .141
 .14431E-02  2.60602 21.5
 .40751E-02  2.17240 19.0
 .19176E-09  6.91216 30.0
 .18258E-13  9.03349 35.0
 40.1  43.3  51.8  64.8  73.1  78.8  81.8  81.3  76.7  64.1  50.2  44.5
 34.3  35.6  44.4  54.6  62.9  69.0  71.2  71.3  67.3  53.1  42.7  38.1
 33.3  34.6  41.7  52.0  61.0  67.1  70.4  69.4  66.0  52.7  41.7  37.0
   473.1   -350.6     74.9    -26.4     20.7
   588.7   -345.4     45.9    -33.6     23.7
   737.1   -319.5    -15.8    -30.4     13.4
   872.8   -239.3   -101.9    -24.6     -7.0
   927.4    -93.6   -166.7    -50.9    -19.8
   976.0    -27.1   -184.0    -55.7    -24.8
   941.4    -78.7   -165.6    -43.1    -19.6
   862.6   -176.9   -126.2    -60.9     -3.6
   776.5   -292.8    -43.2    -40.9      8.6
   709.2   -417.7     41.9    -71.7     39.7
   516.2   -387.0     77.2    -21.7     16.7
   429.5   -316.7     74.4    -28.3     21.9
 638.  876. 1197. 1578. 1817. 1889. 1856. 1696. 1377. 1156.  729.  567.
 284.  426.  583.  716.  764.  856.  822.  660.  589.  413.  285.  276.
CIRA 1.0 LOC=KNOXVILLE,TN, LAT=35.8, TWHT=53, ALT=980
```

KODIAKTM.CTY

```
.191  .195  .194  .177  .161  .140  .114  .118  .138  .169  .189  .198
.159  .229  .156  .171  .178  .122  .102  .166  .155  .196  .207  .219
.58522E-02  2.34165 10.5
.21832E-01  1.55550 11.0
.10000E-30 20.00000 35.0
.10000E-30 20.00000 35.0
33.4  32.2  33.2  39.9  45.1  51.2  57.2  55.9  51.4  42.6  34.6  30.2
32.1  30.1  29.9  35.7  40.6  46.6  52.2  52.1  47.8  38.3  32.8  29.3
31.0  28.7  28.7  34.3  40.7  45.3  51.5  50.5  45.5  36.3  30.9  26.6
   164.6   -150.3     56.6    -12.0      3.4
   298.9   -224.8     65.0    -22.0     13.5
   618.9   -415.4     71.9    -41.6     25.4
   861.0   -402.4     -7.5    -43.5     10.4
   883.7   -255.1    -63.5    -23.5     -7.0
  1066.7   -239.6   -106.1    -31.0    -12.7
   922.6   -223.4    -76.8    -35.7     -8.5
   807.8   -296.6    -40.4    -40.0       .2
   578.5   -289.0     26.6    -37.4     16.2
   431.5   -339.4     84.9    -28.2     17.9
   229.2   -215.4     72.7    -13.6      5.3
   100.1    -85.4     33.2     -6.3      1.1
 155.  331.  802. 1268. 1353. 1685. 1426. 1206.  761.  487.  214.   95.
 104.  216.  397.  619.  773.  897.  816.  635.  481.  262.  126.   74.
CIRA 1.0 LOC=KODIAK,AK, LAT=57.8, TWHT=60, ALT=14
```

LAKECHTM.CTY

```
.121  .105  .074  .039  .031  .046  .056  .049  .040  .048  .077  .123
.185  .197  .195  .245  .182  .181  .151  .122  .155  .159  .183  .194
.60807E-06  4.50103 32.5
.30688E-07  5.16380 35.0
.14054E-10  7.23795 35.0
.49026E-05  4.69641 14.5
55.2  59.5  65.0  72.4  79.3  83.7  85.5  84.4  81.8  73.0  66.1  55.3
47.8  50.3  57.0  63.5  69.5  75.5  77.4  76.6  72.6  62.2  57.4  48.1
47.9  51.2  56.2  62.2  68.2  72.9  76.2  74.8  71.5  63.2  56.6  48.5
   512.0   -357.4     62.1      6.1      6.3
   662.5   -384.8     35.9     -2.2     11.2
   750.7   -302.3    -48.0     -5.3      4.5
   850.3   -203.6   -114.2     -5.5     -7.2
   940.5    -87.2   -177.8     -2.2    -19.9
   975.2    -10.4   -212.7     -1.4    -24.4
   853.5    -27.9   -177.8    -20.1    -21.1
   822.8   -127.8   -139.3    -23.3     -9.5
   809.9   -275.7    -76.7    -12.7      4.9
   745.0   -422.3     13.5      7.2     10.0
   592.3   -413.8     61.0     -5.1     14.2
   539.8   -421.1     74.0     20.9     -1.7
 730. 1045. 1296. 1589. 1870. 2012. 1773. 1568. 1468. 1246.  885.  736.
 347.  484.  591.  748.  841.  831.  734.  730.  659.  508.  356.  307.
CIRA 1.0 LOC=LAKE CHARLES,LA, LAT=30.2, TWHT=22, ALT=9
```

LAKEHUTM.CTY

```
 .199  .190  .167  .134  .091  .053  .043  .044  .061  .099  .143  .179
 .14  .23 .188  .157  .17  .16  .093  .121  .098  .116  .148  .138
 .21182E-01  1.88680 16.5
 .45950E-06  4.76873 27.5
 .10918E-08  6.15696 35.0
 .44190E-13  8.99199 35.0
 32.4  36.3  43.9  53.8  65.2  76.2  80.0  78.2  70.9  61.6  50.1  38.5
 26.4  29.4  36.3  44.4  53.7  64.8  68.4  66.7  60.1  51.6  43.0  34.1
 27.1  30.1  35.7  43.4  52.3  64.0  66.7  65.4  60.0  52.5  42.7  33.3
   453.5   -361.2     90.2    -25.5     19.2
   574.7   -366.5     60.3    -34.7     23.2
   722.9   -322.5     -4.9    -42.8     16.4
   833.1   -249.9    -77.7    -46.4      3.6
   960.7   -133.1   -154.1    -62.3    -12.5
   968.1    -63.2   -159.4    -60.6    -19.5
   941.6   -109.5   -154.3    -47.1    -14.8
   882.8   -205.3   -115.9    -54.3     -3.8
   751.5   -332.5    -11.0    -35.7     13.9
   633.5   -398.0     57.2    -38.4     26.5
   489.7   -354.4     84.8    -39.1     28.0
   353.3   -267.0     73.3    -23.3     17.3
 585.  808. 1135. 1456. 1775. 1776. 1751. 1592. 1261.  962.  661.  445.
 262.  392.  564.  669.  797.  881.  830.  710.  569.  410.  317.  243.
CIRA 1.0 LOC=LAKEHURST,NJ, LAT=40.0, TWHT=20
```

LIHUE-TM.CTY

```
 .023  .013  .007  .004  .013  .019  .026  .028  .032  .024  .012  .008
 .191  .241  .306  .307  .221  .282  .305  .278  .24  .24  .243  .224
 .10000E-30 20.00000 35.0
 .28304E-17 11.37411 35.0
 .13680E-21 14.81301 30.0
 .44382E-16 10.47072 35.0
 73.7  73.3  73.8  75.1  77.0  78.5  79.8  80.2  80.1  78.9  77.1  74.5
 66.8  68.8  70.3  71.6  72.5  74.7  75.8  76.0  76.7  75.4  72.8  70.4
 65.5  64.2  65.8  67.5  69.2  70.6  71.1  71.2  71.7  71.3  68.9  68.1
   647.2   -339.9     42.2   -105.9     64.8
   727.6   -290.1      -.5    -92.2     44.0
   856.0   -162.8    -93.4    -88.6     13.3
   900.2    -15.6   -138.1    -96.4    -12.1
   964.5    151.8   -194.2   -117.5    -37.6
   928.2    184.0   -177.2    -89.4    -35.3
   938.2    196.6   -193.3   -121.6    -40.3
   901.4     71.9   -205.4   -129.2    -31.8
   916.9   -109.2   -155.4   -126.3       .4
   922.1   -323.9    -88.6    -69.0     28.7
   754.9   -364.3      6.1    -82.0     52.1
   632.1   -358.5     55.1    -86.0     54.9
1109. 1269. 1467. 1597. 1850. 1844. 1832. 1807. 1745. 1500. 1178. 1026.
 439.  582.  826.  946.  897.  862.  842.  735.  744.  708.  553.  433.
CIRA 1.0 LOC=LIHUE,HI, LAT=22.0, TWHT=20, ALT=103
```

LITTLEIM.CTY

```
 .164  .153  .119  .065  .052  .047  .054  .051  .044  .069  .126  .156
 .184  .194  .22  .212  .153  .168  .157  .177  .132  .173  .156  .196
 .38077E-02  2.21125 22.5
 .14319E-05  4.09895 35.0
 .21883E-03  3.22156 19.0
 .71291E-14  9.37597 35.0
 44.2  48.0  56.7  69.1  77.4  83.7  84.8  85.5  79.6  67.9  55.5  46.3
 36.6  40.0  47.9  58.2  65.0  72.6  74.3  75.3  67.7  58.7  45.1  40.0
 37.0  40.1  44.5  57.7  63.7  70.4  71.4  71.8  67.6  57.4  45.7  39.1
   545.5   -435.2     95.2    -34.0     26.8
   644.6   -411.6     52.5    -30.4     19.4
   754.6   -338.9    -11.9    -42.9     19.3
   886.2   -242.7   -100.0    -36.6     -3.2
   968.4   -105.6   -187.1    -52.8    -20.5
   993.6    -36.4   -224.9    -36.0    -33.6
   977.0    -43.1   -212.0    -58.3    -29.9
   908.1   -179.1   -159.6    -54.6    -14.2
   833.2   -331.4    -58.8    -49.7     14.7
   746.9   -477.9     42.6    -43.5     31.5
   590.0   -450.2     80.6    -26.0     23.0
   513.2   -439.8    102.3    -26.6     22.3
 764.  990. 1274. 1616. 1961. 2041. 1988. 1798. 1514. 1242.  847.  695.
 271.  390.  558.  720.  739.  740.  736.  639.  558.  389.  295.  227.
CIRA 1.0 LOC=LITTLE ROCK,AR, LAT=34.8, TWHT=20, ALT=257
```

LONGBEIM.CTY

```
 .118  .112  .096  .087  .078  .054  .036  .031  .042  .065  .083  .114
 .122  .14  .152  .148  .173  .144  .146  .145  .149  .121  .138  .144
 .86346E-10  6.77124 35.0
 .12831E-02  2.87038 10.5
 .33271E-01  1.80435 10.5
 .40462E-26 17.04849 35.0
 58.3  60.4  62.2  64.9  65.2  71.2  75.2  75.7  74.7  70.5  65.5  58.6
 48.7  50.4  53.7  55.6  58.6  61.5  65.5  67.0  64.8  59.5  55.5  50.3
 47.1  48.4  50.1  52.6  55.5  60.3  62.1  64.8  61.0  56.9  53.3  46.2
   632.7   -518.3    112.5    -41.7     33.4
   769.6   -536.9     68.5    -41.9     31.2
   835.9   -424.3    -20.0    -26.2     14.7
   997.4   -264.5   -156.5    -55.6     -6.4
   954.7   -152.7   -180.0      5.7    -22.7
   955.4   -117.6   -206.3     35.2    -26.0
  1016.6   -104.4   -244.9    -16.0    -33.0
   944.3   -282.7   -162.9      1.5    -14.9
   904.5   -405.5    -60.3    -15.8      4.0
   798.4   -532.2     50.6    -16.3     20.0
   686.4   -564.5    113.2    -33.5     28.9
   607.3   -536.2    128.9    -41.7     33.6
 912. 1243. 1488. 1975. 1956. 2114. 2315. 2112. 1715. 1340. 1041.  860.
 283.  369.  509.  653.  761.  718.  625.  539.  554.  414.  281.  235.
CIRA 1.0 LOC=LONG BEACH,CA, LAT=33.8, TWHT=20, ALT=25
```

LOSANGTM.CTY

```
.108  .111  .110  .090  .069  .058  .033  .031  .037  .062  .088  .107
.158  .138  .179  .188  .177  .174  .184  .135  .152  .142  .154  .113
.15798E-01  2.11240 10.5
.94048E-02  2.10457 10.0
.10698E-01  2.33469 10.0
.76613E-02  2.09498 11.0
55.7  55.6  55.9  59.5  62.7  63.9  67.9  69.8  67.2  63.5  58.3  55.3
56.5  55.6  55.7  59.1  62.4  64.2  67.3  68.3  68.0  63.5  60.6  56.8
50.3  50.8  50.7  52.6  57.4  60.0  62.2  63.5  62.2  57.7  52.4  47.7
   330.0   -218.4      8.1    -17.7     21.4
   510.4   -234.3    -54.6    -33.4     26.4
   629.5   -193.3   -102.8    -22.7      2.9
   856.2   -114.0   -211.0     -4.8    -31.9
   913.9       .3   -199.4     -5.8    -27.6
  1098.7     80.7   -231.3     -2.3    -35.4
  1080.6     49.6   -262.0      8.7    -35.5
   916.6    -42.8   -248.2    -17.5    -37.1
   750.8   -155.2   -158.8    -28.6    -13.1
   459.2   -191.0    -46.2    -17.1     12.8
   387.3   -227.3     -7.6    -22.4     24.1
   226.8   -155.3     16.6    -28.5     22.8
 388.  624.  850. 1169. 1298. 1490. 1522. 1288.  997.  600.  464.  276.
 188.  338.  497.  712.  858. 1030.  936.  728.  615.  350.  239.  122.
CIRA 1.0 LOC=LOS ANGELES,CA, LAT=33.9, TWHT=20, ALT=97
```

LOUISVTM.CTY

```
.187  .189  .149  .101  .061  .046  .041  .044  .056  .097  .139  .169
.242  .21  .242  .213  .174  .19  .128  .144  .143  .145  .195  .206
.61950E-05  3.80191 35.0
.54680E-03  2.75074 25.0
.27678E-09  6.55746 35.0
.24137E-05  4.31020 26.0
35.3  36.4  48.3  59.3  71.3  77.5  81.0  80.2  74.8  61.7  50.4  40.9
30.3  29.9  40.6  51.9  61.8  69.1  72.8  71.5  64.2  52.6  43.9  36.9
29.8  29.6  38.6  48.8  58.3  65.9  68.7  68.9  61.3  50.7  42.5  35.4
   394.9   -252.2     20.4    -10.7     17.5
   566.5   -256.9    -24.3    -44.7     31.7
   754.4   -238.5    -89.8    -46.1     15.3
   964.1   -105.6   -191.5    -88.6      -.5
  1101.8     39.4   -207.2   -101.7    -10.9
  1187.3    130.6   -221.2   -121.6    -10.6
  1199.0    103.3   -223.4   -117.0    -11.2
  1024.3    -61.0   -224.7    -88.3     -5.6
   892.2   -172.6   -155.2    -96.3     11.9
   732.7   -312.9    -56.0    -44.3     26.3
   479.5   -286.4     14.0    -16.5     21.8
   355.0   -222.7     21.8    -10.1     16.3
 441.  688. 1012. 1402. 1630. 1782. 1741. 1527. 1259.  916.  552.  388.
 280.  452.  645.  855. 1038. 1092. 1135.  882.  750.  564.  349.  270.
CIRA 1.0 LOC=LOUISVILLE,KY, LAT=38.2, TWHT=20, ALT=477
```

MACON-TM.CTY

```
 .151  .134  .096  .067  .048  .046  .044  .040  .045  .073  .111  .130
 .16  .191  .198  .166  .147  .165  .133  .122  .159  .16  .135  .186
 .17742E-02  2.50697 22.0
 .17772E-07  5.35813 35.0
 .20109E-09  6.55421 35.0
 .14036E-14  9.62855 35.0
 48.5  52.8  62.1  71.9  79.2  84.0  84.8  83.9  78.9  70.3  59.4  53.7
 40.5  43.9  51.8  57.8  65.6  72.3  74.0  73.8  68.1  56.8  47.5  44.1
 40.2  43.5  49.6  57.1  64.4  69.5  72.5  73.3  66.1  55.4  47.7  44.0
   492.7   -354.2     68.9    -30.2     24.4
   642.0   -390.4     41.4    -32.8     23.7
   794.8   -322.1    -43.8    -47.1     14.8
   957.2   -222.6   -139.0    -46.6     -8.9
   952.6    -53.7   -188.5    -67.1    -23.6
   976.8      8.8   -202.5    -55.0    -31.3
   912.7    -30.8   -175.1    -41.6    -25.3
   877.3   -155.7   -146.1    -46.1    -11.6
   787.8   -261.9    -62.1    -53.7     10.5
   719.8   -417.1     28.9    -60.2     32.7
   622.5   -465.6     86.5    -44.5     33.7
   532.8   -434.3    100.9    -38.2     28.9
 705. 1004. 1366. 1806. 1899. 1965. 1788. 1732. 1434. 1231.  934.  757.
 291.  408.  570.  742.  772.  819.  812.  691.  602.  402.  309.  254.
CIRA 1.0 LOC=MACON,GA, LAT=32.7, TWHT=23, ALT=354
```

MASONCTM.CTY

```
 .229  .230  .199  .147  .095  .050  .046  .046  .074  .130  .183  .223
 .292  .307  .302  .318  .304  .216  .181  .193  .242  .267  .254  .247
 .28803E-05  3.98777 35.0
 .13172E-04  3.77185 26.0
 .97717E-02  2.09578 15.5
 .11981E-01  2.09370 13.0
 19.1  19.6  32.6  50.3  63.4  74.2  78.9  75.2  67.6  54.5  37.7  21.4
 15.1  14.0  26.7  40.8  52.4  64.3  66.7  64.1  55.9  44.8  32.4  17.9
 15.6  15.6  27.8  41.3  51.1  62.4  64.5  64.0  55.8  44.1  32.9  18.0
   456.7   -403.6    108.2    -44.7     31.3
   630.1   -477.5     92.1    -61.3     37.5
   774.8   -419.2     10.0    -63.8     23.4
   848.6   -283.1    -75.0    -49.0      -.6
  1058.5   -166.9   -182.3    -71.0    -17.6
  1117.7   -112.6   -208.3    -73.6    -29.1
  1100.3   -147.8   -208.8    -74.5    -28.6
   936.8   -286.8   -121.5    -59.8     -3.7
   855.3   -398.8    -32.7    -72.9     23.5
   680.3   -480.3     62.8    -52.5     35.0
   456.9   -378.2     91.3    -34.5     25.0
   360.2   -328.1     94.3    -16.7     10.4
 553.  850. 1227. 1444. 1924. 2143. 2126. 1795. 1425.  984.  576.  412.
 206.  302.  446.  617.  772.  798.  716.  565.  505.  326.  229.  176.
CIRA 1.0 LOC=MASON CITY,IA, LAT=43.2, TWHT=20, ALT=1194
```

MASSENTM.CTY

```
 .234  .222  .208  .159  .111  .061  .047  .060  .096  .140  .185  .217
 .28  .182  .206  .187  .223  .184  .21  .187  .181  .167  .158  .162
 .66871E-05  3.84405 31.5
 .15581E-01  1.92177 15.5
 .14639E-02  2.68081 17.5
 .57445E-13  8.89374 35.0
 16.3  23.1  29.0  46.5  59.1  70.6  75.0  71.7  64.2  51.9  36.6  23.5
 13.5  17.4  22.9  38.5  48.4  58.8  64.0  59.6  53.5  43.0  31.6  20.3
 13.6  18.9  24.0  38.4  47.8  57.8  62.8  59.2  53.9  43.2  32.9  20.5
   341.8   -271.5     72.9    -18.3     12.4
   511.4   -350.3     67.6    -39.2     25.7
   715.0   -377.9     13.5    -48.3     22.1
   905.9   -313.9    -77.1    -55.5      3.1
  1020.5   -200.1   -166.4    -54.3    -18.2
  1092.3   -121.4   -202.5    -68.7    -23.8
  1045.6   -171.6   -179.5    -62.4    -18.9
   938.1   -262.9   -114.2    -69.8     -2.6
   779.7   -387.9     -3.4    -35.3     10.9
   577.6   -364.1     49.7    -43.4     30.3
   350.9   -245.4     62.5    -22.1     15.2
   282.9   -225.9     66.8    -22.8     16.1
 402.  664. 1076. 1514. 1831. 2021. 1979. 1695. 1262.  810.  431.  328.
 216.  330.  478.  647.  724.  804.  731.  636.  520.  376.  262.  188.
CIRA 1.0 LOC=MASSENA,NY, LAT=44.9, TWHT=20, ALT=202
```

MERIDITM.CTY

