Instructions
for

Building Tightness Limits
and
Ventilation Calculations
for
Acceptable Indoor Air Quality

Program "BTL1"
with sub-programs
BTL
BTLa
62.2

April 2004 (V3.0)

Introduction

This program, BTL1, includes three calculation procedures; "BTL", "BTLa" and "62.2". BTL (Building Tightness Limits Based on ASHRAE 62-2001 and LBL Correlation Factors) is the oldest of the three procedures and is considered less accurate than the BTLa ("Building Tightness Limits and Ventilation Requiremt Based on ASHRAE 62, 119, & 136") method. The BTLa method of calculation requires more input information than the BTL method, but it is considered more accurate because it is based on more reliable data.

Finally, the "62.2" method of calculation is similar to the BTLa method of calculation, but is based on the most recent ASHRAE standard, *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings* (Standard 62.2-2003). This latest ASHRAE standard for residential ventilation — the first that is exclusively for residential buildings — renders the previous two methods (BTL and BTLa) obsolete. However, we decided to keep them as a part of the ZipTest Pro^2 software package because many analysts are using these methods. **Analysts in the field should make every attempt to convert to the use of the latest method, "62.2", based on the most recent ASHRAE Standard 62.2-2003.**

"BTL" Calculation Procedure for Determining CFM_{50} Minimum

The objective of this calculation procedure is the determination of a minimum CFM_{50} value. Awareness of this value allows building energy analysts and weatherization workers to add mechanical ventilation if the building is made tighter than the threshold BTL value.

Building Tightness Limits ("BTL") was developed to give weatherization crews a minimum tightness value for air-leakage and insulation work. The "BTL" method used for this software is that which appeared in *Home Energy* magazine in the March/April, 1993 issue. This article—*Building Tightness Guidelines: When is a House Too Tight?*—was written by George Tsongas, Professor of Mechanical Engineering at Portland State University in Oregon. It is strongly recommended that you read this article before using the software. Mr. Tsongas' work was built on the research of others, including Max Sherman at Lawrence Berkeley Laboratory, and Gary Nelson at The Energy Conservatory.

The values calculated by the calculator program are based on ASHRAE Standard 62-2001, *Ventilation for Acceptable Indoor Air Quality*. This standard states that outdoor air requirements for residential living areas shall be "0.35 air changes per hour but not less that 15 cfm per person." **These procedures are not appropriate for commercial buildings.**

Please note, this method is based on an obsolete section of ASHRAE Standard 62-2001 that has been replaced by another ASHRAE Standard, *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*, Standard 62.2-2003.

The calculations included here take into account:

1) The appropriate climate zone in North America.
2) The conditioned square footage of the house. The square footage used for the calculation for the building tightness limit should always correspond to the square footage base for the blower door test. For example, if the basement is not included in the square footage for the building tightness limit, the basement door should be closed when the blower door test is done to determine CFM_{50}.
3) The number of occupants, by design, i.e., the maximum number of people who could live in the house or the number of bedrooms, plus one. Five occupants is the minimum for this calculation method. If you enter fewer than 5 for the number occupants, you will receive an error message.
4) The exposed height of the building. The choices are 1, 1.5, 2, or 3 stories. Cape Cod and raised ranch style houses are usually considered to be 1.5 stories.
5) The exposure of the building. The choices are 1=Well Shielded, 2=Normal, and

3=Exposed. The greater the exposure, the lower the CFM_{50} BTL.

6) The Lawrence Berkeley Laboratory (LBL) correlation factor, N. This number is displayed on the line above the Building Tightness Limit value on the TI-86 screen. This value is dependant on climate zone, building height, and exposure. If CFM_{50} is divided by N, the approximate $CFM_{natural}$ value is obtained.

7) The volume of the heated area of the house when the square footage is more than the number of occupants (by design) multiplied by 322 ft^2. If the calculation of building tightness limit must be done for a house based on 0.35 air changes per hour, you will be prompted to enter ceiling height. The square footage you enter is multiplied by the ceiling height to yield the house volume.

The CFM_{50} BTL numbers calculated by the program represent tightness values when the house is under 50 Pascals of negative or positive pressure, typically created with a blower door. If the house is made tighter than the BTL value, continuously operating ventilation must be installed in order to comply with ASHRAE 62.

"BTLa" Calculation Procedure based on ASHRAE 62, 119, and 136

The objective of this calculation procedure is the determination of 1) a minimum Effective Leakage Area (ELA) value, 2) a minimum CFM value, and 3) the mechanical ventilation required if the building is tighter than the BTLa value. Awareness of these tightness values allows building energy analysts and weatherization workers to 1) stop the building tightening process when the BTLa value is reached and 2) add mechanical ventilation if the building is made tighter than the BTLa value.

As a secondary objective, this procedure calculates the values listed below (in addition to those listed in the previous paragraph):

- Effective Leakage Area (ELA).
- Equivalent Leakage Area (EqLA).
- Estimated Natural CFM.
- Estimated Natural ACH.
- Estimated Natural CFM per Occupant.
- Minimum Effective Leakage Area.
- Minimum CFM.
- Minimum CFM_{50}, below which continuously operating ventilation must be installed for compliance with ASHRAE 62.
- Mechanical Ventilation Required in CFM.

The user inputs required are:

- Building CFM_{50}.
- Leakage Flow Exponent (slope of leakage curve), the typical value is 0.65.
- Weather Factor (from Table 1, ASHRAE 136-1993, reproduced in these instructions).
- Building Occupied area, ft^2.
- Building Volume, ft^3.
- Building Height, ft.
- Story Height, ft (the height of one floor level).
- Occupant Count (either the number of occupants or bedrooms plus one, whichever is greater).

This procedure is based on ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers):

- *Standard for Acceptable Indoor Air Quality* (ANSI/ASHRAE 62-2001).
- *Air Leakage Performance for Detached Single-Family Residential Buildings* (ANSI/ASHRAE 119-1988 (RA 94)) [This document is partially based on the Canadian General Standards Board Standard CAN/CGSB-149.10-M86, *Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method*].
- *A Method of Determining Air Change Rates in Detached Dwellings* (ANSI/ASHRAE 136-1993).
- Palmiter, L., and P. Francisco. 1996. *Modeled and Measured Infiltration: Phase III, A Detailed Case Study of Three Homes*. Palo Alto, CA: Electric Power Research Institute.

Of the calculated values in this procedure, the Minimum Effective Leakage Area ("ELA min" on the calculator screen) and Minimum CFM ("CFM min" on the calculator screen) are the most reliable values because they do not require the flow exponent (slope of the building leakage curve) for their determination. Use of the flow exponent—the range is generally between 0.5 and 1.0—is problematic because its value changes as the building is tightened; this makes any calculation procedure suspect that uses the flow exponent. The CFM_{50} minimum calculation value (number 9. on the "All Data" screen) is suspect for this reason. Therefore, it should not be used unless absolutely necessary.

The calculation of the Minimum Effective Leakage Area takes into account the guidelines set by ASHRAE 62-2001—the dwelling envelope must provide either 0.35 air changes per hour (ACH) or 15 cubic feet per minute (CFM) per person, whichever is larger. **This method is not intended for use in commercial applications.** The calculation of Minimum CFM ("CFMmin" on the calculator screen) also includes the ASHRAE 62-2001 guidelines.

If a dwelling is tighter than the ASHRAE 62-2001 guidelines, the ventilation necessary ("Vent CFM Needed") to bring the dwelling into compliance with the ASHRAE 62-2001 guidelines is displayed as number 8 on the screen of calculated values and the "All Data" screen. The determination of the required ventilation is based on an equation in the paper by Palmiter, L., and P. Francisco (1996) referenced above.

Please note, this method is based on an obsolete section of ASHRAE Standard 62-2001 that has been replaced by another ASHRAE Standard, *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*, Standard 62.2-2003.

"62.2" Calculation Procedure based on ASHRAE 62.2, 119, and 136

This final procedure is based on the most recent ventilation standard for residential buildings published by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*, Standard 62.2-2003. The objective of this procedure is the determination of the mechanical or intermittent ventilation requirements for low-rise residential (three stories or less) buildings.

This method uses calculation procedures that are, for the most part, the same as the BTLa procedure. However, the calculations for the final ventilation requirements are different. As a result of these differences, more houses will require mechanical ventilation than required by the BTLa method, but the required ventilation rate will usually be of a lower magnitude.

This procedure calculates the values listed below:

Effective Leakage Area (ELA).
Equivalent Leakage Area (EqLA).
Estimated Natural CFM.
Estimated Natural ACH.
Estimated Natural CFM per Occupant.
Mechanical Ventilation Required in CFM for intermittent ventilation operating 50 percent on-time when the building is closed up for central heating or cooling.
Mechanical Ventilation Required in CFM for intermittent ventilation operating 75 percent on-time when the building is closed up for central heating or cooling.
Mechanical Ventilation Required in CFM for continuously operating ventilation, in other words, the ventilation is always operating when the building is closed up for central heating or cooling.
The infiltration (air leakage) credit applied to the ventilation requirement.

The user inputs required are:
Building CFM_{50}.
Leakage Flow Exponent (slope of leakage curve), the typical value is 0.65.
Weather Factor (from Table 1, ASHRAE 136-1993, reproduced in these instructions).
Building Occupied area, ft^2.
Building Volume, $ft^{3.}$
Building Height above grade, ft.
Story Height, ft (the height of one floor level).
Occupant Count (either the number of occupants or bedrooms plus one, whichever is greater).

