Instructions
for

Equation Nuggets

April 2004 (V3.2)

INTRODUCTION

The fifty equations loaded into the SOLVER equation section were selected for their relevance to building diagnostics in both the residential and commercial sectors. Each of the equations is explained in this chapter. There is a three-page list of the equations at the end of this chapter that includes the equation names and the equations exactly as they are entered in the calculator. This might be a helpful list to carry around with you when you are analyzing dwellings.

The powerful SOLVER equation feature of the TI-86 calculator allows you to solve for any of the variables of an equation as long as values for all of the other variables are entered. No rewriting of the equation is necessary. You can do "what if" analysis, guess answers and quickly find the right one.

An extremely useful feature of the TI-86 calculator is that variable values from one equation or program are automatically saved to memory until the value is changed by a new value keyed in by the user. A few examples for clarity: If you wish to calculate the dew point temperature of the air in a building, you must first use SOLVER equation "AHRAT" to calculate the humidity ratio, the variable for which is "HuRa." If you solve for "HuRa" and then move to the SOLVER Equation Nugget "ADEWP," the variable "HuRa" in this second equation will not have to be entered, it will already be there.

A second example of this memorized-variable-value feature: You are performing zone pressure diagnostics on a building with the use of the pressure diagnostics (Press) program in the TI-86 calculator. Using the "hole method" you find the building-to-zone pressure is 37 Pascals and the zone-to-outside pressure is 13 Pascals. You enter each of these as program inputs to find building-to-zone, zone-to-outside, and total-path CFM_{50} values. Now you want to find the building-to-zone leakage as a percentage of the zone-to-outside leakage. When you call up the SOLVER Equation Nugget "ASERP" for this purpose, you will find that the needed building-to-zone and zone-to-outside pressure values are already loaded for you; no need to enter them.

Equation Selection

The EQUATION NUGGETS were collected and programmed by Rick Karg of WxWare Diagnostics, a division of R.J. Karg Associates, with the valuable help of Neil Moyer.

Nugget-1		• Activate the TI-86 be pressing the **ON** button. • Press the light orange **2nd** button, and then press the **SOLVER** button (this is the second function of the **GRAPH** button). • You will see the screen at the left. The first menu set of equations available to you are displayed at the bottom of the screen. **Each useful SOLVER equation begins with the letter "A."** The equations are listed in alphabetical order. Press the **MORE** button.
Nugget-2		• The second menu set of five SOLVER equation names is displayed. • For a quick overview of all fifty equations, refer to the equations lists on pages 107 through 109. • Press the **MORE** button.
Nugget-3		• The third menu set of five SOLVER equation names is displayed. • Press the **MORE** button.
Nugget-4		• The fourth menu set of five SOLVER equation names is displayed. • Press the **MORE** button.
Nugget-5		• The fifth menu set of five SOLVER equation names are displayed. • Press the **MORE** button.
Nugget-6		• The sixth menu set of five SOLVER equation names is displayed. • Press the **MORE** button until you have gone through all the equations—fifty on ten menu sets—that begin with "A." **Equations after this (that do not begin with "A") are not intended for your use here.** • You can freely move through this list of SOLVER equations to get to the equation you need. • Press **MORE** until you get back to the first set of five SOLVER equations, beginning with "ABMI."

This is very important!

Nugget-7

- Press the orange **2nd** button, and then press the **RCL** (recall) key (this is the second function of the **STO>** key). **This is the method you <u>must</u> use to call up a SOLVER equation; there is no other way.** You cannot just press the chosen menu key without the **RCL** key.
- You will see the screen at the right displayed on you calculator.
- Notice the "Rcl" (recall) is displayed at the bottom left just above the equation menu.
- Press **F1** for "ABMI."

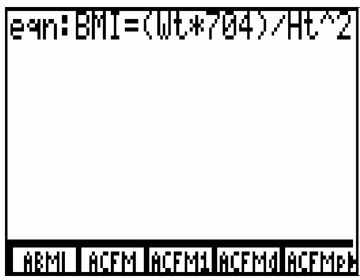
This is very important!

Nugget-8

- Notice that "ABMI" is now displayed at the bottom of your screen to the right of "Rcl".
- Press **ENTER**.

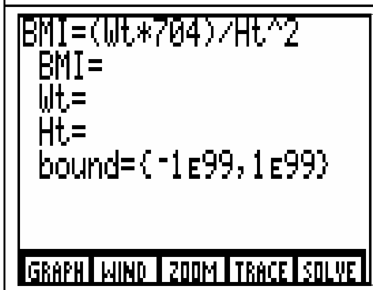
- <u>**ABMI** is the body mass index equation.</u> It has nothing to do with building diagnostics; it will show you whether you are a healthy weight (BMI less than 25), overweight (BMI from 25 to 30), or obese (BMI above 30). It is important that building diagnosticians watch their weight, right?

Nugget-9



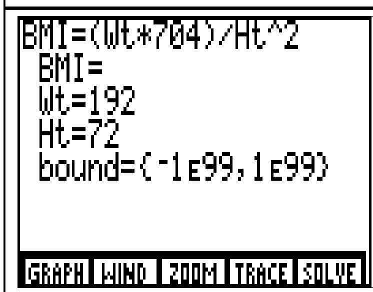
- The "ABMI" equation is now loaded into the SOLVER feature of the calculator; the SOLVER working area.
- This powerful feature allows you to solve for any variable in the equation if you enter values for all the other variables (there is no need to rewrite the equation to do this).
- Notice that the equation seems to extend beyond the right side of the screen. Use your right arrow (cursor) button to view the rest of the equation. Use the left arrow button to move back.

Nugget-10



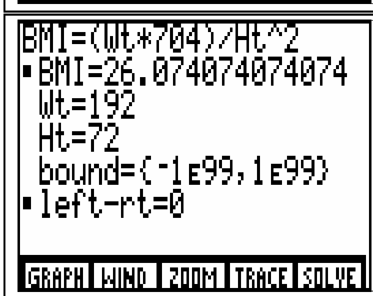
- Press the down arrow button once or the ENTER button.
- The three variables for this equation — "BMI, Wt," and "Ht" — are listed.
- Ignore the "bound" line of information.
- Notice that the menu changed at the bottom of the screen when you pressed ENTER or the down arrow button once. Of these displayed menu features, "SOLVE" is the one you will use the most. For instructions regarding "GRAPH, WIND, ZOOM," and "TRACE," see the TI-86 instruction manual.