```
 .149  .135  .098  .063  .061  .043  .052  .051  .045  .077  .109  .139
 .113  .166  .187  .156  .121  .089  .072  .086  .121  .117  .152  .145
 .69365E-07  5.02015 35.0
 .30043E-03  2.90538 24.5
 .14342E-01  1.96343 14.0
 .12374E-18 12.43111 35.0
 49.4  52.5  61.8  72.1  79.2  83.8  86.7  86.0  80.9  69.0  59.8  52.4
 41.0  42.0  49.7  58.7  63.5  72.4  74.3  72.9  67.5  56.7  48.0  42.7
 41.8  42.8  49.6  57.4  63.4  71.4  73.0  73.1  67.6  57.7  48.9  43.8
   509.4   -346.7     65.2    -33.4     25.1
   632.6   -346.2     31.9    -48.0     29.4
   753.3   -298.5    -35.1    -38.4     13.4
   916.2   -218.2   -129.3    -35.1     -7.6
   929.0    -59.2   -178.3    -50.1    -21.7
   949.7      1.2   -197.9    -45.1    -28.0
   943.9     -5.7   -193.1    -63.7    -27.4
   894.3   -131.5   -162.0    -72.3    -10.7
   801.5   -253.1    -69.3    -64.4     14.6
   708.1   -400.5     25.8    -48.0     32.1
   581.7   -420.6     72.9    -32.4     28.1
   497.5   -363.4     77.7    -38.8     29.0
 729.  995. 1304. 1721. 1827. 1956. 1878. 1814. 1470. 1202.  873.  698.
 326.  445.  581.  736.  797.  797.  809.  663.  612.  438.  317.  294.
CIRA 1.0 LOC=MERIDIAN,MS, LAT=32.3, TWHT=20, ALT=290
```

MIAMI-TM.CTY

```
 .037  .038  .017  .026  .032  .050  .053  .065  .059  .031  .022  .046
 .201  .197  .218  .174  .161  .206  .136  .181  .154  .163  .192  .181
 .10000E-30 20.00000 35.0
 .84785E-06  4.16524 35.0
 .10023E-02  2.79609 13.0
 .41357E-05  5.36532 11.5
 71.4  72.8  75.8  78.2  80.4  83.2  84.4  85.5  84.1  79.9  76.6  71.0
 64.6  65.5  69.3  71.1  75.0  77.6  77.5  79.1  78.7  74.3  69.8  62.8
 62.6  61.0  65.9  66.9  70.8  74.3  75.4  76.1  76.2  71.3  66.5  59.9
   673.0   -462.1     64.8     -4.9     19.8
   784.5   -475.1     23.1      -.8     18.2
   849.6   -334.4    -72.9    -21.8     10.6
   917.3   -190.0   -168.9     -8.4    -10.8
   924.2    -32.9   -175.9      3.7    -22.0
   851.3     56.6   -154.6    -25.0    -20.8
   911.2     37.9   -173.5    -24.8    -22.3
   833.0    -90.8   -149.8    -22.2    -13.0
   839.0   -239.9    -81.4    -10.7      -.6
   742.2   -362.6    -22.3    -19.5     20.7
   733.3   -512.2     57.5      -.5     21.2
   687.7   -517.6     77.6      9.8     14.1
 1045. 1341. 1592. 1901. 1794. 1673. 1748. 1692. 1496. 1285. 1184. 1030.
  414.  479.  594.  702.  889.  857.  903.  755.  774.  510.  402.  375.
CIRA 1.0 LOC=MIAMI,FL, LAT=25.8, TWHT=23, ALT=7
```

MILESCTM.CTY

```
 .236  .223  .194  .157  .111  .065  .056  .058  .092  .133  .189  .219
 .181  .159  .218  .241  .211  .172  .202  .199  .187  .202  .203  .185
 .50622E-04  3.20113 35.0
 .68788E-02  2.08404 21.0
 .98246E-03  2.62753 23.5
 .79659E-06  4.32666 35.0
 15.0  20.8  32.7  44.1  57.2  68.3  79.7  77.8  63.0  52.9  35.8  22.3
 11.3  17.4  29.4  40.0  50.8  63.8  72.4  70.4  55.5  45.0  29.6  19.5
 11.3  17.0  27.8  36.0  45.6  57.3  57.8  55.9  49.4  40.5  27.6  19.0
   230.7   -188.8     31.1     -1.8      2.5
   373.8   -229.4      -.1    -10.5      7.7
   606.1   -243.3    -70.5    -22.5      3.6
   808.7   -159.2   -167.5    -38.0    -11.1
  1096.2     21.0   -255.3    -85.9    -16.8
  1195.8    103.7   -290.3    -81.1    -19.1
  1341.2    108.9   -348.2   -111.0    -27.8
  1140.2    -92.1   -297.1    -73.3    -24.0
   833.9   -256.7   -157.6    -36.5     -5.5
   552.4   -299.5    -47.3    -18.4     12.8
   263.8   -215.4     26.3      6.5       .1
   205.2   -171.3     29.1       .6      2.3
  224.  412.  745. 1080. 1491. 1669. 1861. 1536. 1037.  601.  257.  190.
  114.  223.  434.  636.  919.  945.  984.  801.  575.  311.  124.  104.
CIRA 1.0 LOC=MILES CITY,MT, LAT=46.4, TWHT=40, ALT=2629
```

MINNEATM.CTY

```
 .244  .228  .203  .137  .096  .056  .042  .042  .093  .129  .187  .226
 .241  .205  .28  .245  .287  .22  .191  .212  .187  .199  .206  .208
 .18259E-03  3.19826 24.0
 .21524E-04  3.65372 26.0
 .20429E-02  2.41985 21.0
 .41896E-01  1.77375 10.0
 12.4  19.9  31.3  52.5  62.7  74.7  79.0  75.2  66.0  54.4  36.1  19.6
  8.5  15.4  24.5  42.9  53.2  63.5  67.1  66.0  57.1  46.3  31.9  16.9
  9.1  15.5  24.8  41.4  49.8  59.9  65.4  63.5  55.9  44.5  31.5  16.2
   394.6   -344.6    96.6   -34.5    23.1
   583.1   -440.1    86.7   -41.8    26.6
   763.7   -417.4     7.4   -60.1    23.1
   838.1   -268.3   -70.5   -61.6     5.6
   946.9   -209.3  -130.0   -48.9    -7.3
  1022.9   -131.9  -170.5   -60.7   -19.7
  1035.6   -179.7  -168.3   -55.5   -20.6
   917.4   -259.3  -109.6   -77.8     2.7
   745.1   -364.3    -4.7   -51.9    19.6
   620.8   -407.2    61.7   -48.4    31.5
   375.0   -284.8    73.2   -27.6    19.6
   298.4   -243.4    70.6   -19.3    12.7
 461.  770. 1136. 1395. 1757. 1909. 1957. 1683. 1243.  873.  463.  338.
 198.  306.  448.  634.  717.  794.  747.  615.  480.  380.  242.  189.
CIRA 1.0 LOC=MINNEAPOLIS,MN, LAT=44.9, TWHT=21, ALT=834
```

MISSOUTM.CTY

```
 .213  .195  .185  .155  .122  .092  .070  .075  .111  .158  .187  .209
 .11  .137  .162  .178  .169  .152  .144  .129  .116  .107  .103  .086
 .97022E-02  2.10652 16.5
 .15916E-08  6.44502 27.5
 .58838E-04  3.46364 24.5
 .10000E-30 20.00000 35.0
 25.1  33.8  38.5  48.6  57.7  66.2  76.5  74.4  60.8  47.7  36.7  27.7
 22.6  28.6  30.9  37.7  46.4  51.9  58.9  57.3  47.3  37.8  31.7  24.5
 22.1  28.2  30.3  37.4  43.4  50.0  54.6  52.2  47.0  37.5  31.7  25.1
   264.8   -194.5    54.7   -13.6     9.4
   461.2   -295.2    59.7   -27.7    18.1
   680.8   -320.3    15.8   -52.9    25.2
   840.9   -296.9   -56.5   -35.0     3.2
   985.2   -187.4  -140.9   -69.0    -7.9
  1071.3   -125.9  -178.5   -90.5   -16.8
  1185.4   -255.0  -225.7   -59.2   -27.7
  1030.2   -343.9  -130.0   -74.2    -2.4
   836.8   -444.8    -4.5   -52.6    19.2
   586.5   -406.7    72.8   -43.0    25.0
   325.0   -239.3    66.9    -6.3     2.1
   228.6   -167.6    50.7    -6.3     2.7
 312.  585.  975. 1337. 1716. 1981. 2312. 1874. 1348.  803.  388.  260.
 199.  350.  554.  678.  763.  780.  620.  565.  478.  343.  243.  182.
CIRA 1.0 LOC=MISSOULA,MT, LAT=46.9, TWHT=20, ALT=3190
```

MONTGOTM.CTY

```
.145  .137  .095  .055  .045  .041  .048  .054  .043  .068  .107  .144
.136  .178  .217  .143  .155  .127  .132  .098  .127  .103  .138  .15
.39730E-06  4.59537 33.0
.16289E-07  5.52238 32.0
.63420E-12  8.19111 35.0
.24343E-02  2.73624 11.0
50.1  52.3  61.8  71.3  76.9  83.7  85.0  86.2  81.1  70.0  60.2  50.2
42.2  44.5  52.6  59.4  65.3  72.5  74.7  74.6  69.2  58.7  49.2  42.0
42.8  43.7  50.5  59.0  62.9  71.5  73.5  71.7  70.0  57.5  49.2  41.8
  535.4  -381.5    67.8   -28.3    23.2
  600.0  -342.9    34.9   -39.3    27.6
  777.7  -308.0   -42.0   -44.1    14.2
  895.6  -209.5  -134.7   -39.6    -7.4
  939.2   -82.5  -187.6   -30.8   -24.7
  967.6    21.9  -201.4   -63.9   -30.2
  903.8     2.1  -178.3   -83.7   -22.8
  865.0  -123.2  -148.3   -61.0   -12.8
  838.7  -309.1   -59.7   -42.6     9.7
  712.6  -408.3    23.3   -46.3    28.0
  599.7  -437.4    77.4   -39.7    31.4
  518.9  -392.5    81.9   -43.8    34.3
 756.  922. 1338. 1723. 1882. 1969. 1875. 1723. 1534. 1203.  904.  730.
 313.  418.  579.  687.  773.  811.  756.  689.  616.  420.  314.  280.
CIRA 1.0 LOC=MONTGOMERY,AL, LAT=32.3, TWHT=23, ALT=192
```

MOUNTSTM.CTY

```
.191  .175  .154  .142  .106  .074  .051  .070  .072  .131  .162  .182
.156  .147  .172  .184  .157  .225  .096  .092  .143  .175  .161  .129
.23349E-06  4.72701 33.0
.93837E-02  1.98307 17.5
.40097E-05  4.02543 31.0
.70055E-07  4.96641 35.0
35.0  41.2  46.6  51.4  58.3  66.8  74.7  75.8  69.2  56.1  44.8  38.8
30.7  35.0  41.5  42.6  52.3  59.3  67.9  61.5  57.8  44.2  39.8  33.3
29.9  34.9  38.3  39.9  45.9  52.8  57.9  54.1  51.7  42.4  38.8  33.4
  466.7  -317.5    38.3   -15.9    22.1
  610.5  -360.2    19.1   -52.4    40.7
  893.4  -325.4   -82.0   -58.7    18.3
 1120.8  -175.5  -206.3  -127.5     3.5
 1322.4    15.1  -257.0  -163.6   -11.5
 1490.8   174.6  -311.8  -211.5   -25.2
 1492.8   142.7  -335.1  -244.4   -25.9
 1313.3  -107.0  -296.2  -175.9    -3.8
 1146.8  -319.9  -181.4  -181.5    33.0
  848.4  -432.4   -29.0  -125.9    69.8
  496.3  -330.5    34.0   -36.3    33.9
  449.4  -324.7    50.9   -35.2    34.9
 507.  751. 1225. 1710. 2120. 2447. 2584. 2146. 1748. 1122.  560.  480.
 318.  406.  713.  842. 1016. 1042.  881.  811.  673.  486.  314.  283.
CIRA 1.0 LOC=MOUNT SHASTA,CA, LAT=41.2, TWHT=32, ALT=3535
```

NEWARKTM.CTY

```
 .194  .189  .167  .118  .081  .042  .034  .036  .042  .100  .144  .182
 .242  .248  .265  .228  .24  .192  .197  .167  .196  .193  .209  .263
 .80177E-02  2.02588 18.0
 .24196E-02  2.38076 17.5
 .21751E-01  1.89890 12.5
 .22366E-02  2.68306 12.5
 33.8  35.8  43.6  57.0  67.2  77.0  80.2  77.9  70.8  61.1  48.3  37.2
 29.0  30.6  37.4  48.8  57.3  67.5  70.8  69.0  63.2  53.1  44.2  33.9
 27.8  29.4  35.0  46.0  54.0  63.1  65.8  65.8  60.4  52.0  41.3  32.1
   424.6   -336.7     88.2    -28.2     20.2
   564.4   -376.7     64.4    -37.7     26.6
   732.6   -339.8     -3.6    -32.6     13.6
   848.7   -244.5    -82.3    -55.1      2.3
   968.5   -168.0   -153.1    -38.7    -15.7
   958.1    -90.9   -162.1    -50.1    -19.6
   938.4   -108.5   -162.9    -54.6    -17.5
   837.4   -218.2   -103.9    -48.8     -1.7
   775.4   -338.2    -17.2    -38.9     13.5
   625.5   -397.3     51.1    -32.9     22.7
   438.3   -310.7     72.5    -25.4     18.7
   381.7   -308.6     86.6    -24.7     18.0
  542.  792. 1137. 1458. 1798. 1825. 1768. 1559. 1299.  948.  577.  475.
  253.  360.  566.  682.  778.  809.  773.  634.  579.  387.  301.  235.
CIRA 1.0 LOC=NEWARK,NJ, LAT=40.7, TWHT=20, ALT=7
```

NEWORLTM.CTY

```
 .109  .110  .076  .039  .038  .040  .052  .057  .039  .044  .082  .100
 .18  .181  .169  .197  .156  .138  .147  .116  .116  .118  .157  .156
 .68459E-07  5.00413 35.0
 .67071E-08  5.63786 35.0
 .38985E-02  2.60965 12.0
 .13280E-05  5.86627 12.0
 57.6  58.1  64.6  73.1  79.0  82.3  84.4  84.8  78.1  76.7  63.5  59.1
 50.3  51.2  57.1  65.0  69.3  74.3  77.5  77.5  70.8  66.4  56.6  52.2
 49.4  49.2  55.5  63.2  67.9  72.0  75.8  74.2  69.9  65.7  56.1  52.7
   553.5   -382.6     73.7    -22.5     19.8
   668.0   -372.7     40.8    -40.1     23.3
   803.8   -290.1    -53.3    -61.7     18.0
   893.4   -170.7   -132.9    -57.4     -6.6
   950.0    -10.5   -204.6    -75.9    -28.6
   919.2     53.8   -198.5    -62.4    -30.1
   888.6     57.5   -186.1    -93.6    -26.4
   878.2    -91.3   -162.0    -75.3    -14.3
   818.1   -243.4    -76.5    -77.3     15.6
   774.2   -439.7     16.8    -51.1     32.0
   612.2   -431.8     70.7    -32.4     28.2
   555.4   -406.5     84.9    -22.6     20.1
  816. 1082. 1412. 1698. 1954. 1887. 1780. 1731. 1537. 1372.  949.  806.
  356.  469.  605.  735.  757.  773.  770.  710.  611.  433.  338.  335.
CIRA 1.0 LOC=NEW ORLEANS,LA, LAT=30.0, TWHT=53, ALT=4
```

NEWYCPTM.CTY

```
 .192  .192  .172  .124  .088  .044  .022  .023  .048  .099  .140  .178
 .195  .255  .289  .239  .212  .203  .189  .184  .178  .205  .225  .205
 .43052E-01  1.69889 11.5
 .29059E-01  1.72050 11.0
 .22016E-03  3.46198 14.5
 .25457E-02  2.67683 10.5
 33.7  34.6  41.7  54.5  62.1  71.3  77.1  77.5  69.4  60.6  48.9  39.1
 30.5  29.9  36.6  49.5  56.9  64.2  69.8  71.3  63.4  54.0  45.9  35.0
 28.8  28.8  34.3  46.3  53.0  61.7  65.7  66.9  59.8  52.2  42.2  32.9
   387.0    -339.6      84.4      15.0      -7.9
   534.5    -391.2      67.1      19.3      -1.1
   648.1    -340.1       8.3     -16.0      13.9
   762.4    -265.0     -60.7     -10.5       1.2
   852.5    -184.6    -126.9     -27.0      -8.2
   911.1    -117.0    -134.7     -26.3     -10.2
   868.6    -149.3    -134.0      -6.6      -8.4
   831.0    -243.6     -77.6     -21.1       2.5
   717.7    -328.9     -28.5     -10.5       6.6
   602.7    -414.9      47.3      -1.4      10.8
   400.8    -271.9      59.7     -32.0      22.6
   312.1    -266.0      74.2       3.9      -3.3
 467.  727. 1035. 1351. 1656. 1720. 1625. 1502. 1189.  899.  524.  379.
 205.  346.  463.  621.  656.  837.  770.  719.  517.  343.  282.  185.
CIRA 1.0 LOC=NEW YORK CENTRAL PARK, LAT=40.8 , TWHT=68, ALT=132
```

NEWYLGTM.CTY

```
 .193  .188  .168  .131  .088  .037  .024  .032  .033  .094  .137  .179
 .251  .218  .227  .215  .184  .177  .184  .189  .194  .22   .223  .297
 .90170E-09  6.15579 35.0
 .32073E-02  2.42517 14.5
 .65659E-03  3.06192 14.5
 .79252E-11  7.26812 35.0
 32.5  35.5  43.0  53.0  62.7  74.9  79.3  78.1  71.5  61.3  50.4  38.2
 30.7  31.4  37.6  47.1  55.7  67.0  73.0  71.4  65.4  55.5  47.0  35.3
 27.4  29.0  35.1  42.6  52.8  62.6  66.8  66.1  61.2  52.6  41.9  32.3
   414.0    -326.2      84.9     -19.0      14.7
   557.7    -351.2      59.4     -39.7      28.2
   679.8    -314.2       4.6     -36.8      16.6
   824.7    -253.4     -67.0     -44.3       4.8
   853.2    -134.2    -116.3     -40.8      -8.8
   909.1     -77.7    -138.2     -54.4     -15.6
   870.3    -102.3    -120.6     -56.9     -10.4
   779.4    -172.3     -88.4     -68.5       4.5
   723.3    -291.7      -8.2     -50.1      19.8
   592.6    -368.5      54.7     -34.1      22.9
   421.1    -284.3      69.9     -19.1      14.6
   348.3    -281.7      80.6     -17.2      12.2
 528.  792. 1065. 1422. 1545. 1677. 1614. 1425. 1205.  904.  559.  434.
 257.  389.  537.  687.  775.  839.  805.  647.  598.  394.  325.  220.
CIRA 1.0 LOC=NEW YORK LA GUARDIA, LAT=40.8, TWHT=83, ALT=11
```

NORFOLTM.CTY

```
 .167  .172  .142  .086  .052  .033  .041  .031  .033  .094  .117  .162
 .227  .234  .26  .237  .19  .205  .158  .145  .162  .226  .197  .223
 .95292E-01  1.39347 13.0
 .18058E-05  4.29663 28.0
 .34515E-01  1.77915 12.0
 .65071E-02  2.37702 10.5
 42.2  41.0  50.2  64.1  72.0  79.4  82.9  80.6  75.2  60.7  57.2  43.6
 36.6  37.9  43.9  56.4  63.9  70.4  75.1  72.3  67.6  55.0  49.5  39.4
 35.0  34.6  41.6  52.8  61.6  66.8  72.0  70.6  65.1  53.0  46.6  37.2
   533.5   -447.1    109.5    -31.6     24.4
   548.9   -304.2     42.8    -46.3     29.9
   745.6   -334.6    -11.3    -50.9     21.4
   911.2   -240.6   -112.3    -56.2      -.1
   989.9   -112.6   -182.3    -60.0    -19.9
  1009.7    -46.0   -198.1    -58.4    -27.7
   937.0    -73.7   -171.8    -67.3    -19.7
   872.1   -187.4   -122.6    -67.2     -1.9
   824.1   -350.3    -40.0    -44.0     13.5
   636.5   -386.7     45.8    -36.1     26.9
   617.5   -502.3    107.6    -41.5     32.9
   428.5   -339.3     84.9    -27.3     21.8
 728.  795. 1235. 1644. 1907. 2017. 1904. 1711. 1489. 1011.  882.  564.
 258.  426.  544.  704.  785.  809.  746.  656.  554.  412.  280.  249.
CIRA 1.0 LOC=NORFOLK,VA, LAT=36.9, TWHT=34, ALT=24
```

NORTHBTM.CTY