This procedure is based on ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers):
- *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings* (ANSI/ASHRAE 62.2-2003).
- *Air Leakage Performance for Detached Single-Family Residential Buildings* (ANSI/ASHRAE 119-1988 (RA 94)) [This document is partially based on the Canadian General Standards Board Standard CAN/CGSB-149.10-M86, *Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method*].
- *A Method of Determining Air Change Rates in Detached Dwellings* (ANSI/ASHRAE 136-1993).

The basic requirement for this method is expressed by this equation:

$$Ventilation_{CFM} = 0.01A + (7.5\ CFM\ per\ Occupant)$$

Where:
A = oppupiable floor area in square feet.
Occupant = number of bedrooms plus one or actual number of occupants, whichever is larger.

An infiltration (air leakage) credit is calculated if the estimated natural infiltration is more than two times the floor area/100. In these cases, the infiltration credit is:

$$Infiltration\ Credit_{CFM} = \left(0.5\left[Natural\ Air\ Leakage_{CMF} - \left\{\frac{2A}{100}\right\}\right]\right)$$

This infiltration credit is subtracted from the $Ventilation_{CFM}$ calculated by the equation at the bottom of the previous page.

For the information of the user, this infiltration credit is reported as number "9)" on the screen display that lists all the inputs and outputs for the 62.2 program.

This method is not intended for use in commercial applications.

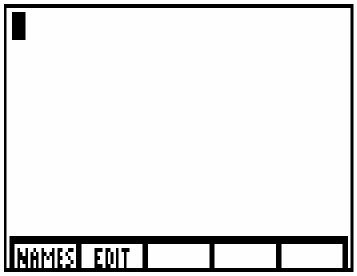
Acknowledgements

Thanks to Collin Olson and Rob Nevitt of The Energy Conservatory and to Max Sherman of Lawrence Berkeley Laboratory for their help in developing this software. Their assistance and expert advice made it possible.

Note about ASHRAE 62 Standard

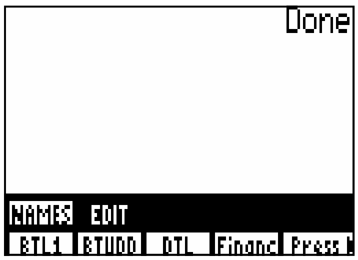
As a result of the publication of ASHRAE 62.2, a Standard for residential buildings only, the residential section in ASHRAE 62 has become obsolete. Within the next few years all references to residential indoor air quality and ventilation will be removed from ASHRAE 62 and it will be renamed ASHRAE 62.1 . At the time of the publication of this ZipTest Pro² instruction manual, the official designation was ASHRAE 62.

BTL1-1



- Turn the TI-86 calculator on.
- Press **PRGM** (Programs).
- You will see this menu on the screen.
- Press **F1** for **NAMES.**
- **NOTE: It is best never to press EDIT, F2.**
- You will see the menu and sub-menu displayed in Panel BTL1-2."

BTL1-2

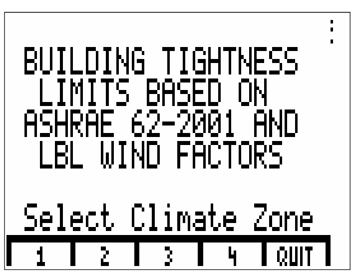


- Press **F1, F2, F3, F4**, or **F5** for the program "BTL1." The menu key for this program will depend upon the number of programs loaded in the memory of your TI-86 calculator. For the screen at the left, four usable programs are loaded onto the calculator, "BTL1" (**F1**), "BTUDD" (**F2**), "DTL" (**F3**) and "Press" (**F5**). Press **ENTER**. **Note: The exact name of the program must appear at the cursor position, if not you will receive an error message.**

BTL1-3

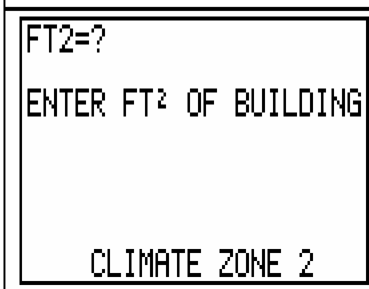
- You will see this menu on the screen. This is the main menu screen.
- **F1, "**BTL" to starts the Building Tightness Limits program.
- **F2, "**BTLa" starts the advanced Building Tightness Limits program.
- **F3, "**62.2" starts the latest (2004) program.
- **F4, "**ACKLG " (Acknowledgments) selection lists the author of the program, etc.
- **F5, "**QUIT" selection allows you to exit the program. Always exit the program by selecting **F5** from this menu; the decimal place is thereby set to "floating," whereas within the **BTL** program it is set to one place.

BTL1-4



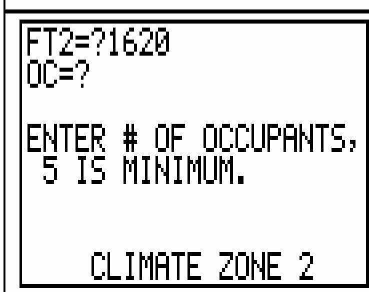
- Select **F1, "**BTL," to start the Building Tightness Limits program.
- You will see this menu on the screen.
- You are asked to select your climate zone. Refer to the map of North America on page 20 for your appropriate climate zone number.
- Note: If you select **F5, "**QUIT," you will exit the program. **DONE** will appear in the upper right corner of the screen If you want to re-enter the program, press **ENTER** or press **PRGM.**
- As a demonstration, select **F2** for climate zone 2.

BTL1-5



- The climate zone you selected appears at the bottom of the screen.
- Enter the conditioned square footage of the house. The value you enter will be displayed after the "**?**" This value is used to determine whether the building tightness limit is calculated using 15 cfm/person or 0.35 air changes per hour. If the square footage is greater than the number of occupants multiplied by 322 ft^2, 0.35 air changes per hour is used rather than 15 cfm per person.
- Enter "1620," for example, and press ENTER.

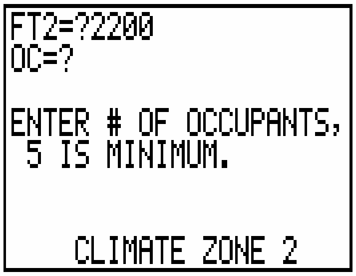
BTL1-6



- Enter the number of occupants—by design. It is common to count the number of bedrooms and add one to determine the number of occupants for this procedure. *Five is the minimum number of occupants that may be entered.* Please refer to "Building Tightness Guidelines: When Is a House Too Tight?" by George Tsongas, *Home Energy,* March/April, 1993, pp. 18-24, for discussion and guidance.
- Enter "6," for example, and press **ENTER**.

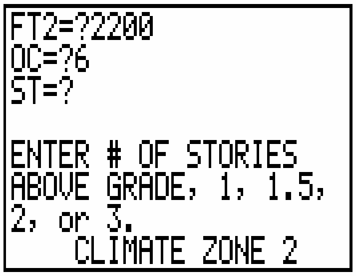
BTL1-7	FT2=?1620 OC=?6 ST=? ENTER # OF STORIES ABOVE GRADE, 1, 1.5, 2, or 3. CLIMATE ZONE 2	• You are prompted to enter the number of exposed stories of the house. Basements below grade generally should not be included in the number of stories. The value you enter will be displayed after the "**?**" • Enter "1.5" stories, for example, and press **ENTER**.
BTL1-8	FT2=?1620 OC=?6 1=SHIELDED ST=?1.5 2=NORMAL EXP=? 3=EXPOSED ENTER EXPOSURE # CLIMATE ZONE 2	• You are prompted to enter the appropriate exposure number for the house The value you enter will be displayed after the "**?**" • Enter "1," for example, and press **ENTER**. • The "EXP" or exposure value should be entered with care. "SHIELDED" is for buildings with significant blockage to the wind (trees or other buildings), "NORMAL" signifies buildings in a typical suburban setting (obstructions to the wind around building, but not dense), "EXPOSED" is for buildings with very little wind blockage (meadow settings, lake-side, etc.).
BTL1-9	FT2=?1620 OC=?6 1=SHIELDED ST=?1.5 2=NORMAL EXP=?1 3=EXPOSED LBL#=20.0 CFM50 BTL=1800.0 CLIMATE ZONE 2	• "CFM50 BTL=1800.0" is displayed. This is the Building Tightness Limit (BTL) for this example house, i.e., at a blower door depressurization of 50 Pascals, the CFM_{50} minimum value is 1800. • Notice that all the values you entered are displayed on the screen, including the climate zone and the "LBL #" value (if CFM_{50} is divided by the LBL#, the approximate $CFM_{natural}$ results). This example has been calculated using 15 cfm per person. • Press **ENTER**
BTL1-10	BUILDING TIGHTNESS LIMIT & VENTILATION CALCULATIONS FOR ACCEPTABLE INDOOR AIR QUALITY (c)2004 WxWare (V3.0) Select from Menu BTL | BTLa | 62.2 | ACKLG | QUIT	• Now enter values for a demonstration of a calculation for a house that exceeds the size limitations for the use of 15 cfm/person calculation procedure. Instead, the calculation for this example will use 0.35 air changes per hour. • Press **F1, BTL**, to begin the demonstration.
BTL1-11	BUILDING TIGHTNESS LIMITS BASED ON ASHRAE 62-2001 AND LBL WIND FACTORS Select Climate Zone 1 | 2 | 3 | 4 | QUIT	• You are asked to select your climate zone. Refer to the map of North America on page 20 for the appropriate climate zone number. • If you select **F5, "**QUIT," you will return to the main menu screen. • Select **F2** for Climate Zone 2.
BTL1-12	FT2=? ENTER FT² OF BUILDING CLIMATE ZONE 2	• The climate zone you selected appears at the bottom of the screen. • Enter the heated square footage of the house. The value you enter will be displayed after the "**?**" This value is used to determine whether the building tightness limit is calculated using 15 cfm/person or 0.35 air changes per hour. If the square footage is greater than the number of people multiplied by 322 ft^2, 0.35 air changes per hour is used rather than 15 cfm per person. • As a demonstration, enter "2200 ft^2" and press **ENTER**.