Nugget-11



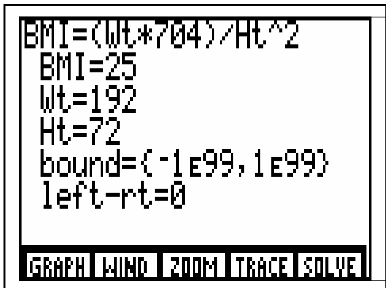
- Let's assume you weigh 192 pounds and you are six feet tall (72 inches). Let's find your body mass index to determine if you are a healthy weight.
- Enter 192 on the "Wt" (weight) line. This should be in units of pounds. Move the cursor to the proper line with the cursor arrow keys on the TI-86.
- Enter 72 on the "Ht" (height) line. Your height must be entered in units of inches.
- **If you make a mistake, just type over it or position the cursor over the mistake and press the DEL (delete) button.**

Nugget-12



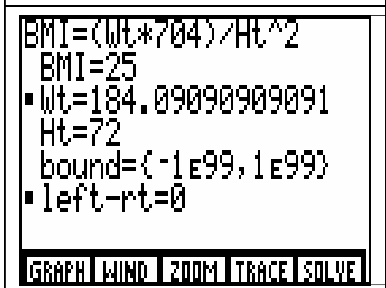
- Now move the cursor to the line for "BMI" (body mass index).
- With the cursor on the "BMI" line, press **F5** for "SOLVE."
- The body mass index is just over twenty-six. You're overweight!
- Let's find out what your weight must be to have a healthy BMI of 25.
- Go to the next panel, "Nugget-13."

Nugget-13



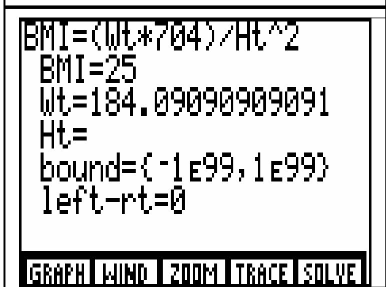
- Enter 25 on the "BMI" line.
- Move the cursor to the "Wt" line below. There is no need to clear the "192" value from the previous example. You may do so by pressing the **CLEAR** key; this clears the line where the cursor is located.
- With the cursor on the "Wt" line, press **F5** for "SOLVE."

Nugget-14



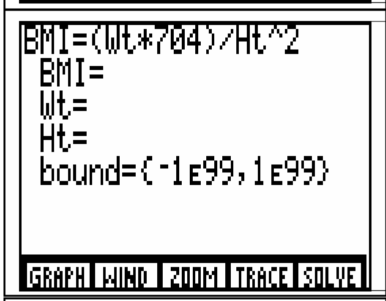
- You see that you must get your weight down to 184 pounds for a body mass index of 25.
- The body mass index can be helpful and fun at parties, but the important point here is getting the Equation Nuggests to work for you. Notice that you can solve for any of the variables by assigning values to the others—a very powerful feature!
- Notice the small black square to the left of "Wt," indicating the last variable for which you pressed the **F1**, "SOLVE."

Nugget-15



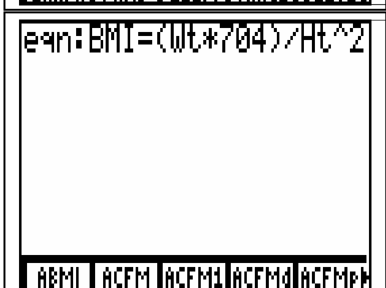
- It is recommended that you delete the values for each variable before you move on to another Equation Nugget. This frees memory in the calculator.
- Place the cursor on the "Ht" line and then press the **CLEAR** key. The value for the "Ht" variable will be deleted.

Nugget-16



- Now delete the variable values for the others, "Wt" and "BMI."

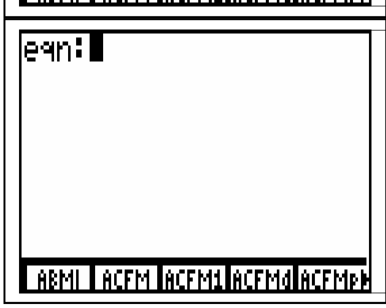
Nugget-17



- Move the cursor to the top line. Notice that the lower lines disappear.
- **It is very important to delete one Equation Nugget from the working area of the SOLVER function before you load another one into the working area.** One equation loaded over another can result in the mixing of the equation variables, yielding strange and meaningless answers.
- So, with the cursor on the top line, press **CLEAR**.

This is very important!

Nugget-18

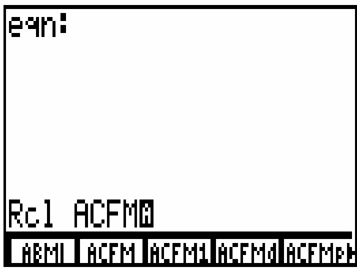


- Now the calculator is ready to load another Equation Nugget in the working area of SOLVER.

Nugget-19

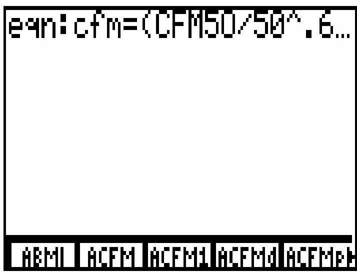
- Let's try the next Equation Nugget.
- Press the orange **2nd** key and then the **RCL** key. You will see the "Rcl" (recall) at the bottom left of the display, as on the example display at the left.
- Press F2 for "ACFM."

Nugget-20



- Notice that "ACFM" is now displayed at the bottom of your screen to the right of "Rcl".
- Press **ENTER**. The **"**ACFM" equation is now loaded into the SOLVER feature of the calculator.

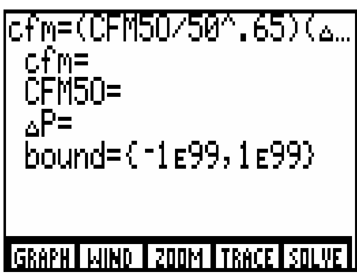
Nugget-21



<u>ACFM (pressure created by exhaust devices)</u>
cfm = cubic feet per minute of exhaust appliances.
CFM50 = blower door test results at 50 Pascals pressure.
ΔP = pressure difference between indoors and outdoors created by operation of exhaust fans (shown as positive number, but actually is negative).

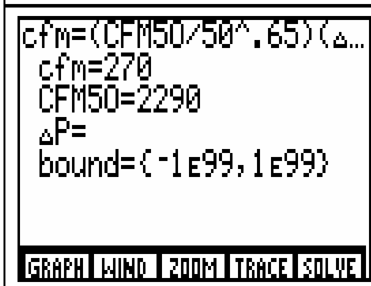
- Press the down arrow button once or the **ENTER** button.

Nugget-22



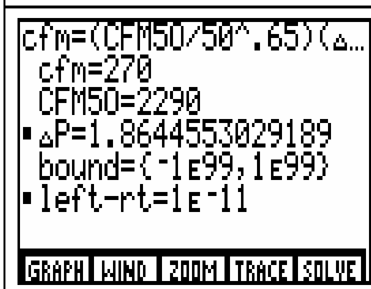
- The three variables for this equation—cfm, CFM50, and ΔP—are listed.
- Ignore the "bound" line of information.
- Notice that the menu changed at the bottom of the screen when you pressed **ENTER** or the down arrow button once. Of these displayed menu features, "SOLVE" is the one you will use the most. For instructions regarding "GRAPH, WIND, ZOOM," and "TRACE," see the TI-86 instruction manual.