```
 .152  .151  .150  .143  .123  .107  .096  .092  .097  .118  .130  .149
 .205  .226  .225  .221  .223  .228  .235  .235  .183  .179  .191  .209
 .57347E-03  3.09167 12.0
 .58081E-02  2.29269 10.5
 .26478E-03  3.74266 10.0
 .10000E-30 20.00000 35.0
 47.4  48.5  49.6  51.0  55.9  59.4  61.7  62.4  61.6  57.1  53.5  47.8
 42.9  43.5  42.7  45.6  50.2  53.9  55.4  55.5  54.5  50.9  49.0  44.7
 42.9  43.2  43.3  45.4  49.8  54.1  55.0  55.3  55.7  51.0  49.2  43.9
   377.0   -285.3     80.9    -27.2     16.7
   544.1   -359.7     71.3    -20.7     14.3
   735.9   -380.5     23.1    -41.9     20.7
   887.2   -327.0    -48.0    -19.2       .4
  1007.0   -240.4   -132.0    -18.3    -13.3
   999.6   -200.3   -139.5     -3.3    -18.0
  1006.3   -253.8   -144.3      1.1    -19.3
   965.6   -352.9    -98.7    -30.2     -4.3
   815.0   -421.5      3.3    -29.4     14.7
   627.1   -413.9     67.6    -33.7     22.6
   391.0   -276.4     70.1    -17.2     11.0
   307.9   -229.7     69.2    -19.0     11.1
 461.  716. 1118. 1508. 1875. 1943. 2043. 1866. 1355.  914.  500.  369.
 258.  395.  543.  729.  803.  829.  719.  593.  541.  396.  286.  228.
CIRA 1.0 LOC=NORTH BEND,OR, LAT=43.4, TWHT=20
```

NORTHPTM.CTY

```
 .220  .207  .186  .144  .085  .063  .052  .059  .091  .124  .183  .207
 .2  .192  .237  .294  .24  .235  .215  .169  .194  .213  .177  .165
 .19151E-04  3.61798 31.0
 .17524E-08  6.01747 35.0
 .87550E-03  2.80574 20.0
 .40008E-02  2.46851 14.5
 25.0  31.8  38.5  51.9  66.7  75.2  80.9  78.8  66.2  59.7  39.9  30.9
 15.8  20.8  27.4  39.1  54.3  60.7  66.7  64.0  51.7  41.3  29.4  21.7
 17.3  22.4  28.8  38.6  53.2  58.1  63.1  62.1  52.3  43.1  30.1  23.1
   557.2   -512.0    127.4    -43.2     32.5
   681.3   -536.6     86.4    -40.0     30.7
   827.6   -445.1    -13.4    -56.7     24.3
   958.9   -310.1   -114.8    -57.3     -2.0
  1039.8   -186.8   -183.5    -54.1    -19.8
  1143.4    -96.8   -252.3    -74.9    -31.4
  1076.3   -166.0   -219.1    -51.8    -26.0
  1000.6   -311.4   -151.3    -59.9     -8.3
   913.3   -462.6    -45.8    -49.4     15.6
   792.3   -581.4     74.4    -68.5     39.3
   585.1   -514.6    123.1    -45.8     32.9
   500.9   -489.5    131.3    -23.0     19.7
 690.  925. 1333. 1699. 2033. 2320. 2227. 1995. 1577. 1191.  767.  589.
 207.  287.  446.  633.  704.  723.  652.  536.  463.  304.  231.  179.
CIRA 1.0 LOC=NORTH PLATTE,NE, LAT=41.1, TWHT=20, ALT=2775
```

OAKLANTM.CTY

```
 .142  .128  .124  .115  .099  .086  .076  .068  .062  .086  .113  .137
 .182  .201  .207  .219  .214  .234  .2  .206  .194  .169  .115  .141
 .63996E-03  3.35923 10.5
 .13614E-02  2.77580 10.5
 .12818E-01  1.99434 10.5
 .10000E-30 20.00000 35.0
 50.1  54.3  54.7  57.7  61.3  62.9  64.8  66.0  68.1  63.2  58.6  51.8
 46.2  50.0  51.2  52.3  54.8  57.2  59.0  60.1  59.5  57.0  51.1  47.7
 45.1  47.8  48.1  50.3  53.4  55.4  57.5  57.9  57.8  54.6  50.0  46.4
   486.1   -392.4     98.1    -22.0     16.3
   658.1   -431.7     70.6    -52.1     32.0
   812.8   -401.3       .6    -45.5     19.8
  1019.5   -327.2   -130.0    -54.7     -1.1
  1046.7   -194.0   -199.8    -33.4    -22.1
  1076.3   -123.2   -232.2    -23.4    -31.4
  1034.7   -162.9   -219.0    -22.4    -26.4
   978.2   -310.0   -150.7    -25.2    -12.8
   900.6   -445.8    -34.9    -39.6     16.3
   732.9   -495.7     61.1    -36.2     27.6
   557.8   -457.7    108.0    -31.5     24.2
   483.2   -429.8    117.1    -33.3     24.2
 658. 1001. 1353. 1973. 2204. 2347. 2284. 2086. 1677. 1190.  784.  635.
 267.  393.  554.  641.  687.  704.  646.  538.  498.  379.  272.  218.
CIRA 1.0 LOC=OAKLAND,CA, LAT=37.7, TWHT=20, ALT=6
```

OKLAHOTM.CTY

```
 .183  .169  .139  .084  .056  .055  .057  .051  .061  .080  .129  .168
 .238  .253  .281  .254  .261  .212  .194  .185  .228  .206  .237  .209
 .62894E-04  3.33300 29.0
 .35715E-01  1.62563 18.0
 .28252E-06  4.75635 32.0
 .28529E-08  5.92023 35.0
 36.7  41.4  50.4  62.5  69.8  77.6  82.9  81.5  76.7  63.2  51.8  41.7
 32.5  36.5  43.9  57.1  64.6  73.9  77.9  77.7  70.8  59.0  47.7  37.7
 31.0  33.7  39.2  49.9  59.2  66.9  68.9  69.2  64.7  53.9  44.5  35.4
   389.2   -257.7      3.3    -18.0      16.9
   514.6   -252.7    -42.6    -23.5      17.8
   646.5   -180.7   -109.0    -45.1       4.7
   922.8    -60.8   -243.5    -84.5     -15.9
   951.7     26.8   -224.6    -50.3     -28.7
  1175.5    167.1   -275.7    -93.1     -31.0
  1193.7    166.8   -306.7   -103.5     -36.3
  1031.0     21.5   -297.7    -90.0     -30.1
   815.3   -190.3   -169.7    -42.7      -8.9
   640.1   -278.1    -73.8    -36.1      12.7
   437.9   -291.8     -2.0    -11.7      12.9
   304.1   -227.9     24.0     -8.0       9.1
 443.  626.  870. 1310. 1421. 1686. 1708. 1463. 1142.  817.  510.  349.
 199.  335.  497.  729.  831. 1024.  981.  794.  608.  406.  210.  147.
CIRA 1.0 LOC=OKLAHOMA CITY,OK, LAT=35.4, TWHT=70, ALT=1285
```

ORLANDTM.CTY

```
 .089  .066  .056  .040  .041  .042  .051  .051  .037  .033  .046  .086
 .194  .208  .227  .228  .193  .167  .153  .13  .212  .185  .164  .192
 .13789E-01  1.99314 15.5
 .61689E-01  1.49882 11.0
 .43008E-02  2.50721 12.5
 .49267E-02  2.33264 10.5
 63.6  68.1  73.0  76.2  82.3  84.0  85.2  85.1  82.6  78.5  73.6  64.3
 53.5  58.4  61.4  65.4  69.9  74.9  76.5  76.6  75.2  70.0  63.1  54.0
 53.7  58.1  60.6  61.9  67.7  73.3  75.0  75.3  73.1  68.5  62.6  53.6
   658.8   -456.8     82.8    -34.4      30.1
   754.2   -426.4     34.7    -42.5      31.7
   890.2   -315.9    -65.3    -57.0      15.2
   992.0   -150.2   -173.0    -71.4     -15.3
   997.3     13.8   -215.7    -74.9     -32.6
   954.0     76.4   -177.2    -67.2     -30.4
   915.0     58.7   -181.1    -75.5     -29.4
   873.7    -43.0   -162.3    -89.2     -16.2
   823.1   -197.6    -81.4    -65.3       8.4
   754.3   -376.3      7.4    -55.2      30.8
   688.7   -484.9     74.8    -54.4      43.2
   601.3   -447.9     92.1    -34.8      30.2
1008. 1256. 1575. 1912. 2013. 1812. 1793. 1670. 1473. 1310. 1124.  908.
 399.  502.  679.  793.  834.  928.  843.  768.  738.  510.  344.  333.
CIRA 1.0 LOC=ORLANDO,FL, LAT=28.5, TWHT=20, ALT=96
```

PALMBETM.CTY

```
.048  .045  .028  .029  .041  .051  .055  .063  .053  .036  .024  .034
.2  .222  .224  .272  .208  .158  .163  .174  .229  .251  .216  .238
.19925       1.13910 10.0
.13840E-01   1.91808 13.5
.83331E-02   2.31743 10.0
.15073E-01   1.94982 10.0
69.4  71.3  75.3  78.3  82.1  83.8  85.1  85.5  83.1  80.0  75.4  71.8
61.9  62.9  66.6  70.9  74.7  77.0  77.6  78.7  78.3  73.6  68.8  64.4
60.7  60.9  63.5  64.5  69.8  74.3  75.7  75.7  75.7  69.9  65.1  60.8
  633.4   -408.6     65.7   -42.4     34.1
  726.3   -354.1      8.4   -54.1     34.6
  877.4   -277.3    -70.8   -59.8     14.1
  965.9   -119.5   -162.0   -69.0    -13.6
  944.3     25.0   -181.9   -64.5    -26.9
  909.7    125.5   -179.4   -87.7    -33.5
  896.7    103.4   -182.8   -92.5    -33.1
  851.3    -32.4   -159.7   -81.7    -17.9
  750.8   -183.6    -77.4   -54.6      4.9
  716.8   -330.7     -3.3   -57.0     29.5
  644.3   -408.0     60.4   -48.8     37.5
  619.0   -432.8     83.6   -47.5     38.5
 981. 1207. 1551. 1843. 1844. 1732. 1733. 1650. 1390. 1268. 1067.  960.
 409.  534.  722.  848.  886.  853.  822.  754.  651.  507.  397.  366.
CIRA 1.0 LOC=PALMBEACH,FL, LAT=26.7, TWHT=20, ALT=15
```

PATUXETM.CTY

```
.183  .172  .143  .112  .055  .036  .037  .034  .042  .078  .136  .170
.199  .198  .186  .171  .169  .142  .129  .172  .115  .148  .155  .165
.14336E-01   1.93292 15.0
.14560       1.13514 10.5
.24782E-05   4.67011 19.5
.10747E-01   2.29618 10.0
37.6  41.7  49.9  58.4  67.6  77.7  81.1  80.1  75.2  63.2  51.0  41.4
32.0  35.9  43.7  51.3  61.4  69.5  73.9  72.3  68.0  57.8  46.9  37.8
30.6  34.6  41.5  48.1  57.7  65.3  70.4  70.0  63.1  54.1  44.1  36.0
  467.4   -366.8     88.6   -29.9     22.4
  620.2   -398.0     61.8   -40.3     25.9
  715.0   -311.7    -10.7   -38.8     15.2
  893.2   -226.8   -100.1   -61.1      1.0
  896.6   -135.6   -134.5   -33.3    -13.6
 1035.2    -51.4   -191.2   -69.6    -27.1
  972.7   -103.6   -163.6   -51.3    -19.5
  892.2   -200.7   -123.4   -67.3     -3.0
  796.0   -318.5    -33.6   -52.5     15.5
  666.5   -414.7     48.4   -35.3     25.2
  517.8   -380.0     84.1   -30.3     22.7
  431.1   -360.0     96.6   -27.8     20.4
 620.  905. 1140. 1559. 1661. 2007. 1896. 1694. 1370. 1036.  711.  559.
 266.  398.  563.  732.  799.  859.  821.  670.  589.  414.  318.  232.
CIRA 1.0 LOC=PATUXENT RIVER,MD, LAT=38.3, TWHT=20, ALT=184
```

PHOENITM.CTY

```
 .121  .112  .081  .060  .065  .097  .121  .110  .083  .062  .076  .115
 .12  .137  .141  .114  .142  .128  .167  .153  .147  .123  .116  .129
 .71484E-02  2.16937 17.5
 .10060E-04  3.99374 25.5
 .20494E-02  2.49408 20.0
 .35068E-02  2.35393 18.5
 55.8  58.7  66.2  72.5  83.5  93.8  96.4  94.5  89.4  78.0  64.8  55.9
 48.1  48.9  56.4  63.3  73.5  83.1  89.1  86.3  81.0  68.3  57.3  48.6
 43.6  43.2  45.9  51.3  55.2  61.8  69.1  68.0  63.8  55.8  50.1  42.9
   546.7   -373.9      3.6      4.1     11.2
   744.0   -423.7    -54.2     18.6      5.7
   901.2   -279.9   -178.6    -26.7     -2.1
  1182.0   -180.8   -311.3     -2.4    -34.1
  1308.3     83.3   -373.7    -58.0    -34.2
  1475.9    176.5   -376.7    -43.1    -30.8
  1298.4    114.3   -341.0    -39.3    -32.8
  1153.8    -20.7   -337.6    -51.7    -28.6
  1083.7   -235.3   -264.6    -44.6     -8.0
   825.8   -394.6   -112.6      6.1      7.8
   730.0   -452.7    -37.7     -2.6     26.4
   420.2   -320.8     15.7     18.2      4.2
 610.  897. 1211. 1706. 1995. 2179. 1928. 1703. 1483. 1027.  811.  461.
 290.  446.  631.  893.  974. 1161. 1035.  865.  800.  509.  405.  203.
CIRA 1.0 LOC=PHOENIX,AZ, LAT=33.4, TWHT=29, ALT=1083
```

POCATETM.CTY

```
 .215  .198  .174  .158  .105  .075  .063  .064  .099  .137  .180  .209
 .241  .263  .262  .27  .24  .254  .17  .158  .237  .209  .215  .236
 .66698E-04  3.31737 28.5
 .30464E-06  4.75641 30.5
 .20425E-02  2.52184 19.5
 .67137E-02  2.20961 15.0
 25.1  33.2  42.7  47.8  61.8  70.7  81.8  79.0  67.5  54.0  39.5  27.6
 20.7  26.6  33.6  37.3  49.1  56.8  63.5  61.7  52.3  41.2  33.3  23.8
 20.2  25.8  32.8  36.0  44.1  51.6  53.8  53.0  45.7  38.7  31.8  22.9
   471.7   -413.3    108.1    -30.3     23.7
   704.7   -554.4     89.3    -23.4     23.1
   879.0   -468.1     -7.8    -64.7     28.6
  1050.1   -331.4   -146.2    -87.3      1.4
  1196.0   -177.9   -235.8    -96.3    -34.9
  1227.0    -89.2   -258.3   -106.1    -38.5
  1291.8   -180.4   -307.2    -92.5    -39.3
  1142.0   -346.1   -189.9    -88.4    -14.9
  1020.5   -523.5    -45.0    -75.2     14.1
   811.2   -603.0     78.3    -77.3     45.5
   542.7   -498.5    129.2    -23.0     15.0
   391.4   -337.5     97.6    -31.0     20.6
 575.  936. 1381. 1815. 2246. 2422. 2671. 2213. 1755. 1195.  687.  459.
 228.  324.  503.  615.  695.  727.  566.  525.  461.  300.  215.  212.
CIRA 1.0 LOC=POCATELLO,ID, LAT=42.9, TWHT=20, ALT=4454
```

PORTMETM.CTY

```
 .213  .212  .186  .161  .119  .072  .041  .054  .086  .133  .172  .208
 .208  .211  .256  .208  .224  .187  .186  .178  .184  .185  .211  .177
 .55625E-02  2.30783 15.0
 .17028E-07  5.81488 25.5
 .14021E-01  2.13180 11.5
 .66498E-14  9.41421 35.0
 26.5  26.5  37.5  46.6  56.9  69.1  73.9  73.1  64.0  54.1  42.3  28.2
 20.6  22.1  30.8  38.3  48.6  57.0  63.0  60.4  54.4  45.6  35.8  23.4
 21.1  21.1  30.1  39.0  47.4  57.2  62.1  61.4  55.4  45.7  36.4  22.9
   364.6    -307.2      82.2     -11.0       8.8
   499.5    -352.0      67.9     -20.7      16.3
   665.4    -329.5      11.1     -33.7      16.7
   754.7    -234.7     -57.6     -39.8       3.3
   886.5    -136.8    -137.8     -52.2     -14.5
   935.7    -105.5    -156.5     -45.5     -16.4
   970.0    -117.0    -148.0     -72.8     -13.5
   832.0    -241.5     -87.9     -48.4       1.5
   733.0    -311.1     -14.0     -56.9      21.0
   587.7    -382.8      61.5     -46.7      27.1
   369.9    -290.5      80.4     -22.6      14.5
   313.8    -273.4      81.4     -17.7      12.2
 438.  679. 1009. 1250. 1574. 1710. 1778. 1488. 1186.  856.  478.  368.
 208.  318.  505.  637.  716.  779.  813.  639.  554.  358.  231.  177.
CIRA 1.0 LOC=PORTLAND,ME, LAT=43.6, TWHT=20, ALT=43
```

PRESCOTM.CTY

```
 .176  .171  .142  .126  .092  .062  .048  .050  .057  .096  .149  .181
 .183  .193  .228  .224  .239  .25  .172  .139  .17  .152  .165  .156
 .85681E-07  4.96597 35.0
 .12779E-01  2.16898 11.5
 .35411E-13  9.05651 35.0
 .95520E-14  9.30423 35.0
 43.9  45.2  54.3  57.7  69.6  81.8  82.4  78.3  76.1  65.5  51.9  42.9
 30.0  32.7  37.9  43.2  51.2  64.1  68.6  64.2  60.8  48.5  36.6  27.8
 29.9  32.1  35.0  39.0  43.0  52.8  60.0  57.3  53.4  44.0  37.0  27.8
   744.3    -688.9     141.4     -50.1      45.0
   833.4    -604.3      67.2     -53.0      41.1
  1020.4    -500.2     -78.0     -88.7      31.6
  1175.5    -266.3    -242.2    -120.3     -20.5
  1237.5     -33.3    -338.1    -135.0     -52.2
  1266.6      63.8    -369.0    -115.4     -61.8
  1100.2        .7    -282.6     -89.1     -43.3
  1036.4    -154.0    -232.8    -104.3     -23.1
  1002.2    -391.7    -115.2    -121.0      22.4
   909.2    -626.8      37.5     -94.8      52.4
   764.9    -669.1     118.7     -74.1      57.8
   664.0    -645.2     155.7     -66.7      52.8
 1044. 1314. 1816. 2313. 2619. 2756. 2266. 2048. 1921. 1569. 1135.  927.
  194.  340.  443.  556.  581.  581.  678.  582.  436.  268.  188.  151.
CIRA 1.0 LOC=PRESCOTT,AZ, LAT=34.7, TWHT=20, ALT=5014
```

PUEBLOTM.CTY