BTL1-13



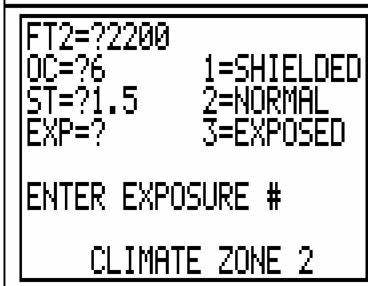
- Enter the number of occupants—by design. You may count the number of bedrooms and add one, using five as a minimum product, to determine the number of occupants for this procedure.
- Enter “6” for this demonstration and press **ENTER**.

BTL1-14



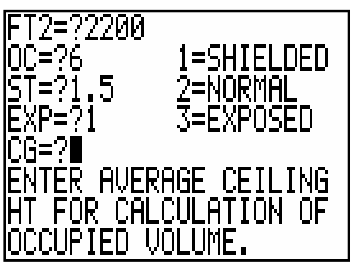
- You are prompted to enter the number of exposed stories of the house. Basements below grade generally should not be included in the number of stories. The value you enter will be displayed after the “**?**”
- Enter “1.5” stories and press **ENTER**.

BTL1-15



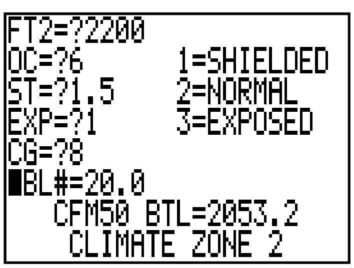
- You are prompted to enter the appropriate exposure number for the house. The value you enter will be displayed after the “**?**”
- The “EXP” or exposure value should be entered with care. “SHIELDED” is for buildings with significant blockage to the wind (trees or other buildings), “NORMAL” signifies buildings in a typical suburban setting (obstructions to the wind around building, but not dense), “EXPOSED” is for buildings with very little wind blockage (meadow settings, lake-side, etc.).

BTL1-16



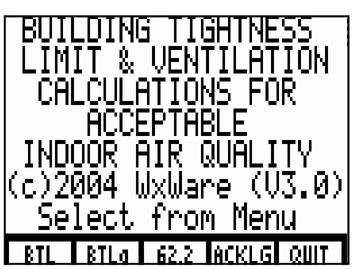
- You are prompted to enter the average ceiling height of the house. For this example, assume ceilings are eight feet high. The ceiling height is multiplied by the square footage you entered, yielding the volume of the house. Because the square footage of this demonstration house is greater then the number of occupants multiplied by 322 ft^2, the program is calculating the Building Tightness Limit using 0.35 air changes per hour rather than 15 cfm/person.
- Enter “8” for this example and press **ENTER**.

BTL1-17



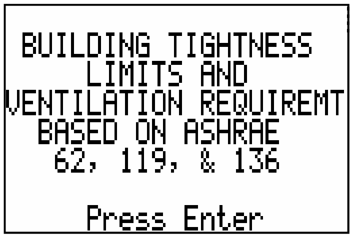
- “CFM50 BTL=2053.2” is displayed. This is the Building Tightness Limit (BTL) for this demonstration house; at a blower door depressurization of 50 Pascals the CFM_{50} minimum value for acceptable air quality is 2053.2.
- Notice that all the values you entered are displayed on the screen, including the climate zone and the LBL “N” number. This example has been calculated using 0.35 air changes per hour rather than 15 cfm per person.
- Press **ENTER**

BTL-18



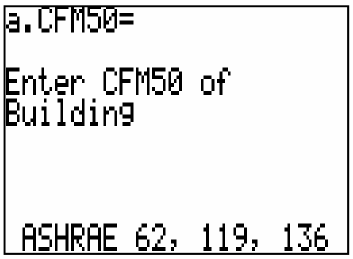
- You will see the at the left screen displayed.
- Select **F2, BTLa**.
- Now we will look at the next calculation procedure which is generally a more accurate method of determining building tightness and required ventilation for tight buildings.

BTL1-19



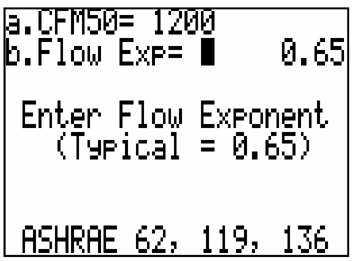
- For an explanation of this procedure, refer to "**BTLa Calculation Procedure based on ASHRAE 62, 119, and 136**" on page 3 of this instruction manual.
- Press **ENTER** to proceed to the next screen.

BTL1-20



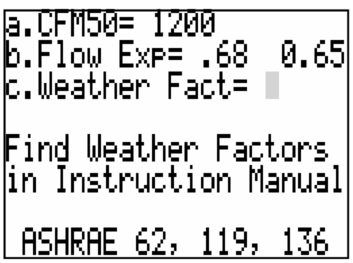
- Enter "a.CFM50" of the building, whether it was measured by a single-point or multi-point blower door test.
- Notice that "CFM50" on the display is preceded by the letter "a." All the input values for this procedure are preceded with a lower-case letter, a through h.
- Notice that "ASHRAE 62, 119, 136" is at the bottom of the display. This is a reminder that you are working on this advanced procedure that includes these ASHRAE Standards.
- For this example, enter 1200 and press ENTER.

BTL1-21



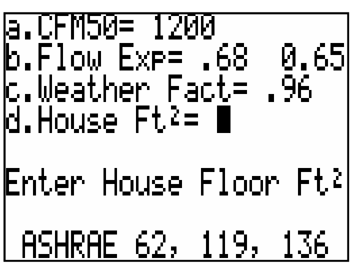
- The next prompt, "b.Flow Exp," requires you to enter the flow exponent for the building (the slope of the air-leakage curve of the building). If you have performed a single-point blower door test on the building, enter ".65," the typical value of the flow exponent (displayed to the right on the screen as a reminder).
- If you performed a multi-point blower door test, you will know the specific flow exponent for the building, usually within a range of 0.5 to 1.0. Enter this value.

BTL1-22



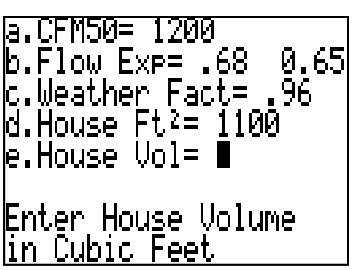
- Enter the weather factor, "c.Weather Fact." These values are listed in this instruction manual on pages 21 through 23 for locations in Canada and the United States, designated as "W." These factors are used to estimate the natural air leakage for the purpose of determining the CFM ratings of added exhaust ventilation to meet the standard set by ASHRAE 62-2001. This calculation procedure can be found in ASHRAE 136-1993.
- Enter ".96" for this example (Cleveland, Ohio) and press **ENTER**.

BTL1-23



- Enter the square footage of building floor area, "d.House Ft^2." It is recommended that you include the basement if it is kept close to the indoor temperature. (If you include the basement here, you should open the basement to the main body of the house when you perform the blower door test).
- For this example, enter "1100" and press **ENTER** .

BTL1-24



- Enter the building volume, "e.House Vol," in units of cubic feet. If you included the basement in the volume figure, include the basement here also.
- Enter "8800" (this value assumes a ceiling height of eight feet) and press **ENTER .**

BTL1-25

```
a.CFM50= 1200
b.Flow Exp= .68  0.65
c.Weather Fact= .96
d.House Ft²= 1100
e.House Vol= 8800
f.Bldg Ht, ft= █
Enter Bldg. Height
 ASHRAE 62, 119, 136
```

- Enter the building height above grade in units of feet, "f.Bldg Ht, ft." For buildings with uneven above grade heights—walk-out basements, one and one-half story buildings—use the average height of the building.
- For this example enter "8" and press **ENTER**
- Notice that "ASHRAE 62, 119, 136" remains at the bottom of the screen as a reminder of the methodology on which you are working.

BTL1-26

```
a.CFM50= 1200
b.Flow Exp= .68  0.65
c.Weather Fact= .96
d.House Ft²= 1100
e.House Vol= 8800
f.Bldg Ht, ft= 8
g.Story Ht, ft=
 ASHRAE 62, 119, 136
```

- Enter the average height of one story of the building, "g.Story Ht, ft." This value and the "Bldg Ht" from the previous entry determines the number of stories in the building. The resulting value (the number of stories) should not exceed three.
- For this example, enter "8" and press **ENTER**

BTL1-27

```
a.CFM50= 1200
b.Flow Exp= .68  0.65
c.Weather Fact= .96
d.House Ft²= 1100
e.House Vol= 8800
f.Bldg Ht, ft= 8
g.Story Ht, ft= 8
h.Occupant Count=
```

- Enter the "h.Occupant Count" as the next and final input value for this procedure. Enter the number of occupants or the number of bedrooms plus one, whichever is larger. This value is used to determine the ventilation requirements for the dwelling. The greater the number of occupants or bedrooms, the greater the amount of fresh air required for acceptable indoor air quality.
- For the example, enter "5"

BTL1-28

```
a.CFM50= 1200
b.Flow Exp= .68  0.65
c.Weather Fact= .96
d.House Ft²= 1100
e.House Vol= 8800
f.Bldg Ht, ft= 8
g.Story Ht, ft= 8
h.Occupant Count= 5
```

- Review the input values you have entered before you press **ENTER**.
- Now, press **ENTER** and move on to the next screen which displays all the output values for the example problem.
- Note that all the input values are lettered (a. through h), and that on the next screen (Panel BTL1-29), all of the output values (answers) are numbered (1. through 8.).
- Press **ENTER** to move to the next screen.