Nugget-23



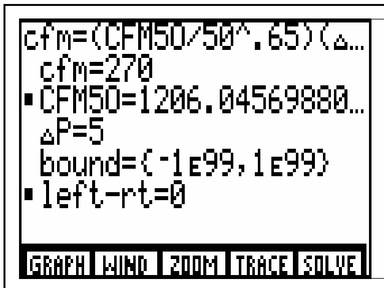
- Let's assume a 1500 square foot dwelling with a CFM_{50} of 2290 has a kitchen vent fan (100 cfm) and a bathroom vent fan (50 cfm). Will venting the existing unvented dryer cause excessive negative pressure in the house? We can't actually test for this until the dryer is vented. This equation can help. The existing exhaust fans plus 120 cfm for the dryer add up to 270 cfm if they are all operating at the same time.
- Enter 270 on the "cfm" line.
- Enter 2290 on the "CFM50" line.

Nugget-24



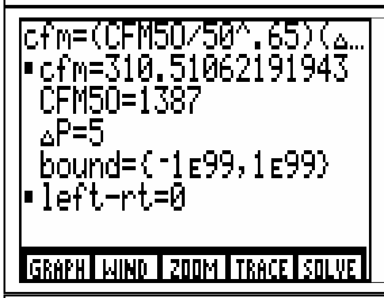
- Move from line to line by using the arrow buttons.
- If you make a mistake, just type over it or position the cursor over the mistake and press the **DEL** (delete) button.
- Move the cursor to the "DP" line.
- With the cursor on the "DP" line, press **F5**, "SOLVE."
- The house pressure created by all the included exhaust appliances running at the same time is displayed (this equation assumes a building flow exponent of 0.65. If you know the actual building flow exponent value, you may change the equation).

Nugget-25



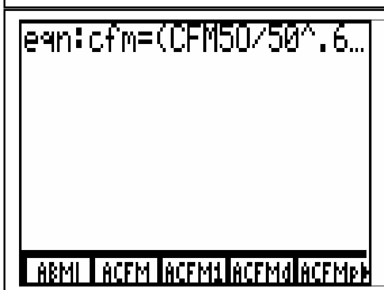
- You may solve for any of the three variables in this equation.
- Notice that a small, square bullet is displayed to the left of the variable for which you last solved.
- Another example: Suppose we assume that -5 Pascals is the highest negative pressure this building can tolerate without backdrafting problems. Enter 5 on the "ΔP" line (no need to enter a negative sign).
- Move the cursor to the "CFM50" line and press "SOLVE," **F5**. We have found that if we tighten to 1206 CFM_{50}, the exhausting units will create a -5 Pa.

Nugget-26



- Another example: Let's assume the Building Tightness Limit (BTL) for this house is 1387 CFM_{50} (this can be calculated with the BTL or BTLa programs loaded in your TI-86 calculator). Enter "1387" on the "CFM50" line.
- We want to find the maximum cfm we can exhaust from this building without creating more than -5 Pascals of pressure.
- With 5 entered on the "ΔP" line, move the cursor up to the "cfm" line. Press "SOLVE," **F5**, to find the answer of 310 cfm.
- Now delete the variable values on the three variable lines.

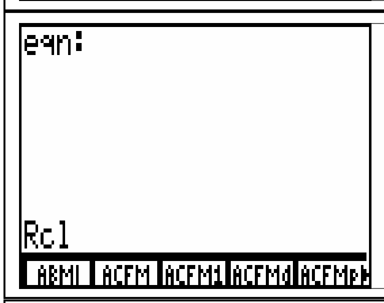
Nugget-27



- Move the cursor up to the top line, the equation line. You may change the equation for your use, but your changes will be temporary. You cannot change the equation in the memory, so the next time you call it up, the answer will not reflect your changes.
- **NOTE: Before calling another equation up, locate the cursor on the equation line (the top line) and press the CLEAR button (just below the down arrow button). This is very important.**

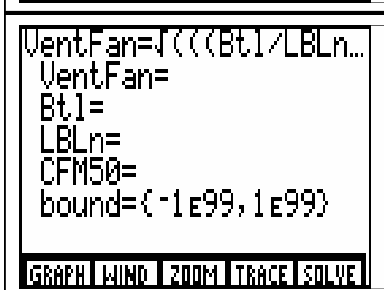
This is very important!

Nugget-28



- The equation is cleared.
- To call another equation, press the light orange **2nd** button, and then press the RCL button (this is the second function of the **STO>** button).
- Your screen will look like the picture at the left.
- When you press one of the menu buttons at the bottom of the screen, the SOLVER equation name will appear to the right of "Rcl." Then press **ENTER** to load that equation into the SOLVER.
- The **MORE** button advances the SOLVER equation menu.

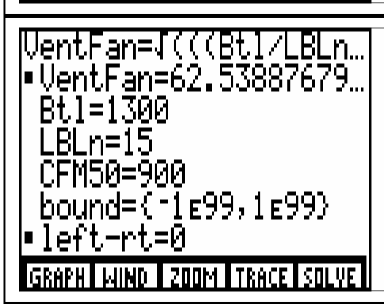
Nugget-29



- The next Equation Nugget is "ACFM1."

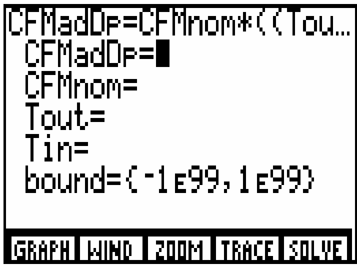
ACFM1 <u>(determination of vent fan size when house is "too tight")</u>
VentFan = required cfm of continuously operating exhaust fan.
Btl = Building Tightness Limit as determined with the "BTL1" program, BTL routine (a program loaded with the ZipTest Pro² software).
LBLn = Lawrence Berkeley Lab. correlation number as determined by the BTL program.
CFM50 = actual blower door test result at 50 Pascals of pressure.

Nugget-30



- For example, assume the "Btl" = 1300, the "LBLn" = 15, and "CFM50" = 900. The house is tighter (900 CFM_{50}) than the Building Tightness Limit (1300 CFM_{50}). Because of this, the building requires continuously operating ventilation when the house is closed up.
- Solving for "VentFan," we find that the required fan CFM is about 62.
- Now clear the variable values and the equation on the top line. We will now move on to the next equation.

Nugget-31



<u>**ACFMd** (*depressurization* blower door result temperature-adusted)</u>

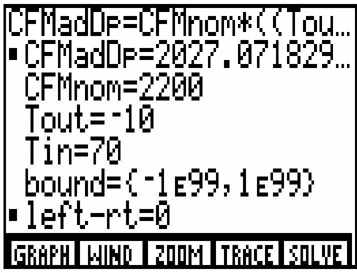
CFMadDp = blower door CFM temperature adjusted for **depressurization** test.

CFMnom = nominal blower door reading before temperature adjustment.

Tout = temperature indoors, ^{O}F.

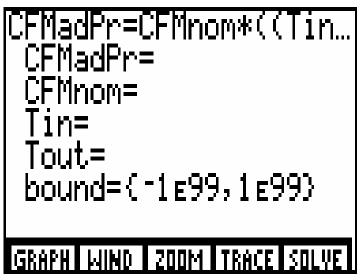
Tin = temperature outdoors, ^{O}F.

Nugget-32



- For example, assure the "CFMnom" = 2200, "Tout" = -10, and "Tin" = 70. Note that to enter a negative number you must use the key to the left of the **ENTER** key, not the subtraction key that is two above the **ENTER** key.
- Move the cursor to the "CFMadDp" line and press **F5** for "SOLVE."
- The temperature-adjusted CFM is 2027, less than the nominal 2200. This adjustment is for a depressurization test.
- Clear the variable values and the equation before moving on to another.