```
 .202  .177  .166  .125  .083  .064  .056  .059  .079  .100  .158  .181
 .126  .168  .161  .214  .24   .223  .181  .149  .178  .155  .149  .164
 .42157E-01  1.61663 19.0
 .19242E-02  2.49717 18.5
 .44702E-04  3.58000 24.0
 .83459E-03  3.06890 14.0
 33.1  42.2  45.4  57.6  69.9  79.5  83.2  82.9  73.4  65.6  49.4  42.6
 20.8  27.4  30.9  43.3  54.2  62.9  68.1  66.6  58.1  47.7  34.8  26.6
 23.0  27.8  31.4  39.7  47.1  54.7  58.9  59.3  51.6  41.7  33.2  26.9
   658.5   -654.8    151.2    -55.2     43.4
   789.6   -628.5     90.8    -75.1     50.8
   947.5   -482.7    -47.3    -96.2     33.7
  1032.5   -295.7   -163.3    -92.1     -2.3
  1112.6   -104.6   -238.5   -111.9    -24.7
  1178.5    -24.5   -286.2   -110.4    -41.0
  1095.6    -30.4   -254.9   -138.5    -32.5
  1017.2   -203.8   -197.5   -128.6     -5.6
   959.5   -449.3    -77.6    -72.9     16.4
   863.8   -633.9     57.4    -62.8     41.7
   701.2   -631.1    126.8    -54.7     43.3
   635.6   -644.6    157.1    -53.2     43.9
 859. 1172. 1603. 1935. 2220. 2501. 2311. 2064. 1742. 1378.  960.  791.
 127.  245.  427.  579.  694.  663.  624.  521.  435.  285.  199.  133.
CIRA 1.0 LOC=PUEBLO,CO, LAT=38.3, TWHT=34, ALT=4684
```

RALEIGTM.CTY

```
 .161  .158  .133  .089  .055  .038  .032  .035  .045  .090  .125  .161
 .188  .219  .181  .204  .149  .158  .16   .139  .149  .173  .179  .181
 .23910E-05  4.01316 35.0
 .27960E-01  1.58736 16.5
 .58267E-07  5.39000 26.5
 .98446E-14  9.19850 35.0
 45.2  46.0  54.1  64.9  71.8  80.4  81.3  80.5  75.9  63.3  55.9  45.2
 38.2  37.2  43.7  52.6  61.9  69.3  72.0  69.6  64.2  52.2  45.1  38.0
 37.5  36.4  42.3  52.1  60.7  67.2  71.4  69.2  63.4  53.1  45.0  37.4
   467.8   -321.5     79.6    -22.6     16.2
   634.5   -360.5     54.3    -48.7     29.2
   780.3   -342.9    -11.3    -34.4     13.4
   939.0   -215.1   -122.3    -60.9     -3.6
   922.0   -109.8   -155.5    -35.6    -18.4
   967.8    -24.5   -182.7    -59.0    -23.8
   944.3    -63.1   -173.8    -51.3    -22.7
   877.1   -171.5   -127.6    -61.6     -7.7
   781.8   -284.3    -37.1    -42.8     11.5
   696.4   -385.6     41.1    -38.0     25.3
   590.3   -397.2     85.8    -41.9     30.9
   463.9   -334.8     87.5    -25.4     18.3
 647.  942. 1263. 1658. 1749. 1863. 1830. 1673. 1355. 1095.  843.  626.
 344.  477.  616.  773.  804.  854.  818.  691.  641.  510.  408.  326.
CIRA 1.0 LOC=RALEIGH,NC, LAT=35.9, TWHT=20, ALT=434
```

RAPIDCTM.CTY

```
 .213  .206  .189  .151  .106  .073  .049  .059  .094  .132  .185  .210
 .252  .234  .272  .337  .246  .244  .198  .204  .217  .233  .233  .207
 .14756E-02  2.51719 25.0
 .21786E-10  7.21749 35.0
 .23524E-02  2.46822 19.5
 .14088E-07  6.07186 22.5
 27.3  29.4  37.8  48.9  61.8  72.1  78.9  82.3  65.7  55.2  36.7  27.3
 19.4  23.7  27.9  39.1  49.1  57.9  65.6  65.7  51.7  43.6  29.5  22.5
 19.9  23.8  28.5  37.5  48.1  53.5  62.3  58.9  47.9  39.6  27.3  22.0
   466.7   -427.8    119.7    -35.4     25.1
   564.4   -418.3     77.9    -45.3     29.9
   809.1   -426.9      3.0    -84.0     34.8
   932.0   -315.7    -88.3    -70.9      4.7
  1042.9   -178.2   -172.6    -78.6    -16.0
  1118.3   -103.5   -214.0    -96.8    -22.8
  1101.1   -162.7   -218.7    -85.8    -21.0
  1053.8   -315.8   -158.7    -92.4     -4.7
   894.5   -442.6    -34.9    -80.1     24.2
   721.1   -533.0     75.6    -55.8     35.2
   535.0   -490.8    120.1    -43.7     30.8
   409.7   -399.3    116.7    -35.1     27.1
 553.  758. 1247. 1589. 1903. 2167. 2197. 2005. 1488. 1037.  657.  462.
 207.  295.  465.  627.  736.  759.  645.  533.  462.  310.  190.  162.
CIRA 1.0 LOC=RAPID CITY,SD, LAT=44.1, TWHT=21, ALT=3162
```

REDBLUTM.CTY

```
 .159  .135  .130  .097  .065  .064  .075  .066  .061  .077  .125  .156
 .183  .255  .185  .198  .176  .195  .176  .171  .173  .194  .192  .193
 .27215E-01  1.72044 15.0
 .14225E-01  2.07086 11.5
 .28606E-01  1.75465 15.5
 .30376E-01  1.83210 11.5
 46.6  53.1  55.3  63.5  73.9  84.2  91.5  89.2  81.6  70.7  55.8  47.1
 38.5  45.1  45.9  50.9  60.1  70.2  74.2  72.2  66.0  56.6  47.6  41.2
 38.7  42.7  44.7  47.7  53.5  59.7  62.6  62.7  57.5  51.0  44.5  40.1
   435.1   -356.5     98.6    -26.3     17.7
   596.9   -424.5     81.7    -34.5     25.1
   807.8   -425.7     11.8    -47.4     22.1
  1056.5   -344.3   -132.5    -68.4      -.8
  1168.5   -182.3   -237.0    -80.1    -26.0
  1229.1    -86.2   -285.4    -83.0    -41.2
  1260.6   -145.5   -305.9    -85.1    -43.7
  1149.6   -324.6   -208.7    -88.4    -13.4
  1017.7   -507.7    -60.6    -77.6     22.0
   798.6   -585.7     77.4    -56.7     40.1
   541.3   -455.1    110.1    -34.6     25.5
   393.5   -338.0     97.5    -18.7     11.8
 568.  864. 1315. 1949. 2332. 2541. 2684. 2346. 1852. 1251.  735.  493.
 249.  352.  524.  645.  704.  706.  601.  518.  450.  330.  252.  215.
CIRA 1.0 LOC=RED BLUFF,CA, LAT=40.1, TWHT=20, ALT=342
```

REDMONTM.CTY

```
 .185  .181  .175  .154  .124  .093  .075  .089  .109  .135  .167  .189
 .154  .143  .155  .142  .2   .158  .123  .127  .144  .109  .122  .181
 .92321E-02  2.05288 18.0
 .16572E-03  3.14093 23.5
 .18512E-01  1.86785 18.5
 .10000E-30 20.00000 35.0
 36.9  40.2  44.4  50.5  57.9  68.2  77.8  72.3  66.5  56.5  44.4  36.4
 30.9  31.4  31.8  37.4  43.7  52.1  58.2  51.6  48.3  40.5  36.6  29.7
 29.9  32.1  32.1  37.5  41.8  48.4  54.0  50.1  45.6  40.7  37.1  30.1
   391.4   -310.0     85.4    -36.6     25.9
   574.4   -410.3     79.8    -31.8     21.5
   783.4   -375.5      6.9    -77.2     34.0
   965.0   -292.6   -105.7    -83.5      7.6
  1117.7   -202.4   -193.1    -69.2    -19.7
  1189.2   -131.2   -248.8    -82.3    -33.8
  1200.7   -145.3   -249.2   -122.1    -30.3
  1086.4   -321.4   -170.5    -92.8     -4.4
   934.5   -489.3    -28.4    -68.1     21.5
   681.0   -472.0     66.1    -60.0     39.7
   449.6   -356.5     91.6    -44.3     31.2
   362.6   -314.0     92.2    -25.9     17.5
 472.  763. 1188. 1648. 2045. 2340. 2385. 2051. 1566.  983.  567.  414.
 242.  350.  558.  670.  760.  695.  626.  545.  463.  348.  255.  202.
CIRA 1.0 LOC=REDMOND,OR, LAT=44.3, TWHT=20
```

RENO--TM.CTY

```
 .189  .178  .156  .142  .108  .074  .077  .079  .092  .132  .169  .193
 .097  .115  .142  .165  .187  .18  .128  .13  .107  .111  .139  .118
 .83044E-03  2.72385 22.5
 .18234E-07  5.33999 35.0
 .16822E-04  3.81418 25.5
 .28360E-03  3.07532 20.5
 38.7  43.3  51.0  54.0  63.0  74.1  83.4  79.8  71.3  58.3  46.3  35.0
 27.7  29.8  34.5  39.2  46.1  56.6  60.3  57.9  49.7  39.0  31.6  28.1
 29.2  30.2  33.9  37.5  42.4  49.6  55.6  51.0  47.3  38.9  32.8  27.0
   638.2   -611.7    157.2    -63.3     46.0
   793.6   -581.5     80.8    -87.5     57.0
  1002.7   -539.8    -33.1    -80.7     26.5
  1108.5   -361.4   -168.4    -81.1     -5.3
  1243.6   -145.6   -293.3    -94.0    -38.2
  1311.1    -49.4   -338.7   -101.0    -51.0
  1257.5   -102.3   -320.3   -102.6    -45.3
  1160.0   -280.4   -235.6   -132.2    -11.9
  1112.8   -549.2    -90.8    -95.2     20.8
   901.6   -679.0     67.5    -67.1     48.1
   679.6   -603.7    126.6    -45.8     37.9
   538.8   -532.1    146.1    -45.9     36.2
 838. 1128. 1673. 2068. 2450. 2725. 2660. 2425. 2022. 1422.  904.  679.
 183.  333.  457.  576.  653.  651.  579.  465.  422.  286.  231.  167.
CIRA 1.0 LOC=RENO,NV, LAT=39.5, TWHT=20, ALT=4404
```

RICHMOTM.CTY

```
 .181  .165  .141  .092  .057  .047  .039  .041  .046  .088  .131  .164
 .16  .183  .204  .194  .162  .164  .143  .153  .131  .136  .149  .16
 .31459E-04  3.52243 28.5
 .17182E-01  1.74321 18.5
 .27714E-09  6.48270 35.0
 .26298E-01  1.69782 12.0
 39.8  44.1  51.2  64.8  70.9  77.6  82.2  81.6  75.3  63.5  55.2  45.4
 31.6  35.5  42.6  53.0  61.2  66.2  71.9  70.5  63.9  52.6  43.1  36.6
 31.5  35.1  40.5  50.0  59.3  65.7  71.0  68.3  64.5  53.6  43.2  36.1
   485.5   -383.9     92.9   -27.5     20.2
   600.0   -360.8     56.6   -50.5     30.5
   770.5   -354.1     -6.6   -36.8     14.6
   872.8   -229.0   -100.2   -48.0     -2.6
   918.2   -114.4   -145.6   -40.4    -16.8
   966.7    -41.8   -181.5   -58.4    -25.3
   935.7    -74.6   -161.1   -53.4    -19.9
   864.8   -162.2   -123.1   -75.4     -3.3
   810.1   -315.5    -40.8   -56.4     18.1
   645.5   -401.4     48.3   -28.1     23.2
   525.5   -391.4     84.7   -42.0     30.3
   426.0   -343.5     89.2   -33.6     25.6
 653.  880. 1231. 1522. 1680. 1856. 1770. 1631. 1398.  995.  740.  562.
 271.  417.  584.  713.  822.  826.  827.  686.  602.  418.  296.  239.
CIRA 1.0 LOC=RICHMOND,VA, LAT=37.5, TWHT=20, ALT=164
```

ROANOKTM.CTY

```
 .182  .167  .150  .099  .061  .044  .041  .036  .043  .103  .139  .171
 .164  .178  .225  .179  .156  .151  .126  .115  .115  .151  .141  .168
 .16993E-01  1.89228 18.0
 .51386E-09  6.29261 35.0
 .72675E-02  2.24043 15.0
 .10278E-16 11.25010 35.0
 38.4  42.8  48.7  61.7  69.7  78.1  80.5  79.3  74.9  61.7  52.1  42.4
 32.6  35.1  40.5  51.1  59.7  66.7  70.0  68.4  64.6  51.6  42.4  35.7
 30.6  32.8  37.5  47.9  57.4  62.9  67.5  66.9  63.8  48.9  41.0  33.9
   493.4   -369.4     81.6   -35.7     28.3
   618.3   -407.1     59.2   -31.0     24.5
   772.6   -371.6     -5.9   -31.0     10.5
   867.9   -264.0    -87.3   -32.8     -3.1
   922.5   -130.8   -148.3   -35.5    -18.8
  1000.9    -40.6   -195.6   -62.0    -29.3
   935.6    -66.0   -170.3   -59.9    -21.7
   843.2   -173.6   -125.4   -57.3    -10.6
   786.2   -313.4    -35.1   -46.2     12.7
   673.8   -432.4     50.6   -45.2     29.3
   534.5   -412.2     86.0   -35.9     26.8
   443.1   -369.2     92.5   -35.0     25.7
 660.  903. 1257. 1578. 1744. 1951. 1806. 1588. 1383. 1085.  744.  577.
 294.  386.  549.  676.  789.  824.  796.  642.  580.  373.  277.  221.
CIRA 1.0 LOC=ROANOKE,VA, LAT=37.3, TWHT=60, ALT=1149
```

ROCHNYTM.CTY

```
 .215  .217  .191  .148  .105  .061  .044  .042  .079  .123  .164  .203
 .252  .274  .262  .213  .249  .211  .141  .162  .165  .171  .231  .234
 .51815E-03  2.78855 24.5
 .36053E-01  1.64846 16.5
 .14228E-01  1.93286 17.0
 .49556E-02  2.18112 20.0
 23.5  23.5  33.0  46.1  56.0  69.9  72.6  70.4  63.5  53.2  42.4  28.6
 22.5  21.0  31.6  44.2  54.2  66.0  69.3  67.6  61.6  50.1  39.3  27.6
 20.9  20.3  29.8  40.0  49.4  60.8  63.7  62.3  56.9  46.4  37.6  26.4
   142.4    -84.8      13.7     -7.2       5.0
   279.2   -141.7        .1    -10.8       7.9
   470.1   -167.6     -44.6    -20.1       4.2
   705.0   -103.6    -130.0    -44.1      -5.6
   923.2    -19.3    -189.7    -50.7     -14.2
  1081.7     66.2    -226.9    -62.9     -20.9
  1063.0     26.9    -227.3    -55.6     -20.4
   844.6    -73.2    -185.0    -45.4     -13.6
   650.3   -170.3     -98.0    -27.1      -1.6
   389.5   -172.1     -23.1    -15.5       9.8
   187.3   -108.7      13.1     -5.5       4.8
   121.6    -74.4      12.7     -5.5       4.2
 166.  339.  612.  968. 1283. 1505. 1488. 1158.  846.  471.  217.  138.
 116.  224.  398.  640.  874.  999.  970.  737.  573.  314.  154.   99.
CIRA 1.0 LOC=ROCHESTER,NY, LAT=43.1, TWHT=60, ALT=547
```

ROCKSPTM.CTY

```
 .217  .217  .199  .174  .129  .091  .059  .064  .100  .151  .195  .218
 .318  .281  .303  .257  .251  .206  .195  .218  .16   .235  .207  .232
 .50603E-05  3.98284 31.0
 .38355E-01  1.73123 12.0
 .17549E-01  2.03482 13.5
 .17190E-02  2.78746 13.5
 25.4  25.2  33.0  43.8  56.4  64.9  76.4  73.9  63.1  48.7  34.6  25.2
 19.1  19.6  26.0  32.2  43.1  51.9  60.2  58.9  49.1  38.8  26.7  19.1
 19.0  20.2  25.2  30.7  39.9  45.0  51.2  47.3  41.9  34.4  26.1  20.0
   591.0   -567.2     151.1    -78.6      56.4
   775.0   -613.9      93.7    -61.3      41.8
   976.3   -557.7     -13.3    -93.1      32.4
  1108.0   -339.4    -168.2   -126.0       1.2
  1214.8   -151.2    -272.9   -108.2     -36.8
  1279.1    -40.7    -318.0   -126.7     -50.9
  1239.7   -119.7    -301.7   -119.3     -44.8
  1128.6   -288.2    -213.5   -128.1     -11.0
  1051.5   -525.6     -71.4   -108.4      27.2
   871.0   -677.7      80.5    -79.6      51.5
   631.9   -588.3     137.2    -57.3      42.2
   543.5   -571.7     163.0    -58.0      41.2
 742. 1072. 1578. 2017. 2315. 2558. 2590. 2234. 1850. 1326.  821.  640.
 175.  285.  411.  535.  643.  647.  538.  479.  403.  251.  186.  120.
CIRA 1.0 LOC=ROCK SPRINGS,WY, LAT=41.6, TWHT=20, ALT=6741
```

SALTLATM.CTY

```
 .204  .185  .162  .135  .096  .073  .064  .066  .086  .119  .172  .201
 .159  .185  .178  .181  .179  .151  .135  .174  .144  .149  .154  .151
 .83805E-06  4.46625 31.5
 .38249E-01  1.60832 15.0
 .53082E-03  2.85395 23.0
 .11052E-03  3.35123 21.5
 30.0  38.1  47.1  52.9  65.0  75.8  87.1  83.4  73.5  58.7  42.7  31.4
 24.8  31.5  36.7  43.5  50.8  60.1  69.5  65.3  56.6  45.1  34.7  25.9
 24.4  30.0  34.1  39.7  45.8  54.0  56.8  54.2  50.6  41.8  34.9  26.3
   478.4   -406.6    104.0    -25.3     20.2
   705.2   -555.9     92.0    -36.0     30.3
   927.6   -524.8     -6.0    -72.4     30.3
  1032.5   -343.7   -131.5    -68.7     -4.9
  1200.2   -146.7   -258.0   -106.6    -35.0
  1223.8    -81.4   -289.2    -88.9    -45.4
  1239.8   -157.9   -303.4    -74.3    -40.2
  1155.1   -315.1   -213.7    -99.1    -18.2
  1043.0   -502.9    -72.3   -100.9     23.7
   844.3   -622.2     73.7    -81.8     50.7
   558.6   -477.2    116.1    -48.1     34.8
   452.4   -419.9    122.2    -37.6     25.4
 596.  992. 1517. 1916. 2308. 2528. 2626. 2306. 1859. 1305.  746.  558.
 247.  303.  446.  586.  690.  649.  573.  507.  438.  298.  244.  193.
CIRA 1.0 LOC=SALT LAKE CITY,UT, LAT=40.8, TWHT=58, ALT=4221
```

SANFRATM.CTY

```
 .141  .129  .130  .116  .109  .095  .083  .078  .078  .092  .120  .141
 .169  .223  .243  .228  .25   .285  .298  .263  .214  .186  .166  .148
 .67896E-02  2.29959 11.0
 .20153E-02  2.46618 12.0
 .12677E-01  1.91386 13.5
 .10000E-30 20.00000 35.0
 50.7  54.6  54.6  57.8  60.0  62.9  65.0  65.6  67.1  63.5  56.6  51.0
 46.0  48.8  48.3  50.3  51.7  54.8  55.6  56.4  57.3  54.8  50.7  46.2
 44.9  48.1  46.6  48.9  50.8  53.8  55.4  55.8  55.6  52.4  49.9  45.0
   493.9   -401.8    101.1    -24.3     17.5
   706.9   -496.5     81.1    -52.4     33.4
   836.7   -429.8     -5.2    -47.0     20.4
  1001.8   -316.2   -131.9    -63.8       .9
  1069.6   -178.3   -208.7    -47.7    -23.3
  1108.2   -103.4   -250.6    -42.8    -34.8
  1074.1   -147.9   -246.6    -42.2    -31.3
   982.8   -301.7   -148.7    -38.1    -10.2
   934.3   -464.6    -40.9    -50.0     19.2
   762.7   -534.3     66.9    -31.4     26.6
   623.0   -521.2    119.1    -48.2     36.4
   464.9   -405.8    110.1    -25.8     18.7
 673. 1076. 1412. 1945. 2243. 2440. 2424. 2097. 1775. 1225.  892.  610.
 265.  366.  516.  611.  698.  679.  592.  544.  478.  373.  266.  225.
CIRA 1.0 LOC=SAN FRANCISCO,CA, LAT=37.6, TWHT=20, ALT=8
```

SANJUATM.CTY