BTL1-29

```
1.ELA in²=61
2.EqLA in²=118
3.Estim Nat CFM=54
4.Estim Nat ACH=.37
5.Natural CFM/occ=11
6.ELA min in²=84
7.CFM min=75
8.Vent CFM Needed=41
```

- On this screen, all the outputs are displayed except number 9.
- "1.ELA in^2" is equal to "61" for the example. ELA (Effective Leakage Area) was developed at Lawrence Berkeley Laboratory (LBL) and is used in their air leakage model. The ELA is defined as the area of a special nozzle-shaped hole (similar to the inlet of your blower door fan) that would leak the same amount of air as the building does at a pressure of 4 Pascals. In the Solver section of the TI-86, the Equation Nugget with the name "AELA" can be used to calculate ELA if you know the CFM_4 of the building. [continued on next panel]

BTL1-30

```
1.ELA in²=61
2.EqLA in²=118
3.Estim Nat CFM=54
4.Estim Nat ACH=.37
5.Natural CFM/occ=11
6.ELA min in²=84
7.CFM min=75
8.Vent CFM Needed=41
```

- "2.EqLA in^2" is equal to "118" for the example. EqLA (Equivalent Leakage Area) is defined by researchers at the Canadian National Research Council as the area of a sharp-edged orifice that would leak the same amount of air as the building does at a pressure of 10 Pascals. In the Solver section of the TI-86, the Equation Nugget with the name "AEQLA" can be used to calculate EqLA if you know the CFM_{10} of the building.
- Typically, EqLA more closely approximates the physical characteristics of building airtightness than ELA. [continued on next panel]

BTL1-31	1.ELA in^2=61 2.EqLA in^2=118 3.Estim Nat CFM=54 4.Estim Nat ACH=.37 5.Natural CFM/occ=11 6.ELA min in^2=84 7.CFM min=75 8.Vent CFM Needed=41	• "3.Estim Nat CFM" (estimated natural CFM) is equal to 54 for the example. This calculated value is based on ELA, the Weather Factor (see Panel BTL1-34) and the dimensions of the building. It is the cubic feet per minute of air leakage based on natural forces such as wind pressure and differences in air density. • "4. Estim Nat ACH" is equal to 0.37 for the example. This is merely the "Estim Nat CFM" multiplied by 60 minutes per hour and divided by the building volume in units of cubit feet. [continued on next panel]
BTL1-32	1.ELA in^2=61 2.EqLA in^2=118 3.Estim Nat CFM=54 4.Estim Nat ACH=.37 5.Natural CFM/occ=11 6.ELA min in^2=84 7.CFM min=75 8.Vent CFM Needed=41	• "5.Natural CFM/occ" (estimated natural CFM per occupant) is number 3, estimated natural CFM, divided by the "Occupant Count" (see Panel BTL1-27). In order to comply with ASHRAE 62-2001, this value must be at least 15 (15 CFM per person). If this value is less than 15, "8.Vent CFM Needed" (ventilation CFM needed to comply with ASHRAE 62-2001) will be a value greater than zero. Notice that for the example, outputs in the screen panel at the left that the CFM per occupant is 11 and "8.Vent CFM Needed" is equal to 41. [continued on next panel]
BTL1-33	1.ELA in^2=61 2.EqLA in^2=118 3.Estim Nat CFM=54 4.Estim Nat ACH=.37 5.Natural CFM/occ=11 6.ELA min in^2=84 7.CFM min=75 8.Vent CFM Needed=41	• "6.ELA min" (ELA minimum) is the minimum effective leakage area of the building that will satisfy ASHRAE 62-2001. If the building is made tighter than this, mechanical ventilation must be added to comply with ASHRAE 62-2001. This value is based on 0.35 air changes per hour or 15 CFM per person, whichever is larger. Notice in this example that the actual ELA, line 1, is 61 in^2 and the ELA minimum, line 6, is 84in^2, thus the building is tighter than ASHRAE 62-2001. Mechanical ventilation should be added. [continued on next panel]
BTL1-34	1.ELA in^2=61 2.EqLA in^2=118 3.Estim Nat CFM=54 4.Estim Nat ACH=.37 5.Natural CFM/occ=11 6.ELA min in^2=84 7.CFM min=75 8.Vent CFM Needed=41	• "7.CFMmin" (CFM minimum) is the minimum natural CFM that will satisfy ASHRAE 62-2001. This value is based on 0.35 air changes per hour or 15 CFM per person, whichever is larger. As with the ELA values for this example, the actual CFM, line 3, is less than the 75 CFM (line 7) required to comply with ASHRAE 62-2001, thus ventilation should be added. • "8 Vent CFM Needed" (ventilation CFM needed) is the CFM of mechanical ventilation required to bring the below-compliance building into compliance with ASHRAE 62-2001. [continued on next panel]
BTL1-35	[intentionally left blank]	**Note: Because estimated air leakage is based on blower door tests that may vary by as much as a factor of 2 from actual air leakage rates, ventilation guidelines should be used with caution.** [continued on next panel]
BTL1-36	[intentionally left blank]	• **Note: Compliance with ASHRAE 62-2001 and the procedures of this ZipTest Pro^2 software do not guarantee that moisture or indoor air quality problems will not develop. A healthy rate of ventilation may be more or less than the suggested estimate calculated here. Be cautions and use common sense.** • Now, press **ENTER** to move to the "ALL DATA" screen

BTL1-37

```
a)1200   1)61    All
b).68    2)118   Data
c).96    3)54
d)1100   4).37
e)8800   5)11   ASHRAE
f)8.0    6)84     62
g)8.0    7)75
h)5      8)41   9)1537
```

- The "All Data" display lists all the your inputs and outputs for a calculation. This is presented as a summary for your convenience. The letters and numbers correspond with the line letters (inputs) and numbers (outputs) on the two previous calculator displays.
- a) CFM_{50} from blower door test (see Panel BTL1-20).
- b) Flow exponent from blower door test or 0.65 (see Panel BTL1-21).
- c) Weather factor from pages 21 through 23 (see Panel BTL1-22).
- d) House square footage (see Panel BTL1-23). [continued on next panel]

BTL1-38

```
a)1200   1)61    All
b).68    2)118   Data
c).96    3)54
d)1100   4).37
e)8800   5)11   ASHRAE
f)8.0    6)84     62
g)8.0    7)75
h)5      8)41   9)1537
```

- e) House volume (see Panel BTL1-24).
- f) Building height (see Panel BTL1-25).
- g) Story height (see Panel BTL1-26).
- h) Occupant count (see Panel BTL1-27).
- 1) Actual ELA (effective leakage area) (see Panel BTL1-29).
- 2) Actual EqLA (equivalent leakage area) (see Panel BTL1-30)
- 3) Estimated actual natural CFM (see Panel BTL1-31).

BTL1-39

```
a)1200   1)61    All
b).68    2)118   Data
c).96    3)54
d)1100   4).37
e)8800   5)11   ASHRAE
f)8.0    6)84     62
g)8.0    7)75
h)5      8)41   9)1537
```

- 5) Estimated actual natural CFM per occupant (see Panel BTL1-32).
- 6) Minimum ELA for compliance (see Panel BTL1-33).
- 7) Minimum CFM for compliance (see Panel BTL1-34).
- 8) Mechanical ventilation CFM needed for compliance(see Panels BTL1-34 & 35).
- 9) Minimum CFM_{50} value. This is the only place this output appears. This is meant to minimize the importance of this value because it is problematic to use it as a house tightening target (see page 4). If you must use it, please do so with caution.

BTL1-40

```
 BUILDING TIGHTNESS
 LIMIT & VENTILATION
  CALCULATIONS FOR
     ACCEPTABLE
 INDOOR AIR QUALITY
(c)2004 WxWare (V3.0)
  Select from Menu
BTL  BTLa  62.2  ACKLG  QUIT
```

- Now, let's look at another example that does not require added mechanical ventilation.
- Press **ENTER** to return to the main screen.
- Press **F2** for "BTLa" and press **ENTER** to go to the first of the inputs.

BTL1-41

```
a.CFM50= 3230
b.Flow Exp= .65  0.65
c.Weather Fact= .96
d.House Ft²= 2400
e.House Vol= 28500
f.Bldg Ht, ft= 16
g.Story Ht, ft= 8
h.Occupant Count= 6█
```

- All of the inputs are listed here. You can enter all of these if you wish. Go ahead, have another go at it; practice helps.
- Notice that this house is not as tight and it is larger than the last example house.
- Press **ENTER** after you enter all the input data. This will advance you to the output display.