Nugget-33



<u>**ACFMp** (*pressurization* blower door result temperature-adusted)</u>

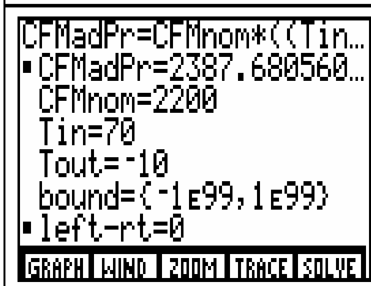
CFMadPr = blower door CFM temperature adjusted for **pressurization** test.

CFMnom = nominal blower door reading before adjustment.

Tout = temperature indoors, ^{O}F.

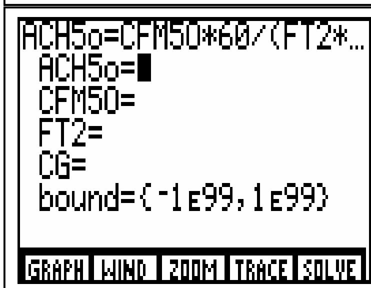
Tin = temperature outdoors, ^{O}F.

Nugget-34



- For example, assure the "CFMnom" = 2200, "Tout" = -10, and "Tin" = 70. Note that to enter a negative number you must use the key to the left of the ENTER key, not the subtraction key that is two above the ENTER key.
- Move the cursor to the "CFMadPr" line and press **F5** for "SOLVE."
- The temperature-adjusted CFM is 2387, more than the nominal 2200. This adjustment is for a pressurization test.
- Clear the variable values and the equation before moving on to another.
- Press MORE to move to the next set of five Equation Nuggets.

Nugget-35



<u>**ACH50** (air changes per hour at 50 Pascals building pressure from CMF_{50})</u>

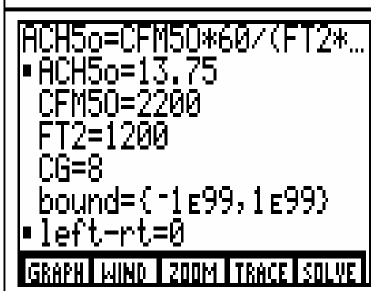
ACH5o = is air changes per hour at 50 Pascals of building pressure.

CFM50 = is the CFM of the building at 50 Pascals of building pressure.

FT2 = is the square feet of occupied building area.

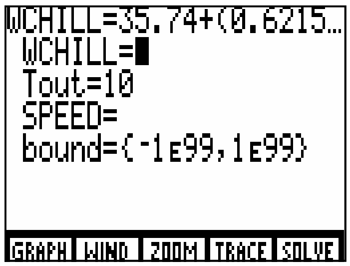
CG = is the ceiling height (FT2 x CG = volume).

Nugget-36



- For example, if the ceiling height, "CG," is 8 feet, the square footage of the conditioned house, "FT2," is 1200, and the "CFM50" is 2200, the "ACH5o" value is 13.75. This is the Air Change per Hour at 50 Pascals of pressure difference between the indoors and outdoors.

Nugget-37



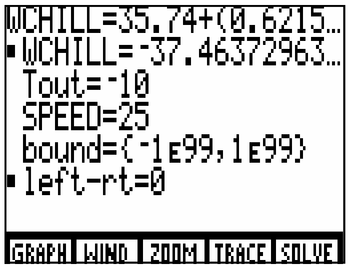
<u>ACHIL (equivalent wind chill temperature)</u>

Tout = temperature in degrees Fahrenheit. If the temperature is below zero, enter a negative sign before the number (you must use the negative-sign button to the left of the **ENTER** button).

SPEED = wind speed in miles per hour (this can be calculated with the "AIRSP" equation included in the Equation Nuggets).

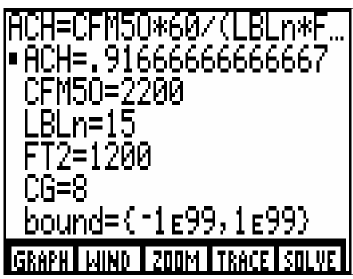
- This is the wind chill temperature spoken of by weather forecasters.

Nugget-38



- Try the example displayed at the left. Remember that the negative temperature "Tout" must be entered by using the **(-)** key to the left of the **ENTER** key.
- Note: This wind chill equation has been used since 2001 by the National Weather Service.

Nugget-39



<u>ACHN (building air change per hour at natural pressure)</u>

CFM50 = CFM_{50} from the blower door test.

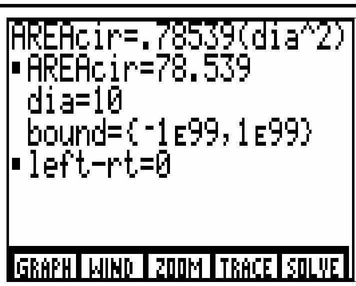
LBLn = Lawrence Berkeley Laboratory correlation factor. This number is displayed by the Building Tightness Limits "BTL1" program, "BTL" routine.

FT2 = square footage of the house.

CG = ceiling height (FT^2 x CG = volume).

- Run through the example at the left, solving for "ACH."

Nugget-40



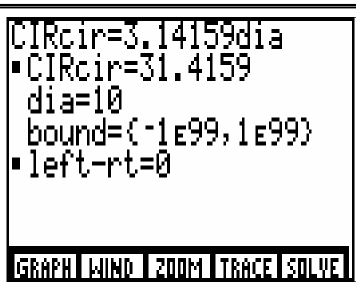
<u>ACIRa (area of a circle)</u>

AREAcir = the area of the circle.

dia = diameter of circle.

- Work out the example at the left.

Nugget-41



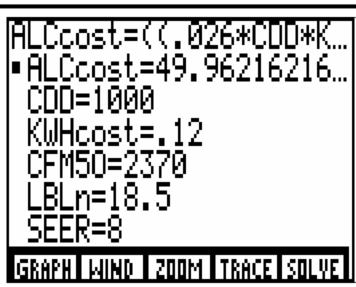
<u>ACIRc (circumference of a circle)</u>

CIRcir = the circumference of the circle.

dia = diameter of circle.

- Work out the example at the left.

Nugget-42



<u>ACLG1 (annual cooling cost of air leakage)</u>

ALCcost = annual cooling cost in dollars.

CDD = cooling degree days.

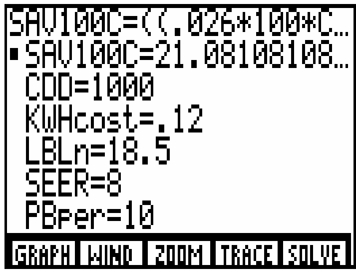
KWHcost = kiloWatt hour cost of electricity.

CFM50 = CFM_{50} from the blower door test

LBLn = Lawrence Berkeley Laboratory correlation factor. This number is displayed by the Building Tightness Limits "BTL1" program, "BTL" routine.

SEER = seasonal energy efficiency ratio for cooling equipment.