```
 .018  .026  .024  .030  .045  .055  .053  .057  .051  .046  .037  .027
 .18  .168  .222  .248  .177  .221  .218  .177  .17  .135  .177  .145
 .10000E-30 20.00000 35.0
 .10000E-30 20.00000 35.0
 .64944E-05  4.86210 11.5
 .70769E-23 14.65182 35.0
 78.7  79.6  79.8  80.6  82.2  83.5  84.1  85.0  82.9  83.6  82.1  80.4
 73.1  72.2  73.3  75.3  77.4  78.1  77.5  77.8  78.0  76.6  74.7  73.3
 69.6  68.7  70.3  69.6  72.3  75.3  75.5  75.8  75.7  75.1  73.7  71.4
   723.9   -453.4     46.7    -46.0     38.6
   810.9   -370.9    -21.0    -52.5     30.3
   898.7   -216.2   -121.5    -69.0      7.6
   943.5    -24.8   -193.2    -61.4    -25.7
   907.3    134.7   -173.2    -64.6    -28.8
   956.0    215.9   -176.3    -64.0    -28.5
   915.7    178.2   -189.2    -55.7    -30.8
   881.8     62.9   -211.3    -74.2    -35.0
   845.4   -119.7   -147.3    -70.9     -5.5
   793.6   -285.0    -57.9    -74.6     29.4
   729.6   -408.5     21.4    -71.7     48.5
   698.0   -464.1     61.9    -51.9     43.3
 1323. 1512. 1793. 1938. 1769. 1891. 1894. 1863. 1691. 1515. 1378. 1260.
  395.  546.  694.  837.  879.  845.  775.  718.  701.  563.  403.  358.
CIRA 1.0 LOC=SAN JUAN,PR, LAT=18.4, TWHT=20, ALT=13
```

SANTAMTM.CTY

```
 .136  .128  .121  .114  .108  .103  .082  .083  .085  .095  .109  .123
 .107  .148  .169  .154  .153  .206  .116  .137  .126  .119  .167  .097
 .50054E-11  7.57960 35.0
 .92922E-02  2.10053 11.0
 .46281E-01  1.40725 14.5
 .10000E-30 20.00000 35.0
 55.2  56.9  57.5  59.8  61.3  61.6  67.3  66.0  66.1  63.5  60.4  57.5
 42.6  45.3  48.4  48.4  51.8  51.3  54.7  55.5  55.5  52.9  50.1  45.8
 43.5  46.3  49.0  49.3  51.2  52.7  55.6  56.3  55.6  54.0  49.9  47.2
   614.6   -541.1    117.8      5.4      6.5
   711.2   -511.5     72.6      7.0     10.3
   874.6   -480.0    -25.0      5.6      8.4
   982.8   -370.3   -132.3     30.7     -8.1
   971.9   -218.2   -192.2     43.7    -23.7
  1050.6   -156.7   -251.2     64.1    -17.5
  1018.4   -224.6   -240.6     78.7    -21.6
   972.8   -352.5   -178.4     60.7    -17.0
   898.4   -482.2    -42.8     47.5     -7.6
   835.7   -601.2     53.0     29.5      1.5
   675.3   -578.6    108.9      3.6     10.2
   599.9   -568.7    132.4      2.8      6.1
  843. 1101. 1549. 1920. 2043. 2394. 2367. 2108. 1688. 1366.  958.  802.
  264.  399.  502.  641.  698.  673.  595.  526.  533.  404.  275.  205.
CIRA 1.0 LOC=SANTA MARIA,CA, LAT=34.9, TWHT=24, ALT=236
```

SAVANNTM.CTY

```
.130  .132  .095  .055  .039  .041  .038  .045  .027  .049  .100  .127
.17  .218  .204  .183  .164  .158  .153  .151  .17  .179  .193  .153
.54249E-06  4.45066 35.0
.13201E-06  4.91616 32.5
.50036E-01  1.70480 10.0
.26681E-05  4.73119 16.5
53.4  54.6  63.2  72.2  77.5  82.7  83.1  84.2  79.2  72.4  60.9  55.1
45.1  44.6  52.1  58.8  66.3  72.9  74.4  74.9  71.3  62.1  51.7  44.8
44.5  44.9  51.0  58.4  64.8  70.1  73.5  74.2  70.9  61.1  51.9  45.7
  513.9   -368.9     75.9    -34.8     28.1
  659.7   -421.0     52.3    -38.0     29.7
  822.6   -355.9    -32.2    -34.0     13.7
  951.6   -173.2   -141.2    -81.7     -7.6
  915.5    -50.2   -176.3    -61.0    -23.3
  934.5     38.4   -192.8    -74.4    -30.6
  867.9      4.8   -170.5    -62.2    -26.2
  825.1    -91.9   -142.5    -79.5    -10.0
  727.2   -237.7    -42.5    -54.3     12.4
  720.2   -390.6     23.5    -63.1     36.9
  593.3   -423.6     76.9    -48.3     38.1
  533.5   -444.9    108.2    -40.0     31.3
758. 1069. 1421. 1788. 1815. 1873. 1683. 1610. 1320. 1219.  915.  785.
307.  391.  599.  757.  777.  797.  768.  675.  597.  455.  322.  243.
CIRA 1.0 LOC=SAVANNAH,GA, LAT=32.1, TWHT=20, ALT=46
```

SCOTTSTM.CTY

```
.213  .199  .184  .147  .105  .072  .058  .055  .095  .137  .178  .206
.246  .243  .22  .296  .254  .24  .193  .198  .202  .202  .258  .222
.70612E-03  2.68521 27.5
.12376E-08  6.03189 35.0
.10651E-01  1.99890 18.0
.38633E-13  9.15058 32.0
27.8  34.1  39.3  51.5  63.7  73.8  80.8  80.4  68.8  54.7  42.1  31.6
19.0  24.3  28.7  37.0  48.6  58.7  64.8  64.7  50.2  40.8  29.9  21.1
19.9  24.9  29.1  36.2  46.3  54.6  60.1  61.0  49.0  40.5  30.1  22.6
  531.7   -441.0     95.1    -70.9     53.5
  691.9   -463.8     62.0   -126.9     70.6
  812.9   -352.9    -40.0    -94.1     29.7
  940.0   -181.3   -123.5   -158.9      8.5
 1077.0    -46.3   -185.2   -152.2    -19.6
 1183.9     58.8   -235.3   -208.1    -39.0
 1179.0      4.3   -229.5   -202.4    -32.0
 1071.7   -185.7   -167.8   -155.6     -3.1
  978.9   -358.6    -75.2   -172.1     32.4
  718.9   -419.2     39.8   -138.9     60.9
  571.7   -459.7    104.8   -105.7     65.8
  434.4   -391.0    112.7    -86.0     58.0
622.  950. 1221. 1606. 1906. 2251. 2276. 1986. 1647. 1067.  733.  521.
236.  308.  512.  631.  794.  766.  731.  616.  510.  344.  230.  169.
CIRA 1.0 LOC=SCOTTSBLUFF,NE, LAT=41.9, TWHT=20, ALT=3957
```

SEATTLTM.CTY

```
 .174  .163  .160  .147  .118  .093  .079  .068  .093  .130  .150  .169
 .206  .198  .223  .21   .169  .193  .177  .163  .172  .137  .193  .277
 .26981E-01  1.93612 10.5
 .11003E-02  2.87282 12.5
 .12782E-08  6.01803 35.0
 .10000E-30 20.00000 35.0
 39.8  43.8  46.1  49.8  57.5  63.2  68.2  67.9  63.3  53.5  47.7  41.2
 38.0  40.7  39.8  43.4  49.4  54.9  57.2  59.0  54.1  48.7  44.8  39.4
 36.5  38.8  39.1  41.7  48.3  53.3  55.7  55.9  53.9  48.0  43.6  39.0
   236.9   -158.1      43.4      -1.9       1.1
   376.7   -251.7      51.0       9.0      -1.8
   633.5   -360.9      22.9      18.7      -2.6
   820.1   -303.7     -47.2      -4.2       2.9
   938.8   -253.3    -102.0       -.1      -4.2
   984.4   -274.0    -131.7      66.5     -13.9
  1068.6   -311.9    -163.6      31.5     -17.3
   975.3   -397.2     -93.3      29.3      -9.9
   740.0   -419.0       6.1      20.5      -2.2
   481.2   -320.9      51.9       6.1        .1
   271.9   -179.1      47.0      -5.5       4.5
   184.9   -140.7      39.3       1.9      -1.3
 279.  466.  897. 1293. 1645. 1761. 1994. 1678. 1146.  637.  330.  201.
 208.  303.  487.  713.  792.  826.  714.  679.  501.  344.  235.  142.
CIRA 1.0 LOC=SEATTLE,WA, LAT=47.5, TWHT=20, ALT=19
```

SHREVETM.CTY

```
 .138  .130  .096  .050  .040  .049  .061  .057  .045  .061  .111  .144
 .233  .204  .244  .201  .19   .156  .192  .154  .192  .221  .184  .192
 .44327E-02  2.30742 18.5
 .23374E-07  5.28302 35.0
 .24703E-11  7.85599 35.0
 .28751E-12  8.34891 35.0
 51.8  54.4  61.7  70.6  77.6  82.6  87.2  86.5  81.2  71.5  58.3  50.8
 43.6  45.5  52.3  61.8  69.0  73.1  76.9  76.0  72.4  61.0  49.7  42.6
 43.5  45.7  50.8  59.6  66.2  70.0  74.4  73.0  70.7  60.1  49.1  41.6
   553.8   -373.6      60.4     -54.1      39.7
   675.3   -363.0      19.9     -71.8      38.2
   829.4   -288.5     -75.0     -64.1      13.0
   887.3   -114.0    -124.5     -92.5      -3.0
  1069.9      5.0    -210.3     -84.8     -15.8
  1091.3    114.4    -227.1    -128.9     -35.8
  1105.2     43.3    -235.3     -77.8     -25.2
  1068.5    -32.5    -217.5    -133.5     -17.4
   865.3   -198.2    -103.9    -122.4      14.9
   778.3   -355.7      -9.1    -115.4      50.9
   624.4   -375.0      55.6    -118.1      67.2
   550.3   -398.5      59.8     -31.4      32.4
 767. 1006. 1346. 1529. 1922. 2059. 2027. 1892. 1517. 1249.  919.  701.
 332.  440.  616.  798.  915.  909.  901.  814.  650.  497.  361.  317.
CIRA 1.0 LOC=SHREVEPORT,LA, LAT=32.5, TWHT=20, ALT=254
```

SIOUXFTM.CTY

```
 .235  .222  .194  .145  .098  .061  .046  .046  .089  .123  .187  .219
 .224  .217  .306  .35  .27  .258  .214  .222  .242  .269  .233  .26
 .19568E-05  4.10581 35.0
 .34632E-01  1.71850 15.0
 .10201E-01  2.12483 16.0
 .13278E-08  6.03684 35.0
 16.8  22.9  34.8  51.5  63.3  75.9  79.5  77.7  64.3  57.7  37.2  23.6
 12.2  17.0  26.5  40.6  51.4  63.2  68.0  66.7  54.4  44.6  29.4  19.2
 12.9  18.0  27.9  39.7  49.4  60.3  65.5  64.7  54.8  42.7  30.3  19.3
   446.1   -405.7    106.9    -17.4     13.3
   607.8   -475.6     90.4    -40.0     29.8
   778.4   -384.0     -5.5    -73.0     29.7
   954.6   -272.9   -106.7    -89.8      3.2
   990.8   -171.8   -163.5    -60.5    -17.4
  1062.3   -143.8   -191.1    -43.8    -26.9
  1056.8   -181.4   -184.1    -50.6    -22.4
   941.3   -279.5   -123.2    -65.7     -6.7
   818.9   -391.3    -21.8    -65.2     18.9
   733.7   -545.7     80.4    -53.5     34.3
   499.0   -444.6    115.5    -44.1     31.1
   409.0   -382.2    110.9    -41.0     27.9
 523.  821. 1188. 1608. 1805. 2043. 2065. 1754. 1359. 1058.  624.  463.
 202.  289.  499.  671.  717.  759.  715.  570.  486.  319.  210.  174.
CIRA 1.0 LOC=SIOUX FALLS,SD, LAT=43.6, TWHT=17, ALT=1418
```

SPRINGTM.CTY

```
 .183  .176  .153  .106  .064  .036  .047  .042  .057  .097  .135  .182
 .278  .306  .298  .323  .184  .2  .234  .191  .266  .224  .233  .243
 .11698E-04  3.71563 32.5
 .13796E-03  3.04582 30.5
 .11784E-07  5.77921 30.0
 .25591E-02  2.49937 18.0
 36.0  39.9  45.3  57.0  66.5  73.2  78.7  78.0  69.8  58.6  49.5  36.6
 33.3  34.0  40.8  51.8  63.7  71.5  75.3  73.9  67.5  55.3  46.0  33.6
 31.5  33.1  37.6  48.0  58.1  66.9  69.5  69.6  62.4  50.6  43.1  31.4
   306.8   -225.6     23.8     -6.9      7.3
   446.4   -232.9    -24.8    -23.2     14.1
   603.4   -207.0    -80.3    -28.7      1.7
   843.1    -73.2   -201.1    -68.8    -13.9
   965.3     18.3   -227.6    -53.8    -25.6
  1132.0    117.6   -271.0    -69.7    -28.5
  1142.1     95.7   -288.8    -70.5    -33.4
  1004.9    -30.0   -280.2    -69.7    -31.1
   813.4   -187.3   -169.1    -42.2    -10.0
   499.9   -227.3    -56.7    -22.4     11.5
   410.5   -246.4     -8.5    -24.3     16.6
   278.9   -239.6     31.7      3.7      2.1
 356.  552.  816. 1193. 1413. 1651. 1663. 1456. 1101.  624.  459.  299.
 155.  276.  454.  698.  847.  986.  950.  738.  615.  316.  227.  104.
CIRA 1.0 LOC=SPRINGFIELD,MO, LAT=37.2, TWHT=20, ALT=1268
```

SYRACUTM.CTY

```
 .219  .213  .191  .139  .095  .056  .045  .044  .070  .129  .164  .197
 .262  .204  .277  .235  .196  .19  .176  .16  .201  .211  .218  .259
 .38656E-03  2.85773 24.5
 .18356E-07  5.31592 35.0
 .25663E-02  2.54974 16.5
 .21295E-03  3.33233 17.5
 23.1  26.7  34.6  51.9  62.0  71.3  75.8  74.3  67.2  54.1  42.4  31.1
 19.3  21.2  30.5  43.2  53.4  61.6  65.0  64.3  58.1  46.4  39.1  27.9
 19.2  21.7  29.3  41.4  52.0  58.9  62.8  62.7  56.8  45.2  37.2  27.3
   307.0   -210.7     56.6    -15.8     10.2
   396.1   -231.7     41.8    -16.9     12.1
   590.5   -271.1      6.1    -21.7      9.1
   800.9   -242.7    -74.4    -43.7      1.4
   898.8   -140.5   -117.1    -55.8     -8.1
   943.7   -117.3   -146.7    -40.8    -18.2
   946.2   -161.5   -137.0    -32.3    -16.8
   862.8   -256.6    -85.9    -35.7     -2.5
   715.5   -312.3     -7.0    -41.7     14.2
   523.2   -300.8     43.1    -24.9     16.9
   306.8   -207.7     52.9    -12.2      8.1
   240.0   -164.1     46.7    -11.5      7.9
 379.  526.  865. 1336. 1572. 1736. 1756. 1553. 1142.  738.  394.  291.
 243.  330.  500.  648.  816.  818.  798.  678.  557.  408.  241.  199.
CIRA 1.0 LOC=SYRACUSE,NY, LAT=43.1, TWHT=21, ALT=410
```

TALLAHTM.CTY

```
 .121  .122  .078  .052  .046  .046  .045  .041  .031  .041  .095  .119
 .144  .16  .171  .14  .155  .165  .1  .102  .117  .137  .118  .116
 .12853E-01  2.03348 17.0
 .73833E-05  3.95943 28.0
 .26525E-01  1.98615 10.0
 .21265E-08  5.64629 35.0
 56.0  56.7  65.2  73.6  79.2  83.3  84.3  83.9  81.4  74.9  63.2  56.8
 46.0  46.5  55.2  61.7  66.0  71.9  75.6  74.0  73.1  64.0  51.2  46.7
 46.7  46.4  54.6  60.6  65.8  70.0  74.5  74.1  71.8  63.5  52.1  48.6
   588.4   -395.5     74.7    -29.9     24.8
   725.1   -424.0     42.0    -40.3     29.5
   850.9   -312.5    -44.3    -46.9     14.4
   963.1   -185.5   -149.1    -52.6     -8.1
   962.2    -56.8   -182.2    -38.2    -23.1
   945.9     19.3   -187.6    -38.3    -27.3
   901.8     10.1   -167.6    -58.0    -23.4
   898.5    -80.6   -165.0    -84.5    -12.7
   821.8   -243.5    -69.1    -63.1     11.9
   724.8   -353.8     12.5    -69.0     35.0
   632.6   -432.2     76.8    -46.2     35.5
   551.5   -393.9     84.9    -29.1     24.8
 870. 1173. 1455. 1822. 1901. 1889. 1761. 1730. 1488. 1251.  992.  799.
 390.  478.  693.  794.  860.  861.  851.  756.  672.  498.  372.  352.
CIRA 1.0 LOC=TALLAHASSEE,FL, LAT=30.4, TWHT=25, ALT=55
```

TAMPA-TM.CTY

```
 .081  .083  .049  .043  .033  .043  .053  .053  .040  .039  .053  .076
 .171  .206  .193  .223  .233  .205  .233  .141  .175  .176  .177  .168
 .37209E-07  5.14647 35.0
 .28188E-10  7.14599 35.0
 .72089E-02  2.29595 12.0
 .14393E-02  3.00799 10.0
 64.0  64.7  72.3  74.7  81.1  83.5  84.4  84.9  83.3  77.9  72.3  65.5
 55.2  54.9  61.2  64.3  71.8  75.5  77.1  77.4  75.3  68.0  61.3  54.8
 54.6  54.3  60.9  61.4  68.7  74.4  74.7  75.0  74.2  66.5  60.8  55.1
   666.6   -478.0     84.4    -39.4     34.3
   717.2   -370.4     19.9    -48.9     31.9
   912.6   -333.8    -67.4    -52.2     13.2
   986.3   -137.2   -170.9    -72.9    -14.2
   995.1     22.2   -214.8    -80.0    -34.4
   958.3     85.5   -188.5    -67.9    -31.8
   916.1     52.3   -182.9    -67.2    -28.8
   869.0    -39.0   -162.7    -87.8    -16.1
   847.8   -208.2    -88.4    -73.7     10.5
   760.1   -356.3     -8.4    -75.1     38.0
   692.9   -476.4     73.0    -51.6     40.8
   621.1   -465.4     96.1    -40.1     34.1
 1042. 1183. 1658. 1898. 2005. 1859. 1812. 1664. 1519. 1340. 1134.  955.
  364.  514.  670.  813.  831.  898.  845.  769.  730.  498.  367.  334.
CIRA 1.0 LOC=TAMPA,FL, LAT=28.0, TWHT=22, ALT=19
```

TONOPATM.CTY

```
 .197  .177  .160  .133  .095  .064  .058  .064  .075  .125  .167  .196
 .172  .167  .268  .262  .226  .241  .19  .209  .196  .232  .209  .199
 .31648E-01  1.74477 15.5
 .18728E-05  4.71065 21.5
 .27862E-01  1.94447 11.5
 .12798E-09  6.70634 35.0
 35.7  43.6  48.5  55.6  65.0  76.9  82.5  80.9  73.4  59.2  46.3  34.8
 24.0  30.7  35.8  39.8  49.1  61.1  66.6  63.1  53.8  41.8  34.5  26.8
 25.2  30.7  32.3  35.3  40.6  47.4  54.7  50.4  44.4  37.9  32.0  26.5
   708.6   -713.3    168.0    -59.9     47.7
   852.3   -662.0     87.8    -74.6     53.6
  1022.6   -550.7    -42.1    -84.2     30.0
  1173.1   -362.9   -213.2   -101.9     -9.7
  1280.6   -105.1   -326.2   -127.3    -40.7
  1295.1    -19.1   -353.8   -102.4    -52.1
  1247.0    -53.4   -333.6   -121.0    -47.3
  1150.0   -278.6   -248.6   -113.3    -17.2
  1119.7   -543.7   -106.2    -89.5     20.5
   957.9   -718.1     58.9    -70.3     48.0
   766.1   -722.7    151.1    -72.5     58.4
   635.1   -651.9    168.9    -58.4     48.1
  939. 1275. 1730. 2272. 2619. 2746. 2678. 2425. 2055. 1545. 1065.  816.
  127.  288.  444.  512.  607.  616.  561.  456.  420.  271.  164.  134.
CIRA 1.0 LOC=TONOPAH,NV, LAT=38.1, TWHT=20, ALT=5426
```

TOPEKATM.CTY