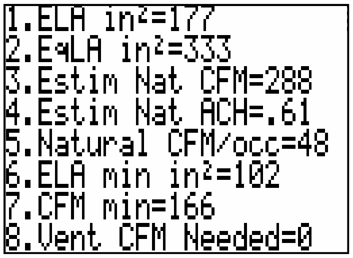
BTL1-42

```
1.ELA in²=177
2.EqLA in²=333
3.Estim Nat CFM=288
4.Estim Nat ACH=.61
5.Natural CFM/occ=48
6.ELA min in²=102
7.CFM min=166
8.Vent CFM Needed=0
```

- All the outputs, except target minimum CFM_{50} are listed on the output display.
- Notice that no mechanical ventilation (line 8) is called for. The natural CFM per occupant, line 5, exceeds the ASHRAE 62-2001 minimum of 15 and the estimated natural ACH , line 4, exceeds the minimum 0.35. The actual ELA, line 1, exceeds the minimum ELA on line 6. This house can be significantly tightened before the ASHRAE 62-2001 minimum values are reached.

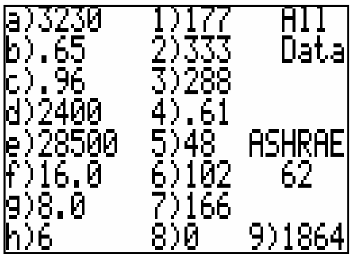
[continued on next panel]

BTL1-43



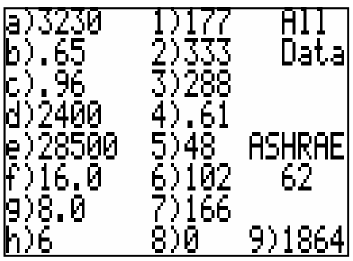
- The strategy for weatherizing this building would be to 1) prepare the house for insulation (seal attic bypasses, etc.) , 2) insulate the walls and attic (if not already insulated), and 3) perform another blower door test. If the ELA (line 1) is now close, but not less than the minimum ELA (line 6) tightening should stop. If the actual ELA is not yet close to the value of 102 in^2 on line 6, tightening should continue until it is no longer cost-effective or until the “ELAmin” is reached.
- Press ENTER to move to the “All Data” display.

BTL1-44



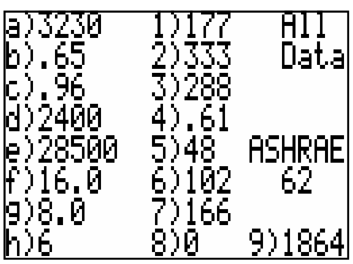
- a) CFM50 from blower door test (see Panel BTL1-20).
- b) Flow exponent from blower door test (see Panel BTL1-21).
- c) Weather factor from pages 21 through 23 (see Panel BTL1-22).
- d) House square footage (see Panel BTL1-23).
- e) House volume (see Panel BTL1-24).
- f) Building height (see Panel BTL1-25).
- g) Story height (see Panel BTL1-26).
- h) Occupant count (see Panel BTL1-27). **1) Actual ELA (see Panel BTL1-29).**

BTL1-45



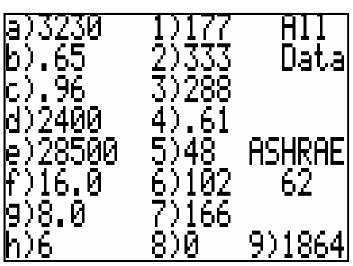
- 2) Actual EqLA (equivalent leakage area) (see Panel BTL1-30).
- 3) Estimated actual natural CFM (see Panel BTL1-31).
- 4) Estimated actual natural ACH (see Panel BTL1-31).
- 5) Estimated actual natural CFM per occupant (see Panel BTL1-32).
- 6) Minimum ELA for compliance (see Panel BTL1-33).
- 7) Minimum CFM for compliance (see Panel BTL1-34).
- 8) Mechanical ventilation CFM needed for compliance (see Panels BTL1-34 & 35)
- 9) Target minimum CFM_{50} value (see Panel BTL1-39).

BTL1-46



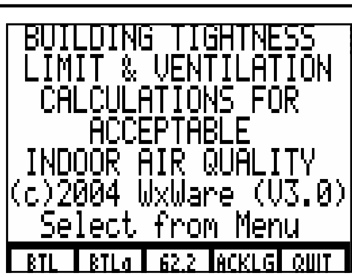
- The “All Data” display for this calculation method is first mentioned in panel BTL1-37. If you have the Texas Instruments Graph Link for the TI-86, you can print this display, or any other, on your computer’s printer. The Graph Link allows you to connect your TI-86 to your computer with a special cable. The companion Graph Link software for the PC or Mac allows storage of your TI-86 programs on your computer. Contact WxWare Diagnostics for more information about the Graph Link cable and software.

BTL1-47



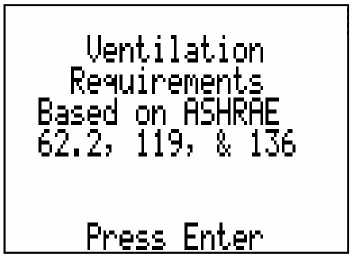
- The TI-86 does not allow storage of this “All Data” display out in the field unless you have the Graph Link cable and software and a portable PC or Mac computer in the field. You cannot store the display in the TI-86 for recall and printing later. You can, of course, re-enter the input data back at your office and then print the screen with the use of Graph Link and your computer and printer.
- A printed display such as the one at the left can be included as a graphic in reports to clients or reports saved for a client’s file.

BTL1-48



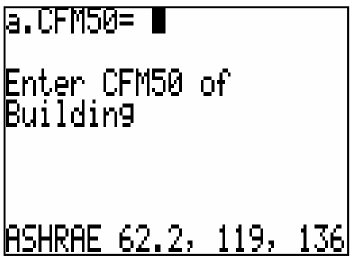
- Press **ENTER** to return to the home screen.
- **F3** takes you to the calculations for the latest ASHRAE Standard 62.2, *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings.*
- Let’s take a look at this newest program.

BTL1-49



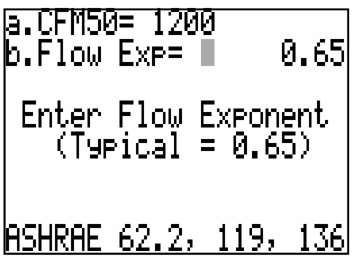
- This program has the same inputs and most of the same outputs as the BTLa program. It is important to understand that this program does not determine a building tightness limit, as BTL and BTLa do (the tightness limit for these two programs calculates the CFM_{50} threshold below which continuously operating ventilation is needed and above which it is not).

BTL1-50



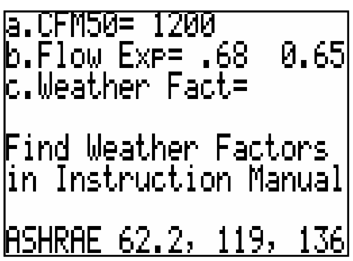
- Enter "a.CFM50" of the building, whether it was measured by a single-point or multi-point blower door test.
- Notice that "CFM50" on the display is preceded by the letter "a." All the input values for this procedure are preceded with a lower-case letter, a through h.
- Notice that "ASHRAE 62.2, 119, 136" is at the bottom of the display. This is a reminder that you are working on this advanced procedure that includes these ASHRAE Standards.
- For this example, enter 1200 and press ENTER.

BTL1-51



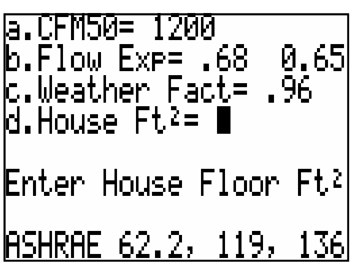
- The next prompt, "b.Flow Exp," requires you to enter the flow exponent for the building (the slope of the air-leakage curve of the building). If you have performed a single-point blower door test on the building, enter ".65," the typical value of the flow exponent (displayed to the right on the screen as a reminder).
- If you performed a multi-point blower door test, you will know the specific flow exponent for the building, usually within a range of 0.5 to 1.0. Enter this value.

BTL1-52



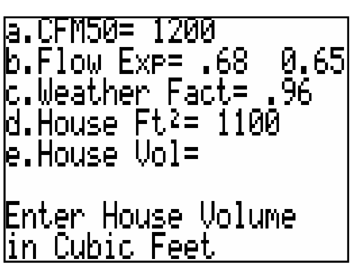
- Enter the weather factor, "c.Weather Fact." These values are listed in this instruction manual on pages 21 through 23 for locations in Canada and the United States, designated as "W." These factors are used to estimate the natural air leakage for the purpose of determining the CFM ratings of added exhaust ventilation to meet the standard set by ASHRAE 62-2001. This calculation procedure can be found in ASHRAE 136-1993.
- Enter ".96" for this example (Cleveland, Ohio) and press **ENTER**.

BTL1-53



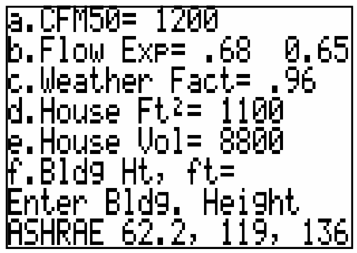
- Enter the square footage of building floor area, "d.House Ft²." This should be the conditioned floor area; the part of the building that is capable of being thermally conditioned for the comfort of the occupants. (If you include the basement here, you should open the basement to the main body of the house when you perform the blower door test).
- For this example, enter "1100" and press **ENTER** .