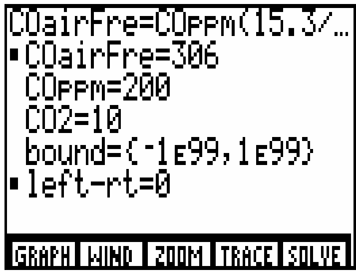
Nugget-43



ACLG2 (cooling cost-effectiveness guideline for air sealing)

SAV100C = cooling cost-effectiveness guideline per 100 CFM_{50} reduction.
CDD = cooling degree days.
KWHcost = kiloWatt hour cost of electricity.
LBLn = Lawrence Berkeley Laboratory correlation factor. This number is displayed by the Building Tightness Limits "BTL1" program, "BTL" routine.
SEER = seasonal energy efficiency ratio for cooling equipment.
PBper = reasonable payback period for weatherization measure.

Nugget-44



ACO2O (air-free carbon monoxide from as-measured carbon monoxide and carbon dioxide for a number 2 oil appliance)

COairFre = air-free carbon monoxide in units of parts per million (ppm).
COppm = as-measured carbon monoxide in units of ppm.
CO2 = percentage carbon monoxide in flue gas (as a percentage, i.e. enter 10% as 10, not as 0.10).

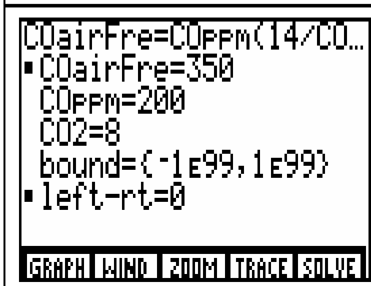
Nugget-45

ACOAR (air-free carbon monoxide from as-measured carbon monoxide and oxygen percentage in flue gas, any fuel)

COairFre = air-free carbon monoxide in units of parts per million (ppm).
COppm = as-measured carbon monoxide in units of ppm.
Oxy2 = percentage of oxygen in measured air sample (enter 9.5% as 9.5).

- Comment: To find a CO air free value in a vent, for example, measure the ppm concentration of CO in the vent. Then measure the percent oxygen. Use this equation to find the air-free level of carbon monoxide.

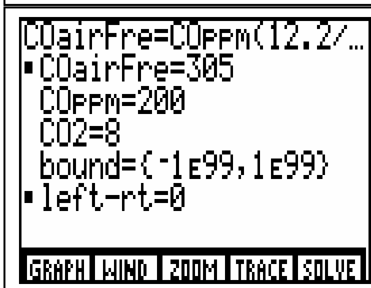
Nugget-46



ACOLP (air-free carbon monoxide from as-measured carbon monoxide and carbon dioxide for a liquified propane, LP, appliance)

COairFre = air-free carbon monoxide in units of parts per million (ppm).
COppm = as-measured carbon monoxide in units of ppm.
CO2 = percentage carbon monoxide in flue gas (as a percentage, i.e. enter 8% as 8, not as 0.8).

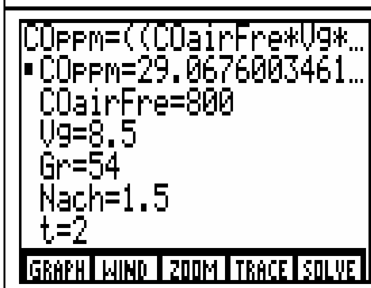
Nugget-47



ACONG (air-free carbon monoxide from as-measured carbon monoxide and carbon dioxide for a natural gas appliance)

COairFre = air-free carbon monoxide in units of parts per million (ppm).
COppm = as-measured carbon monoxide in units of ppm.
CO2 = percentage carbon monoxide in flue gas (as a percentage, i.e. enter 8% as 8, not as 0.8).

Nugget-48



ACORM (for determining the carbon monoxide concentrations in a room from an unvented natural gas or propane appliance, such as a gas range/oven)

COppm = resulting room CO concentration in parts per million (ppm).
COairFre = air-free CO released from gas appliance in ppm.
Vg = ft^3 of flue gas per ft^3 of fuel gas (8.5 ft^3 for natural gas, 21.8 ft^3 for propane).
Gr = gas flow rate in ft^3/hr. This equals $\frac{\text{input rate (Btu/hr)}}{\text{heat value of fuel (Btu/ft}^3\text{)}}$

See next panel

Nugget-49

```
COppm=((COairFre*Vg*…
 COairFre=800
 Vg=8.5
 Gr=54
 Nach=1.5
 t=2
 v=8000
GRAPH WIND ZOOM TRACE SOLVE
```

ACORM continued. (display is scrolled one line from panel "Nugget-48" at the bottom of the previous page).
Nach = natural air changes per hour of room or of house.
t = time interval, in hours.
v = volume of room or of house, in ft^3.

Nugget-50

```
DewPt=1.8*((-4111/(1…
▪DewPt=53.1179778366…
 HuRa=.0084851718767…
 bound={-1E99,1E99}
▪left-rt=0
GRAPH WIND ZOOM TRACE SOLVE
```

ADEWP (dewpoint temperature determination)
DewPt = air dew point temperature, ^{0}F.
HuRa = humidity ratio, the ratio of the mass of water vapor to the mass of dry air. Also called the mixing ratio. Note: the humidity ratio is caluculated by the "AHRAT" Equation Nugget by inputting air temperature and relative humidity.

Nugget-51

```
DuctDia=1.3((s1*s2)^…
▪DuctDia=7.554176309…
 s1=8
 s2=6
 bound={-1E99,1E99}
▪left-rt=0
GRAPH WIND ZOOM TRACE SOLVE
```

ADUCT (round duct diameter to rectangular)
DuctDia = equivalent round duct diameter.
s1 = one rectangular dimension of the duct .
s2 = other rectangular dimension of the duct.

- Remember, you can enter any two variables here and solve for the third. This is a very useful equation for ductwork design, installation, and retrofit.

Nugget-52

```
ELAin2=.2835*CFM4
▪ELAin2=205.821
 CFM4=726
 bound={-1E99,1E99}
▪left-rt=0
GRAPH WIND ZOOM TRACE SOLVE
```

AELA (effective leakage area from CFM_4)
ELAin2 = Effective Leakage Area, in^2 (Lawrence Berkeley Labs).
CFM4 = CFM at 4 Pascals of building pressure. This value can be calculated using a multi-point blower door test. You must know the house constant and the "Fx" number (flow exponent). This is explained later in this instruction document and can be calculated with a blower door and the TI-86 calculator. The Equation Nugget "AIREQ" is also useful for this calculation. This test was developed by Lawrence Berkeley Laboratory.

Nugget-53

```
EQLAin=.2939*CFM10
▪EQLAin=399.1162
 CFM10=1358
 bound={-1E99,1E99}
▪left-rt=0
GRAPH WIND ZOOM TRACE SOLVE
```

AEQLA (equivalent leakage area from CFM_{10})
EqLAin = Equivalent Leakage Area, in^2.
CFM10 = CFM at 10 Pascals of building pressure. See the comments above in panel "Nugget-52." This test was developed by National Research Council of Canada.