```
 .207  .193  .164  .095  .063  .043  .039  .057  .063  .093  .148  .196
 .183  .189  .209  .227  .171  .156  .14  .143  .21  .174  .166  .189
 .19518E-03  3.03048 27.5
 .44938E-02  2.34009 17.5
 .16127E-08  5.99308 35.0
 .28288E-02  2.48491 15.0
 29.1  36.0  45.6  62.3  72.1  78.7  81.9  85.2  73.4  64.1  49.2  33.4
 22.5  27.4  35.0  51.3  60.0  68.6  72.5  73.1  61.7  51.7  39.0  26.7
 22.9  28.5  34.2  48.9  58.7  67.0  70.8  69.5  60.6  52.7  39.4  26.6
   545.0   -467.2    111.3    -45.4     33.9
   650.7   -484.3     73.2    -26.7     23.4
   803.1   -395.4    -15.3    -48.4     16.2
   929.2   -232.3   -113.1    -90.1      3.5
  1023.3   -138.9   -190.7    -60.5    -23.1
  1056.4    -56.0   -217.2    -72.3    -31.9
  1055.9   -130.4   -217.6    -48.1    -31.1
   965.3   -238.9   -144.9    -68.6    -12.7
   841.3   -359.3    -52.9    -57.6     13.5
   720.7   -483.6     50.7    -51.5     33.1
   590.6   -501.3    110.7    -39.4     30.7
   448.5   -385.7    102.5    -34.1     24.4
  705.  939. 1279. 1638. 1969. 2086. 2158. 1903. 1480. 1137.  795.  564.
  238.  317.  512.  688.  741.  775.  701.  604.  513.  346.  248.  220.
CIRA 1.0 LOC=TOPEKA,KS, LAT=39.1, TWHT=72, ALT=877
```

TUCSONTM.CTY

```
 .125  .120  .085  .067  .068  .080  .079  .071  .051  .059  .095  .118
 .185  .156  .165  .179  .197  .214  .195  .179  .195  .196  .176  .201
 .20235E-01  1.91231 15.0
 .30605E-10  7.11110 35.0
 .34046E-01  1.80942 12.0
 .53475E-02  2.52246 11.5
 57.5  59.8  68.0  75.3  83.3  91.9  90.9  89.8  85.2  77.7  64.5  58.3
 45.4  43.6  51.2  58.7  64.6  77.2  79.9  78.0  74.0  62.1  51.0  45.0
 43.0  39.1  42.9  47.5  51.0  57.7  66.4  67.9  61.5  53.6  45.1  40.0
   723.3   -629.8    125.9    -53.2     47.7
   847.7   -626.2     63.0    -59.5     48.7
  1004.4   -455.2    -75.7    -95.4     28.8
  1156.0   -220.5   -253.6   -140.2    -19.1
  1208.3    -15.3   -347.4   -116.3    -55.7
  1207.0    100.0   -347.1   -120.7    -61.2
  1020.8     20.2   -257.4    -99.8    -40.2
  1009.7   -142.2   -220.0   -102.1    -23.5
   970.8   -365.5   -101.8   -106.6     23.8
   896.1   -585.8     23.7    -90.9     52.3
   763.0   -644.2    112.3    -66.7     53.3
   666.5   -621.3    148.4    -64.3     50.7
 1082. 1415. 1873. 2385. 2682. 2714. 2306. 2178. 1948. 1631. 1205. 1001.
  235.  294.  480.  538.  565.  616.  622.  563.  486.  294.  216.  178.
CIRA 1.0 LOC=TUCSON,AZ, LAT=32.1, TWHT=20, ALT=2584
```

TULSA-TM.CTY

```
 .181  .165  .135  .085  .050  .049  .067  .055  .058  .069  .127  .168
 .23  .209  .266  .251  .203  .231  .213  .231  .234  .188  .235  .214
 .82343E-04  3.20266 31.5
 .19712E-01  1.72469 18.5
 .21433E-02  2.47203 19.0
 .82588E-02  2.34206 11.5
 39.2  44.9  53.0  66.0  74.4  82.5  88.3  86.9  77.2  70.6  53.8  43.4
 31.0  35.6  43.4  55.3  64.1  72.3  77.2  74.1  67.5  59.4  45.2  35.1
 30.9  35.2  40.3  51.7  62.7  69.9  73.0  69.6  65.9  57.7  43.9  35.6
   539.1   -443.1    101.9    -51.4     38.3
   631.2   -414.2     54.5    -18.2     17.4
   805.7   -358.3    -24.0    -58.8     22.2
   887.4   -227.2   -104.6    -45.5     -5.5
   976.5   -104.6   -172.3    -51.8    -21.6
  1016.1    -45.7   -203.0    -48.5    -28.7
  1003.0    -71.2   -207.3    -57.0    -26.7
   951.9   -185.9   -159.2    -78.6    -13.4
   809.6   -306.6    -54.1    -54.7     13.1
   703.1   -437.8     44.2    -47.2     30.8
   591.9   -446.8     87.0    -45.0     33.4
   478.3   -395.9     98.6    -41.0     30.0
 730.  933. 1328. 1575. 1848. 2030. 2050. 1906. 1438. 1148.  844.  636.
 248.  394.  559.  725.  819.  818.  748.  633.  573.  396.  303.  236.
CIRA 1.0 LOC=TULSA,OK, LAT=36.2, TWHT=23, ALT=650
```

WASHINTM.CTY

```
 .195  .189  .153  .110  .075  .049  .039  .042  .047  .100  .142  .179
 .139  .155  .18  .154  .184  .103  .115  .099  .103  .108  .141  .13
 .62981E-06  4.40022 35.0
 .82693E-03  2.75107 19.5
 .73793E-02  2.22749 15.0
 .22031E-02  2.74459 13.0
 33.8  37.3  47.9  60.3  68.2  76.1  81.6  80.3  74.9  61.8  51.1  39.1
 27.6  28.9  38.8  49.7  58.8  63.9  70.2  68.3  63.7  51.8  42.2  34.8
 27.0  29.4  38.6  47.3  55.3  64.1  69.2  66.8  63.9  52.4  42.0  32.5
   471.1   -399.5     95.3     -8.2     10.1
   571.5   -401.2     59.3      3.2      6.1
   736.5   -394.5     -8.0     12.9      2.6
   838.3   -295.1    -93.0      2.0     -2.8
   904.3   -171.8   -148.6     -2.0    -12.0
   935.3   -110.9   -167.7    -20.3    -16.5
   925.9   -155.4   -160.3     17.0    -16.9
   896.0   -239.8   -129.2    -24.2     -5.2
   754.1   -358.1    -25.5     -8.1      9.0
   647.0   -438.4     55.0      1.0     10.1
   509.2   -392.0     79.9     -9.0     12.4
   400.6   -347.8     86.8      4.5      -.1
 608.  813. 1180. 1482. 1708. 1891. 1716. 1699. 1312.  982.  676.  489.
 240.  350.  508.  631.  745.  745.  814.  655.  524.  392.  295.  211.
CIRA 1.0 LOC=WASHINGTON,DC, LAT=39.0, TWHT=93, ALT=10
```

WILMINTM.CTY

```
 .199  .192  .161  .123  .082  .033  .037  .031  .048  .093  .146  .180
 .222  .239  .223  .226  .204  .17   .173  .163  .146  .153  .191  .223
 .44577E-01  1.61461 15.0
 .19992E-03  2.97393 24.0
 .16095E-01  2.09554 11.5
 .22746E-01  1.93865 10.0
 31.6  35.0  45.7  56.8  64.4  76.0  80.7  79.2  72.3  62.9  48.6  38.4
 27.0  29.4  38.6  47.6  55.8  67.2  71.1  69.8  63.3  52.9  43.0  34.1
 26.4  28.7  37.7  45.8  53.2  64.0  67.2  67.3  61.4  53.2  41.7  32.3
   445.9    -361.9     90.8    -24.2     18.0
   578.8    -377.5     64.3    -45.5     28.7
   696.8    -308.7     -7.8    -50.9     19.5
   847.6    -243.7    -93.2    -43.1      -.9
   915.8    -151.6   -138.2    -28.5    -15.5
   970.9     -78.6   -166.3    -55.3    -19.8
   964.5    -106.4   -166.1    -54.4    -20.0
   882.4    -212.9   -106.3    -63.8      -.2
   782.6    -342.6    -17.7    -44.0     17.2
   659.8    -422.2     56.4    -39.3     28.5
   470.9    -343.9     79.8    -23.4     17.3
   393.5    -323.6     88.1    -21.3     15.7
  576.  828. 1106. 1484. 1663. 1864. 1859. 1645. 1334. 1011.  633.  495.
  247.  369.  525.  666.  796.  831.  788.  689.  573.  404.  305.  229.
CIRA 1.0 LOC=WILMINGTON,DE, LAT=39.7, TWHT=20, ALT=74
```

YAKUTATM.CTY

```
 .211  .204  .195  .183  .157  .140  .120  .123  .142  .170  .195  .211
 .177  .145  .182  .124  .169  .158  .15   .173  .177  .179  .177  .17
 .15730E-02  2.95155 11.0
 .27342E-02  2.38439 13.5
 .10000E-30 20.00000 35.0
 .10000E-30 20.00000 35.0
 24.8  28.9  31.8  37.4  44.5  49.6  54.6  54.1  49.3  40.2  31.3  25.1
 23.9  26.5  30.5  33.9  43.3  48.4  52.8  52.5  47.3  40.0  30.7  24.0
 22.9  26.4  29.0  33.3  41.0  46.3  51.1  51.8  46.4  38.1  30.0  23.3
    16.0     -10.5      2.9     -1.1       .5
   139.3    -102.1     13.7      1.3      1.1
   340.8    -157.4    -10.4     -8.1      4.7
   671.4    -175.8    -93.6    -28.2      -.9
   810.1     -70.6   -104.7    -33.7      4.5
   923.5     -18.5   -118.5    -50.8      4.8
   833.2     -46.1   -110.4    -26.6      7.8
   548.1     -97.7    -64.8    -23.4      1.9
   393.5    -134.5    -33.8    -12.8      3.5
   181.6     -95.7      5.3     -6.4      4.3
    39.6     -24.6      5.9     -2.5      1.4
     5.3      -3.8      1.2      -.5       .2
   16.  128.  385.  811. 1030. 1211. 1083.  687.  467.  195.   41.    5.
   14.   90.  289.  568.  815.  927.  829.  553.  360.  155.   35.    4.
CIRA 1.0 LOC=YAKUTAT,AK, LAT=59.5, TWHT=20, ALT=28
```

YUCCAFTM.CTY

```
.177  .170  .152  .112  .088  .076  .080  .080  .084  .104  .144  .189
.17  .156  .151  .18  .292  .167  .173  .163  .151  .146  .141  .108
.36565E-06  4.73764 31.0
.19764E-04  3.63756 29.0
.54123E-02  2.23110 19.0
.10663E-02  2.63352 23.0
44.1  46.6  52.3  61.9  70.7  84.1  89.7  87.1  79.7  66.0  54.1  38.1
29.8  30.8  35.3  43.9  53.1  63.2  69.2  65.8  57.8  44.7  37.0  27.5
30.3  30.7  32.8  39.5  43.1  51.4  54.7  53.3  47.5  40.4  35.4  29.3
  689.9   -649.8    155.4    -63.5    48.2
  836.8   -640.4     84.8    -63.3    47.3
 1014.6   -518.0    -52.5    -95.9    37.1
 1141.0   -322.5   -202.8    -96.0    -7.7
 1241.9   -106.4   -310.3   -102.3   -39.7
 1277.7     -6.5   -353.1   -103.6   -54.0
 1234.9    -75.6   -337.7    -88.6   -49.7
 1112.7   -286.5   -243.4    -80.4   -21.3
 1097.1   -521.8   -110.9    -91.1    20.2
  950.5   -673.0     50.6   -103.7    56.6
  717.3   -633.0    134.3    -68.3    50.7
  615.2   -601.5    154.9    -48.2    39.2
946. 1291. 1768. 2159. 2558. 2770. 2704. 2382. 2084. 1562. 1028.  815.
190.  302.  456.  603.  650.  613.  557.  452.  397.  277.  218.  174.
CIRA 1.0 LOC=YUCCA FLATS,NV, LAT=37.0, TWHT=20
```

YUMA--TM.CTY

```
.108  .079  .070  .061  .064  .089  .121  .121  .095  .052  .069  .094
.176  .171  .182  .174  .171  .178  .226  .216  .171  .146  .158  .173
.48089E-02  2.32930 15.0
.28510E-06  5.14165 22.5
.17209E-01  1.99454 13.0
.11888E-01  2.04527 12.5
60.3  68.2  72.5  78.6  88.2  94.3  99.6  99.6  94.3  81.5  71.3  63.2
49.6  52.5  57.1  63.3  72.1  77.6  85.8  85.9  81.3  67.0  57.4  51.1
46.0  44.4  48.6  51.9  58.0  61.1  71.0  72.7  68.6  57.1  49.7  44.9
  779.1   -469.2     32.9   -139.1    91.8
  969.0   -483.8    -34.6   -180.9    99.2
 1173.3   -314.3   -182.8   -193.1    39.8
 1284.1    -34.3   -292.3   -269.4    -1.1
 1465.7    186.8   -373.7   -238.8   -44.6
 1502.0    395.6   -378.9   -330.3   -76.4
 1402.6    250.2   -343.2   -225.3   -48.0
 1272.5     64.0   -310.1   -248.0   -16.1
 1160.6   -193.0   -205.6   -242.1    29.6
 1098.2   -460.2   -109.7   -137.6    61.4
  861.5   -533.4     19.4   -122.3    87.9
  727.7   -528.0     59.5    -70.5    65.6
1008. 1399. 1831. 2301. 2639. 2802. 2489. 2277. 1965. 1552. 1141.  901.
433.  509.  737.  797.  939.  901.  953.  829.  738.  659.  442.  365.
CIRA 1.0 LOC=YUMA,AZ, LAT=32.7, TWHT=20, ALT=194
```

CALIFORNIA CLIMATE ZONES

ARCATA01.CTY

```
 .157  .145  .146  .137  .127  .123  .118  .097  .102  .116  .125  .140
 .091  .135  .124  .112  .131  .111  .103  .08  .07  .09  .086  .076
 .31169E-07  6.42176 16.5
 .83579E-02  2.22924 10.5
 .10325E-15 10.53281 35.0
 .10000E-30 20.00000 35.0
 47.7  49.9  50.2  53.6  56.0  57.3  58.1  61.1  60.1  57.4  55.2  51.4
 39.2  44.6  44.1  45.5  48.0  48.4  49.8  54.8  54.4  51.1  49.4  45.1
 40.4  44.5  45.2  47.5  49.3  50.0  51.2  56.1  55.3  52.1  49.7  45.7
   571.7   -479.8    104.0     -4.2     10.3
   568.8   -374.4     55.8      8.2      1.2
   708.1   -352.2     -2.5     10.1      1.6
   937.0   -373.3    -99.9     31.8    -11.3
  1013.2   -224.1   -170.7     18.5    -17.4
  1089.5   -203.3   -211.5     55.3    -23.1
  1022.1   -244.5   -174.7     69.5    -21.7
   865.5   -286.9    -98.1     48.5    -16.8
   730.7   -330.8    -16.8     25.6     -5.6
   582.0   -342.1     34.5     17.1     -1.5
   489.1   -359.9     78.0      2.4      3.6
   435.8   -353.0     87.8     -1.0      4.0
 676.  761. 1044. 1635. 1862. 2087. 1937. 1457. 1112.  803.  619.  510.
 298.  408.  578.  676.  806.  826.  815.  760.  644.  466.  336.  273.
CIRA 1.0 LOC=CEC ARCATA,CA,LAT=40.6, TWHT=88, REGION=01, ALT=34
```

SANTAR02.CTY

```
 .152  .138  .123  .107  .083  .078  .073  .079  .078  .092  .123  .144
 .087  .115  .151  .146  .166  .153  .139  .124  .103  .1  .093  .065
 .36122E-03  3.04377 19.5
 .62404E-01  1.58124 10.0
 .96267E-06  4.18542 35.0
 .10000E-30 20.00000 35.0
 48.8  54.0  58.6  63.5  67.4  72.2  74.8  73.3  74.2  67.7  58.4  51.1
 40.7  43.2  45.0  47.6  50.9  54.9  56.6  55.1  55.5  51.4  45.1  42.7
 42.7  45.9  47.4  50.2  51.9  57.3  58.7  58.7  57.0  52.5  46.4  43.6
   616.3   -509.9    113.1     13.9     -2.3
   780.4   -569.9     72.8     13.1      6.4
   920.7   -515.1    -16.3      4.6      5.7
  1098.1   -418.4   -165.3     -1.4    -11.8
  1083.1   -250.6   -211.2     28.4    -23.3
  1150.8   -199.4   -262.5     48.3    -28.6
  1165.7   -233.7   -265.4     29.5    -28.6
  1051.7   -388.6   -159.3     41.5    -14.8
  1011.3   -553.8    -56.5     20.6       .9
   834.7   -595.0     63.9     18.9      6.5
   640.8   -506.3    103.6     12.3       .7
   515.7   -420.8    100.3     14.0     -5.0
 756. 1075. 1466. 2020. 2103. 2407. 2470. 2080. 1780. 1256.  833.  618.
 345.  434.  560.  619.  760.  731.  684.  647.  536.  452.  373.  317.
CIRA 1.0 LOC=CEC SANTA ROSA,CA, LAT=38.8, TWHT=20, REGION=02, ALT=167
```

OAKLAN03.CTY

```
.141  .135  .130  .101  .102  .086  .086  .069  .084  .088  .109  .139
.107  .177  .207  .179  .234  .187  .178  .216  .198  .18  .127  .106
.51630E-02  2.29503 13.0
.84490E-02  2.06103 10.0
.44847E-01  1.56166 11.0
.10000E-30 20.00000 35.0
51.6  52.5  54.6  62.1  60.7  65.7  64.0  67.6  63.9  62.7  59.3  51.2
44.0  48.0  48.4  52.9  53.5  56.2  55.8  59.0  57.4  56.5  51.9  46.9
41.7  46.0  46.0  50.7  50.4  53.7  54.4  57.1  55.7  54.5  50.7  46.1
  678.2   -584.8   122.2    5.7     7.7
  650.1   -441.7    53.8   16.0     1.7
  898.2   -505.6   -22.9   24.7    -1.9
 1078.3   -441.3  -159.4   35.5   -16.6
 1111.0   -240.7  -234.6   17.1   -25.8
 1117.2   -207.8  -248.2   68.0   -24.9
 1090.2   -254.9  -229.1   80.3   -27.0
 1036.7   -390.9  -158.7   58.8   -19.1
  904.5   -496.4   -34.5   53.5    -8.3
  727.7   -490.6    44.0   28.6    -1.5
  647.7   -518.9   102.1   14.7      .9
  492.7   -403.2    92.9   12.7    -2.8
 854.  901. 1436. 2030. 2256. 2374. 2293. 2080. 1573. 1083.  852.  600.
 319.  422.  551.  607.  710.  738.  721.  638.  575.  444.  359.  294.
CIRA 1.0 LOC=CEC OAKLAND,CA, LAT=37.7, TWHT=20, REGION=03, ALT=6
```

SUNNYV04.CTY