BTL1-54



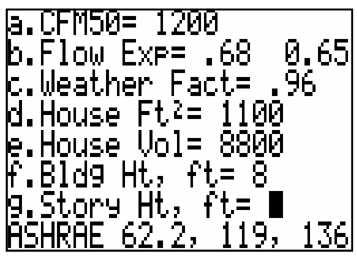
- Enter the building volume, "e.House Vol," in units of cubic feet. If you included the basement in the volume figure, include the basement here also.
- Enter "8800" (this value assumes a ceiling height of eight feet) and press **ENTER .**

BTL1-55



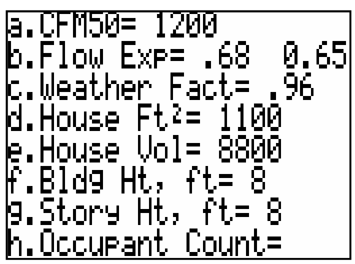
- Enter the building height above grade in units of feet, "f.Bldg Ht, ft." For buildings with uneven above grade heights—walk-out basements, one and one-half story buildings—use the average height of the building.
- For this example enter "8" and press **ENTER**
- Notice that "ASHRAE 62,119, 136" remains at the bottom of the screen as a reminder of the methodology on which you are working.

BTL1-56



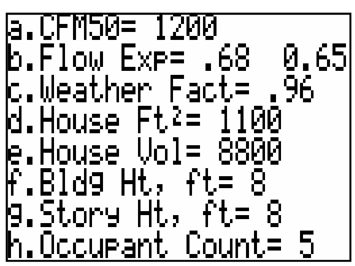
- Enter the average height of one story of the building, "g.Story Ht, ft." This value and the "Bldg Ht" from the previous entry (see Panel BTL1-37) determines the number of stories in the building. The resulting value (the number of stories) should not exceed three.
- For this example, enter "8" and press **ENTER**

BTL1-57



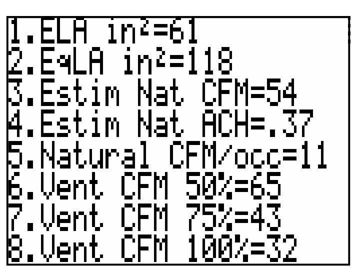
- Enter the "h.Occupant Count" as the next and final input value for this procedure. Enter the number of occupants or the number of bedrooms plus one, whichever is larger. This value is used to determine the ventilation requirements for the dwelling. The greater the number of occupants or bedrooms, the greater the amount of fresh air required for acceptable indoor air quality.
- For the example, enter "5"

BTL1-58



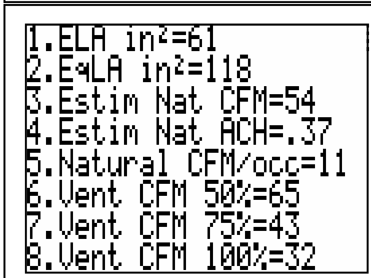
- Review the input values you have entered before you press **ENTER**.
- Now, press **ENTER** and move on to the next screen which displays all the output values for the example problem.
- Note that all the input values are lettered (a. through h), and that on the next screen (panel BTL1-59), all of the output values are numbered (1. through 8.).
- Press **ENTER** to move to the next screen.

BTL1-59



- On this screen, all the outputs are displayed except number 9.
- "1.ELA in²" is equal to "61" for the example. ELA (Effective Leakage Area) was developed at Lawrence Berkeley Laboratory (LBL) and is used in their air leakage model. The ELA is defined as the area of a special nozzle-shaped hole (similar to the inlet of your blower door fan) that would leak the same amount of air as the building does at a pressure of 4 Pascals. In the Solver section of the TI-86, the Equation Nugget with the name "AELA" can be used to calculate ELA if you know the CFM_4 of the building. [continued on next panel]

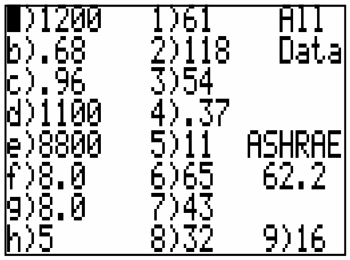
BTL1-60



- "2.EqLA in²" is equal to "118" for the example. EqLA (Equivalent Leakage Area) is defined by researchers at the Canadian National Research Council as the area of a sharp-edged orifice that would leak the same amount of air as the building does at a pressure of 10 Pascals. In the Solver section of the TI-86, the Equation Nugget with the name "AEQLA" can be used to calculate EqLA if you know the CFM_{10} of the building.
- Typically, EqLA more closely approximates the physical characteristics of building airtightness than ELA. [continued on next panel]

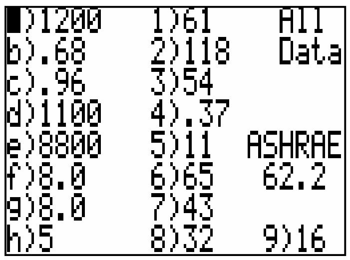
BTL1-61	1.ELA in^2=61 2.EqLA in^2=118 3.Estim Nat CFM=54 4.Estim Nat ACH=.37 5.Natural CFM/occ=11 6.Vent CFM 50%=65 7.Vent CFM 75%=43 8.Vent CFM 100%=32	• "3.Estim Nat CFM" (estimated natural CFM) is equal to 54 for the example. This calculated value is based on ELA, the Weather Factor (see Panel BTL1-34) and the dimensions of the building. It is the cubic feet per minute of air leakage based on natural forces such as wind pressure and differences in air density. • "4. Estim Nat ACH" is equal to 0.37 for the example. This is merely the "Estim Nat CFM" multiplied by 60 minutes per hour and divided by the building volume in units of cubit feet. [continued on next panel]
BTL1-62	1.ELA in^2=61 2.EqLA in^2=118 3.Estim Nat CFM=54 4.Estim Nat ACH=.37 5.Natural CFM/occ=11 6.Vent CFM 50%=65 7.Vent CFM 75%=43 8.Vent CFM 100%=32	• "5.Natural CFM/occ" (estimated natural CFM per occupant) is number 3, estimated natural CFM, divided by the "Occupant Count" • "6.Vent CFM 50%" is equal to 65 for the example. This means that intermittent ventilation operating 50 percent of the time requires 65 CFM when the house is closed up if the ventilation is to comply with the ASHRAE Standard 62.2-2003. **Note: This intermittent ventilation MUST operate at least once every three hours; if it does not, this CFM rate must be doubled.** [continued on next panel]
BTL1-63	1.ELA in^2=61 2.EqLA in^2=118 3.Estim Nat CFM=54 4.Estim Nat ACH=.37 5.Natural CFM/occ=11 6.Vent CFM 50%=65 7.Vent CFM 75%=43 8.Vent CFM 100%=32	• "7.Vent CFM 75%" is equal to 43 for the example. This means that intermittent ventilation operating 75 percent of the time requires 43 CFM when the house is closed up if the ventilation is to comply with the ASHRAE Standard 62.2-2003. **Note: This intermittent ventilation MUST operate at least once every three hours; if it does not, this CMF rate must be multiplied by 1.33.** • "8.Vent CFM 100%" is equal to 32 for the example. This means that **continuously operating** ventilation of 32 CFM is required when the house is closed up in order to comply with ASHRAE Standard 62.2-2003. [continued on next panel]
BTL1-64	1.ELA in^2=61 2.EqLA in^2=118 3.Estim Nat CFM=54 4.Estim Nat ACH=.37 5.Natural CFM/occ=11 6.Vent CFM 50%=65 7.Vent CFM 75%=43 8.Vent CFM 100%=32	• We designed this program to report three levels of ventilation for compliance with AHRAE Standard 62.2-2003, the first two for intermittent ventilation and the third for continuously operating ventilation. This gives the field analyst more flexibility for compliance. For example, if this hypothetical house already had a bathroom exhaust fan with an actual ventilation rate of 60 CFM, operating this fan 50 to 75 percent of the time when the house is closed up, will comply with the ASHRAE 62.2-2003 as long as the fan operates at least once every three hours. [continued on next panel]
BTL1-65	[intentionally left blank]	In such a case, the occupants must be instructed regarding the importance of operating the bathroom exhaust fan at least 75 percent of the time. On the other hand, if there is no exhaust ventilation installed during the initial analysis, a continuously operating 32 CFM exhaust fan can be installed in the bathroom or central hallway for compliance.
BTL1-66	[intentionally left blank]	• **Note: Compliance with ASHRAE 62.2-2003 and the procedures of this ZipTest Pro^2 software do not guarantee that moisture or indoor air quality problems will not develop. A healthy rate of ventilation may be more or less than the suggested estimate calculated here. Be cautions and use common sense.** • Now, press **ENTER** to move to the "ALL DATA" screen

BTL1-67



- The "All Data" display lists all the your inputs and outputs for a calculation. This is presented as a summary for your convenience. The letters and numbers correspond with the line letters (inputs) and numbers (outputs) on the two previous calculator displays.
- a) CFM_{50} from blower door test (see Panel BTL1-51).
- b) Flow exponent from blower door test or 0.65 (see Panel BTL1-51).
- c) Weather factor from pages 21 through 23 (see Panel BTL1-52).
- d) House square footage (see Panel BTL1-53). [continued on next panel]

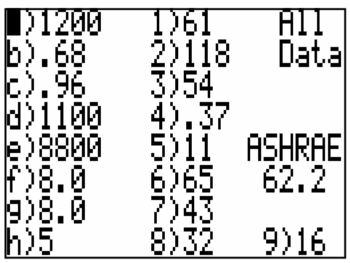
BTL1-68



- e) House volume (see Panel BTL1-54).
- f) Building height (see Panel BTL1-55).
- g) Story height (see Panel BTL1-56).
- h) Occupant count (see Panel BTL1-57).
- 1) Actual ELA (effective leakage area) (see Panel BTL1-59).
- 2) Actual EqLA (equivalent leakage area) (see Panel BTL1-60)
- 3) Estimated actual natural CFM (see Panel BTL1-61).
- 4) Estimated actual natural ACH (see Panel BTL1-31).