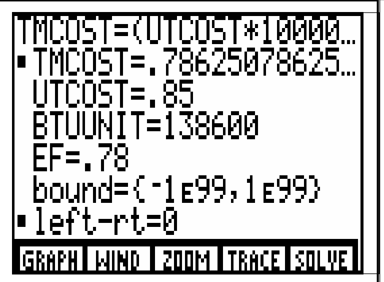
Nugget-54

```
PI=PRIN(i(1+i)^per)/…
▪PI=177.95558147923
 PRIN=8000
 i=.01
 per=60
 bound={-1E99,1E99}
▪left-rt=0
GRAPH WIND ZOOM TRACE SOLVE
```

AFCOM (payments on loan, interest, principle, periods)
PI = principle and interest or payment per period, usually each month.
PRIN = the principle or amount of the loan, or present value.
i = interest payment per period (per). A 12% annual interest rate on a loan paid back monthly is 0.12/12 months per year = 0.01, as in the example.
per = the number of periods of the loan. A five year load with monthly payments has a "per" = 60, as in the example at the left.

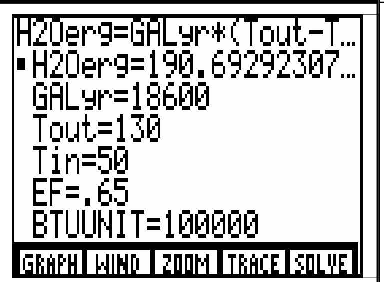
- Remember, you can solve for any of these variables by entering the others.

Nugget-55



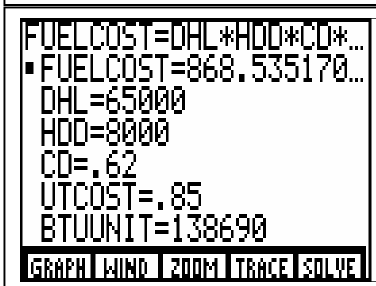
<u>AFUEL</u> <u>(per therm cost of fuel)</u>
TMCOST = per unit cost of fuel, in dollars and cents.
UTCOST = per unit cost of fuel under consideration, in dollars and cents.
BTUUNIT = British thermal units (BTU) per unit of fuel under consideration, input value.
EF = <u>seasonal</u> efficiency of the space heating unit. Use decimal points. If you enter 1.00, you will get <u>input</u> cost per therm; if you enter seasonal efficiency, you will get <u>output</u> cost per therm.

Nugget-56



<u>AH2O (annual domestic water heating energy consumption)</u>
H2Oerg = energy per year for water heating, in fuel units.
GALyr = gallons of hot water used per year.
Tout = hot water output temperature from heater, ^{0}F.
Tin = water input temperature, ^{0}F.
EF = efficiency of water heating appliance.
BTUUNIT = per unit input value of water heating fuel.

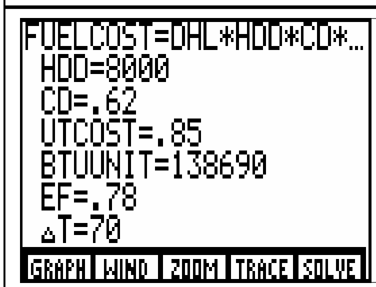
Nugget-57



<u>AHET1 (annual space heating cost)</u>
FUELCOST = annual space heating fuel cost, in dollars.
DHL = calculated design heat load of building, in Btu/hr. Use an acceptable method of calculation.
HDD = heating degree days, base 65°F.
CD = empirical correction factor for HDD_{65}. Refer to page 106 of this document for appropriate CD values for your area.
UNITCOST = unit cost of fuel, e.g., per gallon of oil, per therm natural gas.

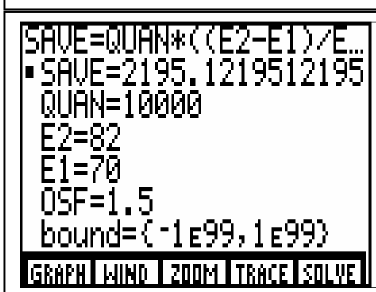
See next panel

Nugget-58



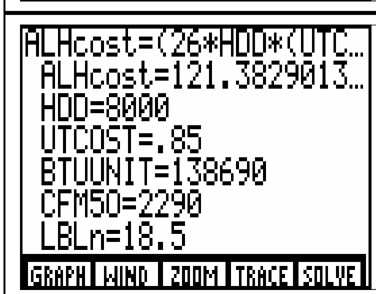
AHET1 continued. (The screen has been scrolled up two lines)
BTUUNIT = input value per unit of fuel, e.g., per gallon of oil.
EF = <u>Seasonal</u> efficiency of the space heating unit. Include losses from distribution system. Note: seasonal efficiency is always less than steady-state efficiency (that which is calculated with a flue-gas analysis tester).
ΔT = the design temperature difference. This value should be the same design temperature difference used to calculate the design heat load (DHL) of the building.

Nugget-59



<u>AHET2 (savings from heating system efficiency improvements)</u>
SAVE = cost or quantity of fuel saved from efficiency improvements.
QUAN = cost or quantity of fuel consumed <u>before</u> efficiency improvements.
E2 = <u>steady-state</u> efficiency as a result of efficiency improvements.
E1 = <u>steady-state</u> efficiency before efficiency improvements.
OSF = Off-Cycle Factor: hot air systems, 1.2 to 1.4; hot water systems, 1.4 to 1.6; steam systems, 1.6 to 1.8.

Nugget-60



<u>AHET3 (annual heating costs of air leakage)</u>
ALHcost = annual heating cost of air leakage, in dollars.
HDD = Heating degree days, base 65°F.
UTCOST = Unit cost of heating fuel, e.g., cost per therm of natural gas.
BTUUNIT = Input value per unit of fuel, e.g., per therm of natural gas.
CFM50 = CFM_{50} from the blower door test.
LBLn = Lawrence Berkeley Lab. correlation factor. This number is displayed by the Building Tightness Limits "BTL1" program, "BTL" routine.

See next panel

Nugget-61

```
ALHcost=(26*HDD*(UTC…
 HDD=8000
 UTCOST=.85
 BTUUNIT=138690
 CFM50=2290
 LBLn=18.5
 EF=.78
GRAPH WIND ZOOM TRACE SOLVE
```

AHET3, continued. (The screen has been scrolled up one line).
EFF = Seasonal efficiency of the space heating unit. Include losses from the distribution system. Note: seasonal efficiency is always less than steady-state efficiency (that which is measured with a flue-gas analysis tester).

Nugget-62

```
SAV100H=(26*100*HDD*…
▪SAV100H=53.00563379…
 HDD=8000
 UTCOST=.85
 BTUUNIT=138690
 LBLn=18.5
 EF=.78
GRAPH WIND ZOOM TRACE SOLVE
```

AHET4 (heating cost-effectiveness guideline for air sealing)
SAV100H = Heating Cost-Effectiveness Guideline per 100 CFM_{50} reduction
HDD = Heating degree days, base 65°F.
UTCOST = Unit cost of heating fuel, e.g., cost per therm of natural gas.
BTUUNIT = Input value per unit of fuel, e.g., per therm of natural gas.
LBLn = Lawrence Berkeley Lab. correlation factor. This number is displayed by the Building Tightness Limits "BTL1" program "BTL" routine.