```
.145  .121  .124  .101  .105  .067  .056  .049  .067  .085  .119  .145
.087  .115  .151  .146  .166  .153  .139  .124  .103  .1  .093  .065
.69417E-02  2.38359 11.5
.10461E-01  2.25051 10.0
.35896E-01  1.60887 12.0
.41538E-12  8.11097 35.0
49.9  56.7  56.7  62.4  60.7  69.1  70.9  69.0  69.6  65.4  57.3  49.8
44.1  49.5  48.5  51.2  52.5  60.1  61.7  62.4  59.0  55.9  49.4  45.0
44.2  48.8  48.2  51.0  51.1  58.3  59.4  60.4  57.2  53.4  47.6  44.2
  614.5   -503.6   109.5   14.4    -2.0
  777.4   -560.1    67.6   13.7     6.3
  915.9   -501.4   -23.5    5.2     5.3
 1091.1   -398.1  -175.1    -.8   -13.3
 1077.6   -229.7  -219.2   29.0   -24.6
 1143.8   -174.4  -270.6   49.1   -29.3
 1158.6   -207.9  -274.5   30.3   -29.8
 1044.7   -367.4  -169.0   42.1   -16.3
 1004.8   -536.0   -65.6   21.3      .1
  830.3   -583.1    57.6   19.5     6.6
  638.6   -499.3    99.8   12.8      .9
  514.5   -416.0    97.7   14.5    -4.8
 775. 1096. 1485. 2036. 2110. 2412. 2477. 2093. 1801. 1278.  851.  633.
 345.  434.  560.  618.  760.  730.  684.  647.  535.  451.  373.  317.
CIRA 1.0 LOC=CEC SUNNYVALE,CA, LAT=37.4, TWHT=20, REGION=04, ALT=130
```

SANTAM05.CTY

```
 .136  .128  .121  .114  .108  .103  .082  .083  .085  .095  .109  .123
 .107  .148  .169  .154  .153  .206  .116  .137  .126  .119  .167  .097
 .53862E-11  7.55842 35.0
 .54914E-02  2.28693 11.5
 .46233E-01  1.40748 14.5
 .10000E-30 20.00000 35.0
 55.2  56.9  57.5  59.8  61.3  61.6  67.3  66.0  66.1  63.5  60.4  57.5
 42.6  45.3  48.4  48.4  51.8  51.3  54.7  55.5  55.5  52.9  50.1  45.8
 43.3  46.3  48.9  49.3  51.2  52.7  55.6  56.4  55.7  54.0  49.9  47.1
   614.8    -528.9     115.2      -8.4      14.5
   696.1    -483.7      70.5     -18.3      21.0
   866.3    -457.4     -27.1     -15.3      12.3
   979.4    -361.4    -133.0      20.5      -8.3
   973.0    -220.6    -194.6      48.4     -23.3
  1041.8    -151.0    -249.9      50.3     -21.0
  1017.0    -205.7    -241.1      57.7     -23.4
   973.1    -337.3    -179.2      44.8     -16.8
   901.8    -485.8     -49.8      55.4     -10.2
   855.0    -620.3      41.1      53.8      -6.7
   694.3    -601.6     104.7      26.1        .6
   624.7    -580.9     125.7      12.1       2.8
 841. 1085. 1532. 1904. 2027. 2379. 2360. 2098. 1670. 1344.  952.  807.
 274.  393.  499.  639.  698.  662.  592.  527.  534.  419.  287.  231.
CIRA 1.0 LOC=CEC SANTA MARIA,CA, LAT=34.9, TWHT=24, REGION=05, ALT=236
```

LONGBE06.CTY

```
 .118  .113  .095  .086  .078  .054  .035  .031  .042  .066  .084  .114
 .11  .132  .137  .138  .16  .132  .134  .137  .137  .109  .128  .13
 .12761E-09  6.65263 35.0
 .18328E-02  2.71514 10.5
 .28097E-01  1.82280 11.0
 .10845E-26 17.42680 35.0
 58.1  60.1  62.7  64.9  65.3  71.7  75.3  75.2  74.6  70.7  64.9  58.5
 48.9  50.5  53.7  55.7  58.5  61.8  65.7  66.7  64.9  59.3  55.3  50.1
 46.9  47.9  50.4  52.5  55.3  60.5  62.0  64.6  60.8  56.5  52.9  46.0
   675.4    -574.7     113.4       7.1       8.8
   832.5    -625.3      65.9      21.1       7.3
   926.7    -522.0     -25.5      35.8      -1.5
  1006.9    -330.2    -157.1      16.0     -12.2
   983.8    -209.2    -190.9      63.4     -21.2
   979.9    -161.3    -217.4      90.0     -20.8
  1026.3    -174.3    -249.4      57.6     -27.1
   969.6    -346.4    -173.8      75.8     -21.0
   913.7    -452.8     -68.3      43.9      -8.9
   841.7    -600.4      43.2      38.1       -.7
   708.2    -601.2     109.5      17.1       3.2
   667.7    -611.7     134.8       7.2       7.0
 928. 1281. 1587. 1941. 1981. 2110. 2300. 2083. 1677. 1356. 1023.  896.
 305.  386.  562.  681.  782.  743.  646.  577.  568.  414.  299.  256.
CIRA 1.0 LOC=CEC LONG BEACH,CA, LAT=33.8, TWHT=20, REGION=06, ALT=25
```

SANDIE07.CTY

```
 .107  .110  .113  .086  .077  .069  .040  .026  .040  .064  .090  .109
 .109  .145  .136  .15  .152  .151  .144  .138  .136  .132  .11  .111
 .14849E-02  2.83754 11.0
 .55150E-14  9.07520 35.0
 .11741E-02  3.06883 10.0
 .29811E-34 22.21393 35.0
 60.3  58.4  58.8  63.9  64.3  65.2  69.5  72.2  69.7  66.6  62.4  59.1
 51.3  53.3  51.5  56.7  58.7  60.2  63.6  65.9  64.0  60.4  56.2  52.6
 47.8  50.9  48.9  54.9  55.5  57.9  61.3  63.6  61.6  58.3  54.1  50.9
   752.2   -616.4    106.3     5.2     13.3
   762.0   -501.8     47.2    13.2      8.5
   931.8   -475.8    -58.2    19.3       .4
   980.7   -335.6   -156.2    49.9    -18.5
  1002.5   -185.9   -209.3    48.8    -24.7
   939.5   -121.4   -189.6    67.2    -17.0
  1013.5   -185.8   -229.8    86.6    -22.0
  1015.1   -326.0   -192.8    72.7    -21.7
   937.1   -480.8    -68.6    68.4    -12.4
   854.8   -585.6     44.6    48.5     -7.6
   710.5   -542.6     96.9    27.3     -5.6
   664.3   -541.4    112.5    13.9      1.9
1025. 1141. 1570. 1862. 2020. 1918. 2223. 2125. 1743. 1386. 1006.  887.
 351.  478.  576.  691.  770.  819.  732.  654.  589.  480.  413.  361.
CIRA 1.0 LOC=CEC SAN DIEGO,CA, LAT=32.4, TWHT=20, REGION=07, ALT=13
```

ELTORO08.CTY

```
 .124  .115  .100  .083  .068  .058  .047  .042  .049  .063  .095  .101
 .094  .124  .094  .111  .114  .092  .096  .09  .079  .09  .079  .11
 .13451E-05  4.74630 21.5
 .10586E-01  2.03981 10.5
 .19529E-01  1.94542 12.5
 .18531E-02  2.65838 11.5
 56.0  58.0  61.9  67.0  69.8  70.5  77.3  74.5  77.3  69.9  62.2  61.2
 48.3  50.6  53.3  55.7  58.6  60.5  64.5  63.8  65.2  59.9  53.7  52.2
 46.5  48.4  52.6  53.9  56.4  60.1  63.4  63.6  63.8  57.4  52.2  47.7
   727.9   -589.4    108.7    -1.6     16.0
   803.2   -547.9     49.5      .8     17.3
   917.7   -485.7    -39.8    34.3     -4.8
  1066.0   -366.1   -187.4    20.8    -18.0
  1085.6   -165.4   -256.7    14.0    -30.2
  1017.7   -158.7   -224.3    89.0    -19.8
  1112.8   -148.8   -282.9    33.3    -31.0
  1049.8   -336.0   -202.1    58.6    -21.3
  1005.3   -508.8    -83.8    37.5     -5.7
   890.7   -601.8     33.8    26.2      5.2
   717.3   -552.3     95.8    11.6      6.3
   741.2   -641.6    135.4     -.1     13.9
 986. 1204. 1530. 2068. 2236. 2168. 2466. 2196. 1885. 1428. 1002.  981.
 362.  450.  594.  633.  720.  777.  679.  640.  559.  469.  396.  335.
CIRA 1.0 LOC=CEC EL TORO,CA, LAT=33.7, TWHT=20, REGION=08, ALT=240
```

SANFER09.CTY

```
 .124  .121  .116  .096  .083  .086  .081  .085  .083  .084  .092  .116
 .094  .124  .094  .111  .114  .092  .096  .09  .079  .09  .079  .11
 .10010E-06  5.18152 28.5
 .27556E-01  1.66328 11.0
 .14393E-03  3.13279 25.5
 .10000E-30 20.00000 35.0
 57.5  57.9  60.3  66.8  71.5  74.0  82.9  81.4  77.7  72.4  64.9  58.8
 46.3  46.5  47.2  50.9  53.9  54.4  59.8  58.6  57.1  54.2  52.1  48.0
 46.1  47.0  49.8  52.3  55.5  58.5  62.9  62.8  61.0  56.1  52.2  45.9
   728.1   -590.5    110.4     -3.9     16.9
   803.8   -549.6     51.6     -1.6     18.1
   919.1   -488.7    -36.9     31.7     -4.1
  1068.4   -370.7   -183.9     17.7    -17.2
  1087.9   -170.8   -254.0     10.9    -29.9
  1019.5   -164.7   -222.4     86.0    -20.3
  1115.5   -155.3   -280.0     29.8    -30.8
  1052.4   -341.5   -198.5     55.4    -20.7
  1007.0   -512.7    -80.2     34.2     -4.7
   891.6   -604.4     36.3     23.4      6.2
   717.3   -553.5     97.4      9.4      7.2
   740.9   -642.6    136.9     -2.5     15.0
 978. 1196. 1525. 2064. 2234. 2169. 2465. 2193. 1878. 1420.  995.  971.
 363.  450.  594.  633.  720.  777.  679.  640.  558.  469.  396.  335.
CIRA 1.0 LOC=CEC SAN FERNANDO,CA, LAT=34.2, TWHT=20, REGION=09, ALT=977
```

RIVERS10.CTY

```
 .126  .122  .110  .092  .075  .065  .065  .065  .063  .069  .094  .117
 .098  .098  .123  .123  .123  .123  .123  .123  .098  .098  .098  .098
 .25078E-06  4.83855 30.0
 .79763E-02  2.22501 14.0
 .39041E-05  4.09839 28.5
 .11434E-05  4.51940 26.5
 55.8  58.0  61.6  66.4  71.1  77.4  84.5  85.1  82.5  74.0  64.9  58.8
 46.2  46.1  48.4  52.1  57.0  62.6  66.9  69.1  65.6  57.9  51.1  47.2
 44.1  46.5  49.3  50.3  52.6  56.0  60.4  62.6  59.0  53.9  50.6  45.2
   681.6   -497.0     86.2    -33.3     28.3
   820.2   -507.4     23.9    -48.2     30.4
   960.2   -425.0    -80.9    -46.3      7.8
  1056.1   -274.2   -195.4    -35.8    -18.6
  1068.0    -92.6   -223.0    -28.0    -27.2
  1148.4     19.7   -270.3    -34.3    -34.5
  1154.9    -19.4   -283.5    -44.4    -38.4
  1091.7   -194.1   -234.8    -44.6    -27.4
  1031.1   -413.5   -131.3    -25.9     -5.6
   886.9   -539.4      6.9     -5.8     13.1
   810.1   -623.0     79.9     -3.8     18.3
   700.1   -563.2    115.6    -17.4     22.9
 901. 1211. 1599. 1918. 2009. 2179. 2264. 2078. 1790. 1359. 1083.  912.
 391.  439.  564.  671.  825.  809.  746.  686.  593.  502.  385.  370.
CIRA 1.0 LOC=CEC RIVERSIDE,CA, LAT=33.9, TWHT=20, REGION=10, ALT=1511
```

REDBLU11.CTY

```
 .159  .135  .130  .097  .065  .064  .075  .066  .061  .077  .125  .156
 .171  .243  .171  .187  .165  .183  .164  .159  .163  .18  .179  .18
 .23361E-01  1.78106 15.5
 .19195E-01  2.02531 11.0
 .15573E-03  3.11447 25.5
 .70212E-02  2.13809 16.0
 46.2  52.6  55.0  63.0  73.4  83.6  90.6  88.3  80.9  70.7  55.8  46.9
 38.8  45.5  46.2  51.5  60.6  70.8  75.1  73.1  66.7  56.6  47.6  41.4
 38.7  42.6  44.7  47.7  53.5  59.6  62.6  62.7  57.4  50.9  44.4  40.0
   466.1   -394.0     97.0      6.5       -.6
   623.6   -472.0     79.8     11.4       4.1
   832.4   -484.2      8.3     10.5       5.3
  1067.6   -417.6   -136.8      4.4      -8.1
  1162.5   -262.3   -238.2      -.8     -22.3
  1209.3   -169.0   -285.3      1.3     -30.3
  1248.8   -237.2   -307.3      9.4     -33.9
  1167.1   -417.5   -216.9      7.3     -17.6
  1035.1   -589.9    -62.1      3.4       6.4
   828.4   -647.1     75.6      3.9      16.2
   572.3   -498.8    111.8      3.5       5.1
   421.5   -367.8     96.0      7.0      -2.9
 576.  865. 1314. 1943. 2321. 2519. 2667. 2341. 1849. 1252.  747.  503.
 261.  357.  533.  653.  704.  696.  599.  539.  453.  337.  265.  230.
CIRA 1.0 LOC=CEC RED BLUFF,CA, LAT=40.1, TWHT=20, REGION=11, ALT=342
```

SACRAM12.CTY

```
 .168  .148  .132  .088  .083  .077  .077  .070  .073  .082  .116  .152
 .112  .181  .153  .143  .178  .17  .138  .134  .125  .109  .066  .051
 .23428E-10  7.19697 35.0
 .58761E-02  2.40502 11.5
 .47583E-04  3.50662 25.0
 .38872E-11  7.60496 35.0
 43.8  49.0  55.2  68.6  69.7  80.1  83.0  82.2  77.2  65.9  58.3  47.5
 36.8  44.2  45.1  51.9  53.4  59.8  61.8  62.7  59.5  55.9  48.8  42.7
 37.5  44.3  45.9  52.2  52.9  57.5  59.9  60.6  58.8  56.1  50.0  43.5
   565.9   -475.2    104.3     18.8      -4.7
   548.8   -337.6     39.8     13.3        .3
   909.9   -516.5    -26.8     14.9       3.8
  1182.0   -455.6   -202.5      7.3     -16.9
  1230.1   -248.1   -289.0     16.6     -31.1
  1353.2   -140.3   -354.7      9.1     -39.1
  1306.0   -205.0   -330.5     16.1     -36.8
  1221.5   -390.8   -246.1      5.4     -23.2
  1097.4   -578.2    -92.5      2.8       3.3
   745.3   -508.8     40.6     21.8       1.6
   683.4   -578.7    117.0     19.9      -1.2
   398.1   -298.7     70.0     12.6      -4.6
 706.  748. 1470. 2182. 2433. 2787. 2701. 2412. 1931. 1105.  890.  480.
 308.  422.  527.  599.  697.  714.  690.  610.  525.  422.  337.  288.
CIRA 1.0 LOC=CEC SACRAMENTO,CA, LAT=38.5, TWHT=20, REGION=12, ALT=17
```

FRESNO13.CTY

```
 .159  .134  .108  .092  .069  .068  .073  .065  .067  .075  .124  .161
 .11  .129  .143  .156  .184  .162  .131  .125  .14  .11  .092  .122
 .12818E-03   3.46934 18.0
 .13274E-01   2.05222 13.0
 .17399E-06   4.77204 34.0
 .61275E-06   4.74333 26.0
 47.2  54.6  61.9  66.4  75.8  84.5  90.3  87.3  81.9  72.0  57.4  46.0
 39.5  44.4  48.9  52.2  60.4  67.7  72.9  70.3  63.9  55.4  46.2  39.2
 40.3  45.5  49.5  50.5  54.2  58.3  62.4  63.2  58.6  52.9  48.0  40.1
   512.6   -386.8     86.0      5.9      1.6
   682.2   -470.8     63.2     -8.5     16.2
   930.3   -509.5    -38.9     -8.1     11.4
  1124.4   -424.5   -179.8     24.9    -13.7
  1200.4   -235.9   -285.3     23.1    -28.0
  1234.6   -126.3   -330.2     16.7    -34.8
  1248.3   -159.6   -337.7      9.4    -38.9
  1151.9   -366.9   -247.4     13.2    -22.5
  1084.5   -601.7    -96.6     23.1       .7
   898.8   -719.2     58.9     40.1      5.5
   680.3   -587.6    106.5     33.2     -5.0
   461.7   -364.9     81.4     15.0     -3.6
 667. 1020. 1571. 2097. 2479. 2695. 2687. 2382. 2001. 1432.  904.  571.
 339.  401.  504.  651.  688.  632.  590.  531.  456.  313.  304.  295.
CIRA 1.0 LOC=CEC FRESNO,CA, LAT=36.8, TWHT=20, REGION=13, ALT=328
```

CHINAL14.CTY

```
 .154  .125  .101  .070  .056  .094  .108  .079  .059  .077  .127  .159
 .05  .118  .227  .195  .223  .142  .15  .143  .148  .151  .098  .067
 .23322E-08   5.98318 35.0
 .12702E-02   2.70345 17.5
 .29540E-03   3.02285 22.5
 .18731E-03   3.24265 20.0
 50.7  57.2  62.2  72.5  75.3  93.5  97.5  91.0  82.5  72.2  56.2  47.9
 36.5  44.7  50.5  58.9  62.4  78.0  83.6  78.5  67.9  58.9  44.6  37.8
 34.5  40.2  43.1  47.9  51.4  59.2  61.7  63.9  55.4  49.1  41.3  37.6
   726.7   -623.1    130.5      1.7     12.8
   868.5   -651.7     75.0      4.5     18.8
  1058.7   -613.7    -57.4      8.7      8.6
  1207.5   -425.2   -237.7      7.2    -21.2
  1265.2   -191.8   -326.4     -5.2    -35.4
  1319.4    -85.2   -366.7      7.7    -40.3
  1247.4   -144.6   -329.0     10.4    -36.5
  1121.7   -314.2   -223.8     -2.0    -20.5
  1117.7   -562.0   -113.4      4.1      1.5
   893.3   -597.7     38.1    -13.7     23.8
   738.0   -603.9    113.0     -1.8     15.4
   688.2   -617.3    143.5      2.2      9.3
 963. 1293. 1804. 2312. 2606. 2787. 2621. 2266. 2038. 1422. 1026.  888.
 338.  413.  496.  597.  681.  702.  699.  644.  531.  448.  351.  305.
CIRA 1.0 LOC=CEC CHINA LAKE,CA, LAT=35.7, TWHT=20, REGION=14, ALT=2265
```

ELCENT15.CTY

```
 .111  .097  .081  .072  .073  .090  .114  .111  .090  .072  .082  .101
 .146  .146  .146  .146  .146  .146  .146  .146  .146  .146  .146  .146
 .78366E-04  3.05020 35.0
 .22199E-01  1.85133 15.5
 .33543E-02  2.37078 20.5
 .16259E-02  2.57926 20.0
 60.8  64.2  71.7  79.6  86.8  95.0  99.8  98.6  94.6  83.9  70.5  63.5
 46.0  50.8  56.0  62.4  69.8  75.6  84.6  84.9  77.9  66.2  54.7  48.1
 44.5  45.1  47.3  52.9  55.5  61.4  69.4  68.8  64.4  56.9  50.8  44.9
   888.1   -732.2    107.7    -33.9     36.9
   958.9   -649.0     27.9    -45.5     34.7
  1062.6   -523.4    -96.2    -40.7      8.9
  1212.9   -329.0   -270.6    -26.1    -30.1
  1198.1   -111.5   -331.0    -18.6    -43.0
  1294.7     54.3   -369.5    -24.8    -45.8
  1173.9    -14.2   -306.1    -33.5    -41.1
  1147.3   -205.6   -279.1    -33.4    -34.3
  1121.9   -485.2   -174.5    -13.3    -12.0
  1013.1   -677.7     -5.9      8.2     12.4
   970.1   -801.7     86.8      8.9     20.6
   815.2   -727.9    140.9     -9.6     25.9
 1169. 1428. 1826. 2317. 2517. 2613. 2361. 2272. 2026. 1590. 1292. 1080.
  333.  409.  504.  602.  610.  659.  709.  618.  496.  425.  346.  303.
CIRA 1.0 LOC=CEC EL CENTRO,CA, LAT=32.8, TWHT=20, REGION=15, ALT=-30
```

MTSHAS16.CTY