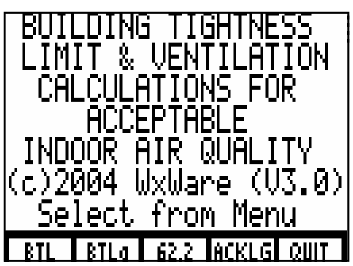
[continued on next panel]

BTL1-69



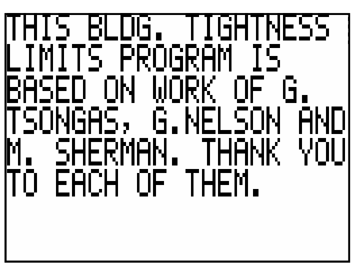
- 5) Estimated actual natural CFM per occupant (see Panel BTL1-62).
- 6) Ventilation requirement, 50% on-time (see Panel BTL1-62).
- 7) Ventilation requirement, 75% on-time (see Panel BTL1-63).
- 8) Mechanical ventilation requirement, always-on when the house is closed up (see panel BTL1-63).
- 9) This is the "infiltration credit" used in the ASHRAE 62.2-2003 procedure. This amount is subtracted from the **gross** continuous-ventilation requirement (48 in this example) to calculate number 8 (in this example, 32 CFM).

BTL1-70



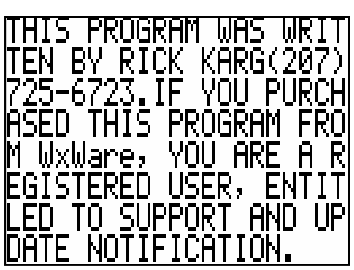
- Press **ENTER** to return to the main screen.
- From the main screen press **ACKLG** (acknowledgements).

BTL1-71

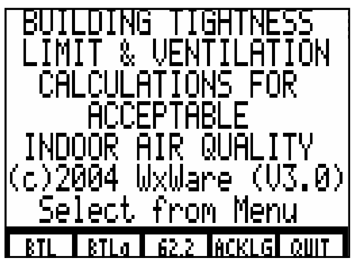
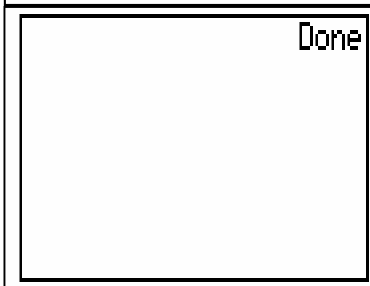


- Press **ENTER**.

BTL1-72

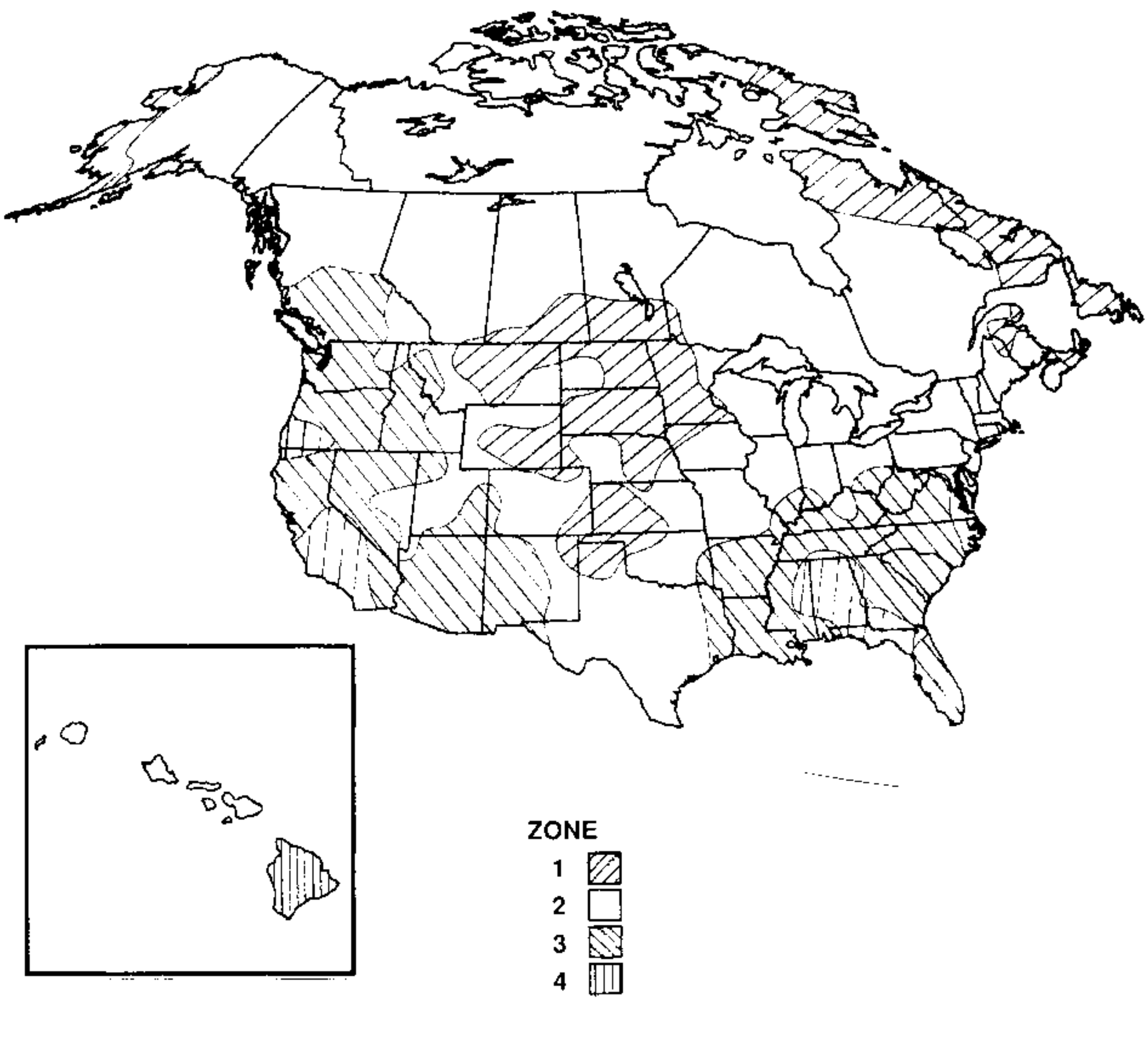


- Press **ENTER**.

BTL1-73		•You will see the screen at the left displayed • Press **ENTER**.
BTL1-74		• Press F5, "QUIT."Note: Always exit the program by pressing the QUIT menu button; this automatically resets the decimal place for calculator use. • Note: If you make a mistake while entering data before you press ENTER, use the arrow buttons to move the cursor over the erroneous entry and type the correct entry. If you notice you have made a mistake after you have pressed ENTER, press the "2nd" button, the "QUIT" button (next to the "2nd" button), and then ENTER. This will return you to the main menu. *This is very important!*
BTL1-75		•If you want to re-enter the program, simply press **ENTER.** • **Note: The TI-86 automatically shuts off after two minutes of non-use. When you turn it back on, you will be able to pick up right where it was shut off.** *This is very important!*
BTL1-76	[intentionally left blank]	
BTL1-77	[intentionally left blank]	
BTL1-78	[intentionally left blank]	

BUILDING TIGHTNESS LIMITS CLIMATE ZONE MAP

(For use with BTL method)



Values of the Weather Factor, *W*, for Canadian and U.S. Locations

(Reproduced from *A Method of Determining Air Change Rates in Detached Dwellings*, ANSI/ASHRAE 136-1993
(For use with BTLa and 62.2 methods)

VALUES OF THE WEATHER FACTOR *W* FOR CANADIAN AND U.S. LOCATIONS

Note: "Source" indicates the source of the Weather data.