See next panel

Nugget-63

```
SAV100H=(26*100*HDD*…
 HDD=8000
 UTCOST=.85
 BTUUNIT=138690
 LBLn=18.5
 EF=.78
 PBper=10
GRAPH WIND ZOOM TRACE SOLVE
```

AHET4 continued. (The screen has been scrolled up one line).
EF = Seasonal efficiency of the space heating unit. Include losses from distribution system. Note: seasonal efficiency is always less than steady-state efficiency (that which is calculated with a flue-gas analysis tester).
PBper = Reasonable payback period for weatherization measures.
•Comment: The weatherization crew should continue to seal the building until cost of 100 CFM_{50} reduction is equal to the Cost-Effective Guideline for 100 CFM_{50} reduction. **See ZipTest Pro^2 program "WCEG."**

Nugget-64

```
BTU=Area*HDD*24*U
▪BTU=102816000
 Area=1500
 HDD=8000
 U=.357
 bound={-1E99,1E99}
▪left-rt=0
GRAPH WIND ZOOM TRACE SOLVE
```

AHET5 (transmission heat transfer through a surface)
BTU = transmission heat loss per year through a surface area (Btu/yr).
Area = surface area in square feet.
HDD = heating degree days, base 65°F.
U = thermal transmittance, U-factor. The inverse of R-value.
Comment: Use this equation to calculate Btu/hr savings resulting from a decrease in U-factor (increase in R-value).

Nugget-65

```
BTU=FT2*CG*ACH*.0182…
▪BTU=25998336
 FT2=1500
 CG=8
 ACH=.62
 HDD=8000
 bound={-1E99,1E99}
GRAPH WIND ZOOM TRACE SOLVE
```

AHET6 (air leakage heat loss per year)
BTU = air leakage heat loss (Btu/yr). **FT2 =** square feet area of building floor.
CG = ceiling height. (FT2 x CG yields building volume).
ACH = air changes per hour, natural. See Equation Nugget "ACHN."
HDD = heating degree days, base 65°F.
•Comment: For this equation, a CFM_{50} value is not needed as it is in "ACHN." If you know a pre-weatherization ACH and a post-weatherization ACH, subtract the post-value from pre-value and enter the remainder as "ACH."

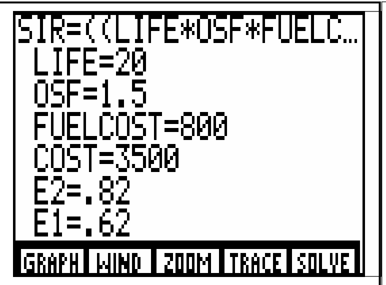
Nugget-66

```
SIR=((LIFE*OSF*FUELC…
▪SIR=1.6724738675958
 LIFE=20
 OSF=1.5
 FUELCOST=800
 COST=3500
 E2=.82
GRAPH WIND ZOOM TRACE SOLVE
```

AHET7 (analysis for heating system replacement)
SIR = savings-to-investment ratio.
LIFE = reasonable life of upgrade equipment or replacement heating system. May also use for this variable the Uniform Present Value (UPV) which represents a discounted life value.
OSF = Off-Cycle Factor: hot air systems, 1.2 to 1.4; hot water systems, 1.4 to 1.6; steam systems, 1.6 to 1.8.

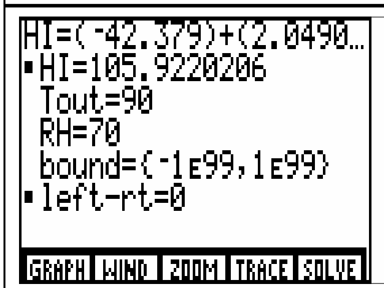
See next panel

Nugget-67



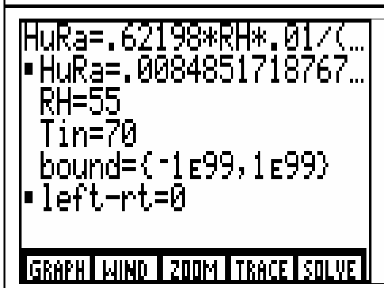
AHET7, continued. (The screen has been scrolled up one line).
FUELCOST = annual space heating cost **before** upgrade or replacement.
COST = total cost of upgrading or replacing heating system, dollars.
E2 = steady-state efficiency **after** upgrade or replacement.
E1 = steady-state efficiency **before** upgrade or replacement.

Nugget-68



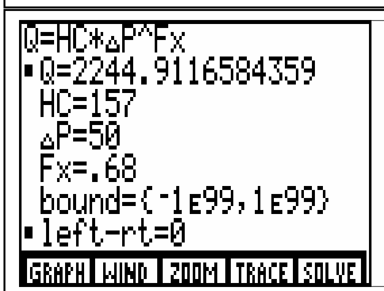
AHI <u>(heat index or apparent temperature)</u>
HI = heat index or apparent temperature, used by weather reporters during hot and humid weather.
Tout = temperature outdoors, ^{0}F.
RH = relative humidity, as a percentage (enter 70% as 70, not as 0.70).

Nugget-69



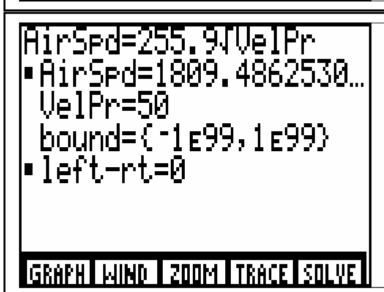
AHRAT <u>(humidity ratio)</u>
HuRa = humidity ratio, the mass of mater vapor to the mass of dry air.
RH = relative humidity. Measure this with a good sling psychrometer or digital humidity gauge (inexpensive devices might give inaccurate readings).
Tin = Temperature, °F. This may be indoor or outdoor temperature.
•Comment: the humidity ratio, "HuRa," is required for the dewpoint calculation, Equation Nugget "ADEWP."

Nugget-70



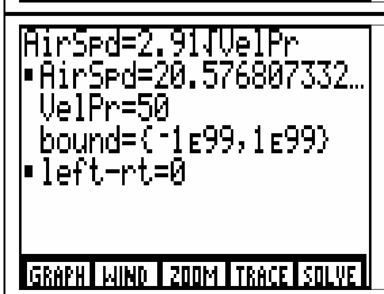
AIREQ <u>(building air flow rate, air equation)</u>
Q = building air leakage flow rate.
HC = house constant. This value can be calculated using a multi-point blower door test (the TI-86 can perform this test).
ΔP = building pressure, Pascals.
Fx = building flow exponent. This also can be determined with a multi-point blower door test.

Nugget-71



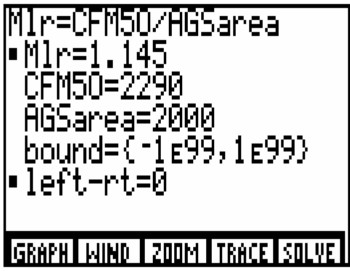
AIRSF <u>(air speed in units of feet per minute)</u>
AirSpd = air speed in units of feet per minute.
VelPr = velocity pressure, in Pascals
- Comment: This equation is for sea-level air density. This equation will give the pressure against the side of a building, in Pascals, if the wind speed at the side of the building is known. Also, you can measure the velocity pressure of moving air with a digital pressure gauge, enter the value into the equation, and solve for "AirSpd."