```
 .190  .174  .151  .144  .104  .074  .051  .071  .072  .132  .163  .183
 .144  .135  .162  .174  .144  .212  .084  .076  .133  .16   .153  .118
 .90143E-08  5.57847 35.0
 .11207E-02  2.68793 18.5
 .12321E-04  3.78448 29.0
 .58976E-04  3.44237 24.5
 34.7  42.1  46.7  52.3  58.3  65.2  74.5  76.4  68.5  56.4  43.7  38.5
 31.5  34.9  42.5  41.2  53.0  60.8  68.8  60.6  58.5  42.7  40.4  32.8
 31.1  36.4  40.0  41.2  47.8  54.8  60.2  55.8  53.6  43.6  39.8  34.0
   479.5   -396.6     90.8     -5.3      8.9
   607.9   -462.5     75.9     10.3      3.3
   844.5   -459.0     -2.5      5.4      5.6
   996.0   -396.0   -120.1      1.9     -3.1
  1117.7   -260.5   -211.4     -4.1    -18.2
  1172.5   -170.6   -266.8    -18.6    -26.1
  1203.6   -246.9   -292.1      2.0    -31.2
  1109.9   -421.7   -198.8      6.0    -16.1
  1007.0   -615.6    -46.8     15.2      3.3
   796.4   -632.6     75.9      7.4     12.9
   497.0   -422.2     92.1      9.6       .2
   465.4   -408.6    105.4      -.6      3.5
  574.  797. 1303. 1769. 2180. 2457. 2583. 2224. 1778. 1167.  607.  540.
  267.  345.  583.  629.  721.  657.  530.  475.  404.  318.  258.  247.
CIRA 1.0 LOC=CEC MT SHASTA,CA, LAT=41.2, TWHT=32, REGION=16, ALT=3535
```

OTHER CITIES

DENVER76.CTY

```
 .192  .166  .172  .133  .105  .068  .048  .052  .085  .135  .172  .184
 .208  .258  .248  .247  .221  .233  .178  .181  .167  .182  .179  .185
 .24099E-02  2.44508 22.5
 .24184E-02  2.44443 16.0
 .14193E-02  2.63924 19.0
 .43260E-19 12.80489 35.0
 36.1  45.7  42.5  55.0  61.9  73.7  80.7  76.1  66.5  54.7  43.6  40.1
 26.3  33.9  32.5  42.9  49.8  59.3  67.3  63.1  55.8  41.0  32.1  29.0
 25.5  30.1  29.2  39.3  45.6  50.4  57.7  55.8  50.7  37.7  30.2  26.9
   542.9   -485.7    104.6     -8.7     16.4
   626.7   -472.1     61.8    -10.5     18.9
   818.8   -447.1     -7.7    -12.3     10.6
   982.6   -292.9    -86.9    -40.5      2.2
  1063.5   -160.0   -136.5    -30.7    -12.6
  1095.8   -102.5   -204.0    -51.2    -20.7
  1091.5   -111.2   -195.6    -75.1    -21.2
  1008.7   -261.0   -128.8    -43.2     -5.2
   839.1   -365.9    -41.5     -4.8       .2
   770.2   -592.7     46.6      8.3     11.8
   569.1   -478.3     92.4      -.0     10.1
   558.3   -533.3    120.7      8.3      4.6
 654.  850. 1277. 1615. 1768. 2137. 2104. 1803. 1341. 1120.  709.  630.
 231.  311.  520.  867. 1078.  849.  839.  802.  646.  294.  272.  212.
CIRA 1.0 LOC=DENVER,CO, LAT=39.8, TWHT=20, YEAR=1976, ALT=5283
```

DESMOI56.CTY

```
 .227  .213  .179  .126  .080  .046  .036  .051  .073  .112  .171  .200
 .202  .225  .254  .235  .225  .177  .178  .154  .126  .166  .178  .213
 .76216E-06  4.33372 35.0
 .20248E-02  2.53712 17.5
 .44974E-03  3.05987 18.5
 .26242E-03  3.30827 16.0
 20.1  26.2  39.8  56.4  65.7  75.8  79.0  77.9  68.7  58.7  41.9  31.5
 15.4  21.2  32.6  45.5  55.6  65.4  69.2  66.1  57.7  48.9  36.5  26.2
 16.7  21.9  32.5  43.4  53.8  63.0  65.2  64.7  55.7  47.8  35.7  26.7
   462.3   -392.1    102.2    -43.8     30.7
   631.8   -445.3     71.4    -68.8     42.3
   754.6   -382.2       .4    -65.9     25.3
   898.9   -255.7   -103.1    -72.2      1.8
  1009.2   -146.6   -180.5    -71.1    -18.0
  1093.9    -90.0   -220.4    -69.7    -31.7
  1072.0   -128.9   -205.9    -66.0    -29.0
   951.9   -217.4   -146.4    -91.7     -4.6
   852.4   -387.5    -39.4    -58.7     16.0
   691.3   -463.2     48.5    -51.9     34.9
   468.7   -394.3     91.0    -27.5     21.5
   380.2   -333.4     96.3    -21.7     13.5
 579.  882. 1201. 1553. 1862. 2140. 2093. 1796. 1438. 1033.  599.  460.
 226.  318.  468.  647.  732.  759.  732.  612.  520.  347.  221.  197.
CIRA 1.0 LOC=DES MOINES, IA, LAT=41.5, TWHT=69, YEAR=1956, ALT=948
```

HONOLU53.CTY

```
 .016  .011  .011  .013  .018  .024  .026  .032  .029  .025  .011  .012
 .137  .166  .183  .181  .231  .234  .243  .223  .179  .18   .208  .173
 .10000E-30 20.00000 35.0
 .18604E-23 15.39109 35.0
 .75331E-23 16.34341 26.0
 .49084E-32 26.77145 16.0
 75.8  75.3  75.8  77.0  78.4  79.6  80.2  81.2  80.8  80.0  76.9  75.0
 68.7  69.8  69.8  71.2  73.3  74.4  75.0  75.8  75.1  74.3  72.7  69.8
 66.0  65.7  65.8  66.5  67.7  68.5  69.0  70.0  69.0  69.1  66.7  66.4
   823.1   -542.5     40.7     -2.0     21.8
   945.3   -439.2    -21.9    -12.0     18.3
   986.0   -288.8   -106.9    -19.8      -.5
  1076.5   -121.8   -190.2    -10.1    -24.2
  1089.8     49.0   -230.6     -4.7    -30.6
  1118.5    116.4   -194.5      3.8    -18.4
  1059.5     77.8   -205.7      8.5    -21.6
  1045.2    -64.6   -216.0      2.1    -30.5
  1001.5   -257.5   -179.1     -2.9    -21.0
   948.6   -418.2    -58.9     -9.5     10.8
   832.9   -468.7     30.7      -.4     15.3
   724.5   -447.6     45.2    -10.9     24.1
 1284. 1486. 1712. 1932. 2095. 2038. 2046. 2008. 1856. 1620. 1292. 1076.
  473.  760.  881. 1067. 1005. 1124. 1015.  956.  775.  690.  624.  506.
CIRA 1.0 LOC=HONOLULU, LAT=21.3, TWHT=93, YEAR=1953, ALT=7
```

UTILITY PROGRAMS

Section XI

UTILITY PROGRAMS

The utility programs supplied on disk "C" are designed to help you alter CIRA to your special needs. Currently, two utility programs are available: one to tailor CIRA to your terminal and another to help you file the houses you build with CIRA. A third feature described here is the use of metric units for CIRA input and output.

Additional utility programs may be issued in the future. They would make it easier to change the wording of questions, their "ghost status" and their units, help you define new retrofits or change the assumptions in existing ones. You can do all of these things now, but you have to use your own editing program (not supplied in this package). More important, you have to be careful not to violate the question and retrofit formats, as described in sections VIII and IX, respectively.

CIRATRM

CIRA needs to know how to operate your terminal. It has to be told what codes your terminal uses to do such things as clear the screen or send the cursor to the top left of the screen. These codes are stored in a file called TERM.DEF (for terminal definition). CIRA comes with a number of ready-made terminal definitions. These are stored in files named, for example, ADM3A.DEF for the ADM3A terminal. These files are stored on the "C" disk.

If your terminal is one of these, simply copy the appropriate file from your copy of disk "C" into the file TERM.DEF on your copy of disk "A". If your terminal is any other type, you need to use the CIRATRM program to build your own TERM.DEF. This program will help you put the codes in the correct format.

BEFORE you use the program, find the manual for your terminal and write down the codes it uses for the following operations:

- **Clear SCREEN and HOME cursor**
- **NORMAL video (or RESET video)**
- **UNDERLINE**
- **BLINK**
- **REVERSE video**
- **UNDERLINE and BLINK**
- **UNDERLINE and REVERSE video**

- **BLINK and REVERSE video**
- **UNDERLINE, BLINK and REVERSE video**
- **FULL intensity**
- **HALF intensity**
- **HOME cursor**
- **Clear LINE**
- **Cursor OFF**
- **Cursor ON**
- **Cursor ADDRESSING type**

Once you have done that, put your COPY of the "C" disk in any drive and log into that drive. Type CIRATRM then press carriage return. The screen will display some existing .DEF files for popular terminals from which you can choose as a start, e.g.:

```
-------------\/-------------\/-------------\/-------------
  ADM3A.DEF      ADM31.DEF      TV950.DEF     STANDARD.DEF
-------------/\-------------/\-------------/\-------------
```

Please enter the file to read or <return> to edit existing TERM.DEF

________.DEF

Enter the name of the ".DEF" file you think is closest to your terminal, (the manual for your terminal may provide some helpful hints) and press carriage return. The program will now display the first page of terminal codes and their effects:

HOME - SUMMARY of cursor & screen control (a,b,c & f must work!)....

a) **CLEAR SCREEN: should have occured before this was printed.**

b) **HOME: the word 'HOME' should be at upper left.**

c) **CLEAR LINE: no X's should follow this message ->**

d) **VISIBLE CURSOR: enter this letter to check.**

e) **NO CURSOR: enter this letter to check.**

f) **CURSOR ADDRESSING test.**

Unless your TERM.DEF is correct, your screen will not look like this; it will probably be a mess. The first step to fixing it is to put in the correct code for clear screen. Type the letter "a" and the following should appear:

CIRA---------Computerized Instrumented Residential Audit---------CIRA

Values for CLEAR SCREEN are currently set as:

Characters:	**'<ESC>*'**
HEX of Characters	**'1B 2A'**
DECIMAL of characters	**'27 42'**

The screen should have been CLEARED before this entry

Any changes (y/n)?

Answer "y", and then enter the code your terminal uses for clear screen. The computer will then use that code to try to clear the screen, so you will know immediately if you got it right. If it works, confirm that you don't want to make any more changes by typing "n" , and move on to fix the other codes. **Note** :Be careful to enter the right code. If you just guess and enter the wrong code, your screen may end up looking very, very odd. Codes that <u>must</u> be entered correctly are those for clear screen, cursor addressing, <u>and</u> home; blank spaces can safely be entered for the others.

You may also have to invent codes. For example, for clear line on the adm3a, CIRA types a carriage return plus the precise number of tabs and spaces to fill in a line, and another carriage return to get back to the beginning of the line.

If you have one of the types of terminal shown below, item "f" can be answered by one of six preset addressing types (1-6):

1:	<ESC>={row+32.}{column+32.}	- ADM 3a / Televideo
2:	<ESC>Y{row+32.}{column+32.}	- DEC vt52 / Zenith/ADDS
3:	~<DC1>{column+32.}{row+32.}	- Hazeltine
4:	<ESC>a{row+32.}{column+32.}	- Concept
5:	<ESC>Y{row+32.}<ESC>X{column+32.}	- Perkin Elmer
6:	<DC4>{row}{column}	- Micro-Term

If your terminal does not use one of these types, choose type 0 and enter the full sequence of codes for your terminal. Below is shown the way in which these codes are entered.

```
*****************************************************************************
CIRA--------------Computerized Instrumental Audit----------------------CIRA
*                                                                           *
* CURSOR ADDRESSING info is currently set as:                               *
*                                                                           *
*       1)  Initial lead in sequence is                                     *
*                   Characters:                  '<ESC>='                   *
*                   HEX of characters:           '1B 3D'                    *
*                   DECIMAL of characters:       '27 61'                    *
*       2)  ROW address is sent first.                                      *
*       3)  Secondary sequence is (ok if none!):                            *
*                   Characters:                  ''                         *
*                   HEX of characters:           ''                         *
*                   DECIMAL of characters:       ''                         *
*       4)  OFFSET added to row/column address is: 32                       *
*                                                                           *
*   'Initial seq. , (R or C)+offset , Secondary seq. , (R or C)+offset'     *
*---------------------------------------------------------------------------*
* The CURSOR should draw a box of *'s around the screen...                  *
*---------------------------------------------------------------------------*
*                                                                           *
* Any CHANGES (1, 2, 3, 4 or NONE) ?                                        *
*                                                                           *
************************************** This corner should be left blank-->
```

When you have finished items "a" through "f", press carriage return to move on to the second page. This should look like:

```
    SUMMARY of supported video attributes (your terminal may not have them!).

     a) NORMAL > < 1 character

     b) NORMAL > < 1 ch UNDERLINE > < 1 ch NORMAL

     c) NORMAL > < 1 ch BLINKING > < 1 ch NORMAL

     d) NORMAL > < 1 ch REVERSED VIDEO > < 1 ch NORMAL

     e) NORMAL > < 1 ch UNDERLINE/BLINK > < 1 ch NORMAL

     f) NORMAL > < 1 ch UNDERLINE/REVERSE > < 1 ch NORMAL

     g) NORMAL > < 1 ch BLINK/REVERSE > < 1 ch NORMAL

     h) NORMAL > < 1 ch UNDERLINE/BLINK/REVERSE > < 1 ch NORMAL

     i) FULL >< 0 characters FULL INTENSITY

     j) FULL >< 0 ch HALF INTENSITY >< 0 ch FULL

Enter choice, <RETURN> if all are OK or <Q> to re-read terminal:
```

The first item ("a") is "reset to NORMAL video"; this is essential if any of the other codes are used. If your terminal does not support these features, you should leave a blank space in this field.

The code actions as displayed are not obligatory. If your terminal supports only some of the availiable codes, feel free to substitute anything you wish, such as underline for reverse video, etc. In fact, if you have a "no bells and whistles" terminal, you might have to use a blank space for all terminal codes (except, of course cursor addressing, clear screen and home). One item of great importance to the output format is the amount of space which each code occupies on your screen. If the program indicates a code should take "1 ch.", you should make sure there is in fact only one space between the "> <" on the screen.

After having thus created a TERM.DEF file for your terminal, transfer it to your COPY of disk "A" using the "PIP" program supplied with CP/M. You also might want to copy TERM.DEF into a holding file, called, say, MYTERM.DEF, since the file you just created may be altered if you run CIRATRM again.

If, for any reason, you want to fiddle with the TERM.DEF file using your own editor, you may do so, but at your own risk! You must respect the following format: Each of the terminal codes discussed above appears on a separate line in TERM.DEF in the exact order indicated, and is defined with two or more numbers separated by spaces: The first number indicates the NUMBER of CHARACTERS which make up the code and, also, how many more numbers follow on the current line. Each following number represents the DECIMAL value for the ASCII character in the code sequence. For example, reverse video on a Televideo 950 is activated by the code sequence "<ESC>G4". In the file TERM.DEF, this would be represented as:

3 27 71 52

Line 16 is the code for cursor addressing, indicated by a single digit between 1 and 6, corresponding to the six fixed types of cursor addressing currently supported:

1:	<ESC>={row+32.}{column+32.}	- ADM 3a / Televideo
2:	<ESC>Y{row+32.}{column+32.}	- DEC vt52 / Zenith/ADDS
3:	~<DC1>{column+32.}{row+32.}	- Hazeltine
4:	<ESC>a{row+32.}{column+32.}	- Concept
5:	<ESC>Y{row+32.}<ESC>X{column+32.}	- Perkin Elmer
6:	<DC4>{row}{column}	- Micro-Term

The last three lines are an expansion of the cursor addressing type. Line 17 is the initial lead in. Line 18 is the secondary lead in. Line 19 consists of two items: first is a flag indicating whether X or Y is sent first, next is the cursor offset (the same for X and Y).

CIRAHSE

This program will help you with "house-keeping" during your CIRA runs in more than one sense. It permits you to store a house that you've built for later use or to retrieve a house you built earlier. When you input information to CIRA, the program looks on "disk A" for the file called HOUSE.DAT. At the end of a session, you should copy HOUSE.DAT to another safe file, for example, JOE.HSE, or 4BR3STRY.HSE. This will keep it from being altered by CIRA during your next session (As the latter file name suggests, you may generate a whole library of prototype houses; next time you analyze a 4-bedroom 3-story house, you can pull the closest file from your library and alter it to match the new house). To use a previously defined house, for example, INLAW.HSE, you must copy INLAW.HSE into HOUSE.DAT. CIRAHSE helps you do both of these things by asking the name of the stored house and onto which disk you want it to go.

The first question you are asked after you start CIRAHSE is if you want to SAVE or GET a house. To "SAVE" a house, you must tell the program where the HOUSE.DAT file is (it should be on the drive where "disk A" is). Then, you can choose a file name to "SAVE" it in (see our examples for ideas and your CP/M manual for legal file name formats). If you don't specify a file type, the program will automatically add ".HSE" as a file type. When you want to run this house again, you can simply "GET" it from that file. NOTE: There is only limited space on the CIRA disks; thus, it is suggested that you store your ".HSE" files on a separate disk.

To "GET" a saved house, you follow the same procedure in reverse. First you are asked the file name of the saved house, then the drive where you want it copied to (again, you will normally choose disk "A"). Simply follow the instructions.

METRIC INPUT AND OUTPUT

CIRA is supplied with two parallel sets of files, one for English units and one for Metric units. The metric files have exactly the same names as the English ones, and to avoid confusion they are stored on disk C as system files. Therefore, they will not be listed if you use the CP/M DIR command; you have to use the STAT *.* command. Similarly, they will not be copied if you use the usual PIP A:=B:*.* command; you have to use the PIP A:=B:*.*[R] command. The parallel files are: all the .INF files; the energy calculation program CIRAEGY.COM; and the report program CIRARPT.COM

To make a metric version of CIRA:

1. Make an English version by copying our disks A and B.

2. Use the CP/M PIP command with [R] to copy all the .INF files from our disk C onto your copy of disk A. (You can copy the .INF files as a block by using PIP A:=B:*.INF[R])

3. Use the CP/M PIP command with [R] to copy the metric CIRARPT.COM and CIRAEGY.COM from our disk C onto your copy of disk B.

You now have a metric version of CIRA.

COMPUTERIZED INSTRUMENTED RESIDENTIAL AUDIT

CIRA™

CIRA is a set of computer programs to predict the energy consumption of small buildings. It can also provide an optimized list of retrofits to help improve the energy efficiency of a building. No specific knowledge of building science or of computer systems is needed to use CIRA. However to run the program as distributed by LBL, certain hardware requirements must be met.

The hardware requirements are as follows:

- Z80, 8080 or 8085 family of microprocessors.
- CP/M operating system (version 2.0 or greater).
- 64k of random access memory.
- Two 8″ single density disk drives or equivalent (2×240k or 450k bytes total).
- 80 column video terminal (cursor addressing is necessary).
- 132 column printer for retrofit output.

The price for the manual and three 8″ single density disks (two CIRA and one utility) is $240. The manual is approximately 350 pages and is enclosed, with the disks, in a 2″ loose leaf binder. Please take this into consideration when specifying a mailing address.

CIRA ORDER FORM

Mail Order Form and Payment to:

Technical Information Department
Lawrence Berkeley Laboratory
University of California
Berkeley, Ca 94720

Manual @ $80.* each ____________

Disks(set of 3)$180.* ____________

Manual & Disks @ $240.* ____________

TOTAL ____________

Enclosed please find $_______ for material marked above. (Please make check payable to: Regents University of California)

SHIP TO:

Name ______________________ Company ______________________

Address ____

City ______________________ State ____________ Zip ____________

State type of computer system: ______________________________

State type of terminal: ______________________________

*Prices reflect printing and book rate shipping charges and are subject to change without notice.

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