WYEC[2] = weather year for energy calculations
TMY[3] = typical meteorological year
CAN[4] = average of the ten recent years of weather data

City, State	w[ACH]	Source
Adak, AK	1.16	TMY
Annette, AK	0.94	TMY
Bethel, AK	1.21	TMY
Big Delta, AK	0.99	TMY
Fairbanks, AK	0.90	TMY
Gulkana, AK	0.95	TMY
Homer, AK	0.87	TMY
Juneau, AK	0.95	TMY
King Salmon, AK	1.09	TMY
Kodiak, AK	0.93	TMY
McGrath, AK	0.90	TMY
Summit, AK	1.12	TMY
Birmingham, AL	0.69	TMY
Mobile, AL	0.76	TMY
Calgary, AB	0.94	CAN
Edmonton, AB	0.88	CAN
Fort Smith, AR	0.76	TMY
Little Rock, AR	0.75	TMY
Phoenix, AZ	0.68	TMY
Prescott, AZ	0.81	TMY
Tucson, AZ	0.79	TMY
Winslow, AZ	0.82	TMY
Yuma, AZ	0.77	TMY
Castlegar, BC	0.71	CAN
Fort St. John, BC	0.93	CAN
Prince Rupert, BC	0.88	CAN
Vancouver, BC	0.78	WYEC
Victoria, BC	0.69	CAN
Williams Lake, BC	0.83	CAN
Arcata, CA	0.74	TMY
Bakersfield, CA	0.68	TMY
China Lake, CA	0.67	TMY
Dagget, CA	0.90	TMY
El Toro, CA	0.57	TMY
Fresno, CA	0.69	TMY
Long Beach, CA	0.64	TMY
Los Angeles, CA	0.66	TMY
Mount Shasta, CA	0.78	TMY
Point Mugu, CA	0.63	TMY
Red Bluff, CA	0.81	TMY
Sacramento, CA	0.75	TMY
San Diego, CA	0.67	TMY
San Francisco, CA	0.92	TMY
Santa Maria, Ca	0.70	TMY
Sunnyvale, CA	0.63	TMY

City, State	w[ACH]	Source
Colorado Springs, CO	0.98	TMY
Denver, CO	0.87	TMY
Eagle, CO	0.80	TMY
Grand Junction, CO	0.87	TMY
Pueblo, CO	0.85	TMY
Hartford, CT	0.86	TMY
Washington, DC	0.76	TMY
Wilmington, DE	0.84	TMY
Apalachicola, FL	0.63	TMY
Daytona, FL	0.73	TMY
Jacksonville, FL	0.77	TMY
Miami, FL	0.69	TMY
Orlando, FL	0.73	TMY
Tallahassee, FL	0.63	TMY
Tampa, FL	0.75	TMY
Augusta, GA	0.69	TMY
Atlanta, GA	0.75	TMY
Savannah, GA	0.75	TMY
Hilo, HI	0.60	TMY
Honolulu, HI	0.81	TMY
Lihue, HI	0.94	TMY
Burlington, IA	0.90	TMY
Des Moines, IA	0.93	TMY
Mason City, IA	1.01	TMY
Sioux City, IA	0.99	TMY
Boise, ID	0.87	TMY
Lewiston, ID	0.71	TMY
Pocatello, ID	0.95	TMY
Chicago, IL	0.93	TMY
Moline, IL	0.86	TMY
Springfield, IL	0.93	TMY
Evansville, IN	0.76	TMY
Fort Wayne, IN	0.92	TMY
Indianapolis, IN	0.86	TMY
South Bend, IN	0.89	TMY
Dodge City, KS	1.11	TMY
Goodland, KS	1.09	TMY
Topeka, KS	0.87	TMY
Lexington, KY	0.80	TMY

Values of the Weather Factor, *W*, for Canadian and U.S. Locations

(Reproduced from *A Method of Determining Air Change Rates in Detached Dwellings*, ANSI/ASHRAE 136-1993
(For use with BTLa and 62.2 methods)

VALUES OF THE WEATHER FACTOR *W* FOR CANADIAN AND U.S. LOCATIONS

City, State	w[ACH]	Source
Baton Rouge, LA	0.70	TMY
Lake Charles, LA	0.72	TMY
New Orleans, LA	0.71	TMY
Shreveport, LA	0.77	TMY
Boston, MA	1.07	TMY
Churchill, MB	1.24	CAN
Thompson, MB	0.92	CAN
Baltimore, MD	0.82	TMY
Bangor, ME	0.75	TMY
Caribou, ME	1.00	TMY
Portland, ME	0.91	TMY
Alpena, MI	0.82	TMY
Detroit, MI	0.92	TMY
Flint, MI	0.90	TMY
Grand Rapids, MI	0.89	TMY
Sault Ste Marie, MI	0.95	TMY
Traverse City, MI	0.94	TMY
Duluth, MN	1.00	TMY
International Falls, MN	0.98	TMY
Minneapolis, MN	0.97	TMY
Rochester, MN	1.03	TMY
Kansas City, MO	0.85	WYEC
Springfield, MO	0.95	TMY
St. Louis, MO	0.87	TMY
Jackson, MS	0.68	TMY
Meridian, MS	0.62	TMY
Billings, MT	1.07	TMY
Cut Bank, MT	1.04	TMY
Dillon, MT	0.90	TMY
Glasgow, MT	1.02	TMY
Great Falls, MT	1.05	TMY
Helena, MT	0.89	TMY
Lewistown, MT	0.90	TMY
Missoula, MT	0.79	TMY
Saint John, NB	0.95	CAN
Asheville, NC	0.69	TMY
Cape Hatteras, NC	0.94	TMY
Charlotte, NC	0.74	TMY
Greensboro, NC	0.72	TMY
Raleigh, NC	0.72	WYEC
Bismarck, ND	0.99	TMY
Fargo, ND	1.10	TMY
Grand Island, NE	1.06	TMY
North Platte, NE	0.95	TMY
Omaha, NE	0.87	TMY
Scottsbluff, NE	0.99	TMY

City, State	w[ACH]	Source
Stephenville, NF	1.03	CAN
Concord, NH	0.76	TMY
Lakehurst, NJ	0.70	TMY
Albuquerque, NM	0.80	TMY
Clayton, NM	1.06	TMY
Roswell, NM	0.86	TMY
Truth or Conseq, NM	0.79	TMY
Tucumcari, NM	0.87	TMY
Shearwater, NS	0.87	CAN
Baker Lake, NT	1.25	CAN
Fort Smith, NT	0.92	CAN
Inuvik, NT	1.01	CAN
Elko, NV	0.77	TMY
Ely, NV	0.98	TMY
Las Vegas, NV	0.81	TMY
Lovelock, NV	0.78	TMY
Reno, NV	0.75	TMY
Tonopah, NV	0.90	TMY
Winnemucca, NV	0.84	TMY
Yucca Flats, NV	0.77	TMY
Buffalo, NY	0.99	TMY
Massena, NY	0.90	TMY
New York Cen. Pk, NY	0.98	TMY
New York LaGuar., NY	0.99	TMY
Rochester, NY	0.92	TMY
Syracuse, NY	0.88	TMY
Akron, OH	0.91	TMY
Cincinnati, OH	0.84	TMY
Cleveland, OH	0.96	WYEC
Columbus, OH	0.86	TMY
Dayton, OH	0.86	TMY
Toledo, OH	0.90	TMY
Youngstown, OH	0.92	TMY
Oklahoma City, OK	1.05	TMY
Tulsa, OK	0.93	TMY
Kapuskasing, ON	0.92	CAN
Sault Ste. Marie, ON	0.90	CAN
Thunder Bay, ON	0.86	CAN
Toronto, ON	0.82	WYEC
Windsor, ON	0.87	CAN
Astoria, OR	0.85	TMY
Medford, OR	0.67	TMY
North Bend, OR	0.90	TMY
Portland, OR	0.76	TMY
Redmond, OR	0.80	TMY
Salem, OR	0.80	TMY

Values of the Weather Factor, *W*, for Canadian and U.S. Locations

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(For use with BTLa and 62.2 methods)

VALUES OF THE WEATHER FACTOR *W* FOR CANADIAN AND U.S. LOCATIONS

City, State	w[ACH]	Source
Allentown, PA	0.80	TMY
Erie, PA	1.00	TMY
Harrisburg, PA	0.76	TMY
Philadelphia, PA	0.85	TMY
Pittsburgh, PA	0.85	TMY
Charlottetown, PE	1.04	CAN
Quebec, PQ	0.84	CAN
Schefferville, PQ	1.13	CAN
Sept Iles, PQ	0.96	CAN
Montreal, PQ	0.86	WYEC
Providence, RI	0.91	TMY
Charleston, SC	0.77	TMY
Columbia, SC	0.67	TMY
Greenville, SC	0.69	TMY
Huron, SD	1.09	TMY
Pierre, SD	1.00	TMY
Sioux Falls, SD	1.05	TMY
Regina, SK	1.05	CAN
Saskatoon, SK	0.98	CAN
Chattanooga, TN	0.64	TMY
Knoxville, TN	0.68	TMY
Memphis, TN	0.78	TMY
Nashville, TN	0.74	WYEC
Abilene, TX	1.05	TMY
Amarillo, TX	1.14	TMY
Austin, TX	0.80	TMY
Brownsville, TX	0.90	TMY
Corpus Christi, TX	0.86	TMY
El Paso, TX	0.76	TMY

City, State	w[ACH]	Source
Fort Worth, TX	0.89	TMY
Houston, TX	0.81	TMY
Kingsville, TX	0.72	TMY
Laredo, TX	0.91	TMY
Lubbock, TX	1.00	TMY
Lufkin, TX	0.64	TMY
Midland Odessa, TX	0.96	TMY
Port Arthur, TX	0.79	TMY
San Angelo, TX	0.84	TMY
San Antonio, TX	0.83	TMY
Sherman, TX	0.80	TMY
Waco, TX	0.92	TMY
Wichita Falls, TX	0.99	TMY
Cedar City, UT	0.81	TMY
Salt Lake City, UT	0.87	TMY
Norfolk, VA	0.84	TMY
Richmond, VA	0.75	TMY
Roanoke, VA	0.74	TMY
Olympia, WA	0.77	TMY
Seattle, WA	0.85	TMY
Spokane, WA	0.87	TMY
Yakima, WA	0.81	TMY
Eau Claire, WI	0.93	TMY
Green Bay, WI	0.94	TMY
La Crosse, WI	0.86	TMY
Madison, WI	0.91	TMY
Milwaukee, WI	1.00	TMY
Charleston, WV	0.66	TMY
Casper, WY	1.15	TMY
Cheyenne, WY	1.08	TMY
Rock Springs, WY	0.98	TMY
Sheridan, WY	0.83	TMY
Whitehorse, YT	0.94	CAN

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