Nugget-72



AIRSP <u>(air speed in units of miles per hour)</u>
AirSpd = Air speed, mph.
VelPr = Velocity pressure, in Pascals
- Comment: This equation is for sea-level air density. This equation will give the pressure against the side of a building, in Pascals, if the wind speed at the side of the building is known. Also, you can measure the velocity pressure of moving air with a digital pressure gauge, enter the value into the equation, and solve for "AirSpd."

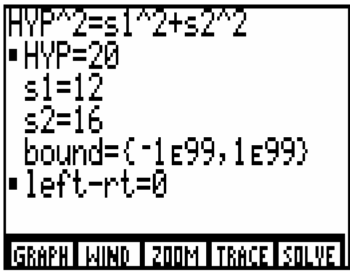
Nugget-73



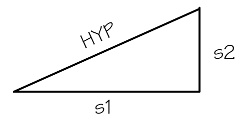
<u>**AMLR** (Minneapolis leakage ratio)</u>
Mlr = Minneapolis leakage ratio.
CFM50 = CFM_{50} from blower door test.
AGSarea = Above grade surface area of building. Include above grade walls, windows, doors, attic floors, and other floors over unconditioned space.

- Comment: For houses with MLR values greater than 1.0, large cost-effective reductions in air leakage can be made. If the MLR is in the range of 0.5 to 1.0, it is more difficult to achieve cost-effective reductions.

Nugget-74



<u>**APYTH** (Pythagorean theorem)</u>
HYP = Pythagorean theorem
s1 = side 1 of right triangle, in units of length.
s2 = side 2 of right triangle in units of length.



- Comment: The theorem is: The square of the hypotenuse of a right triangle is equal to the sum of the squares of the other two sides. A great equation to know for construction work, i.e., for finding right angles. Multiples of 3, 4, and 5 always work out perfectly. This is Leslie's (my wife) favorite equation.

Nugget-75

<u>**AREFR** (saving-to-investment ratio for refrigerator replacement)</u>
SIR = Saving-to-Investment Ratio for the refrigerator replacement.
kWhyrOld = kWh/yr refrigerator usage NOT adjusted for temperature differences. This value is the metered usage or the estimated usage from the manufacturer or the AHAM directory of refrigerators. If the refrigerator is metered, the metering time should be at least two hours.
AAAT = the Average Annual Ambient Temperature to which the refrigerator is exposed. This is an estimate of the average

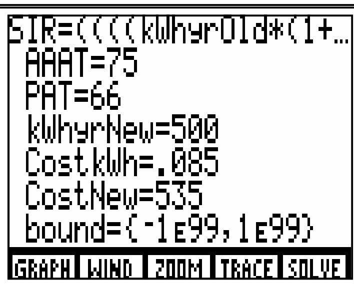
See next panel

Nugget-76

temperature, in Fahrenheit degrees, around the refrigerator over a year.
PAT = the Present Ambient Temperature, in Fahrenheit degrees. This is the temperature while the metering is taking place. If this temperature is greater than the AAAT, the metered reading must be adjusted downward for a more accurate annual kWh/yr estimate. If this temperature is lower than the AAAT, the metered reading must be adjusted upward. The "AREFR' equation makes this adjustment automatically. Note: If you want to negate the impact of the temperatures — AAAT and PAT — set each equal to 70.

See next panel

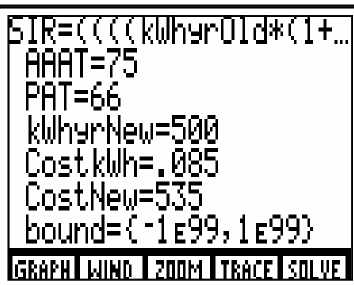
Nugget-77



(The screen has been scrolled up two lines).
kWhyrNew = the estimated kWh/yr consumption of the replacement refrigerator.
CostkWh = the cost of delivered electricity per kWh.
CostNew = the cost of replacing the old refrigerator. This price should include the refrigerator cost, any delivery charge, and any disposal charge for the old refrigerator.
LIF = the discounted expected life (15 years) of the refrigerator. This is a

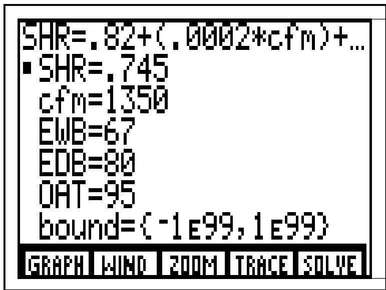
See next panel

Nugget-78



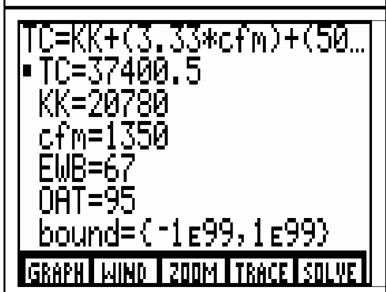
value you can adjust in the calculator memory. Notice it does not show up in the screen displays at the left. See the Texas Instruments TI-86 instruction manual, pages 58 - 61 for help. "LIF" is fifteen years discounted by a specific Department of Energy (DOE) rate. From April 1, 2004 to March 31, 2005 the U.S. average "LIF" value published by the DOE was 11.49 (the SIR values in panels Nugget-75 and 76 are calculated with this value). The value for "LIF" must be adjusted annually for your area. See "Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis - April 2004" at <u>http://www.eere.energy.gov/femp/pdfs/ashb04.pdf.</u>

Nugget-79



<u>ARISR</u> <u>(sensible to total capacity ratio of air-to-air cooling equipment)</u>
SHR = sensible to total capacity ratio.
cfm = cubic feet per minute flowing through refrigerant coil.
EWB = entering wet-bulb temperature, °F.
EDB = entering dry-bulb temperature, °F.
OAT = outdoor dry-bulb temperature, °F.
- Comment: See *Residential Equipment Selection: Manual S*, by Air Conditioning Contractors of America (ACCA), pages A3-1 through A3-2.

Nugget-80

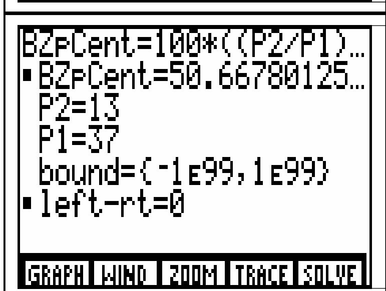


<u>ARITC</u> <u>(total capacity of air-to-air cooling equipment)</u>
TC = total capacity of air-to-air cooling equipment.
KK = a constant, for generic cooling equipment, use 20780.
cfm = cubic feet per minute flowing through refrigerant coil.
EWB = entering wet-bulb temperature, °F.
OAT = outdoor dry-bulb temperature, °F.
- Comment: See *Residential Equipment Selection: Manual S*, by Air Conditioning Contractors of America (ACCA), pages A3-1 through A3-2.

Nugget-81

<u>ARVAL</u> <u>(determine R-value with non-contact thermometer)</u>
RvalU = calculated R-value of surface using non-contact thermometer.
WALLiT = Indoor wall temperature, °F.
WALLoT = Outdoor wall temperature, °F.
AIRiT = Indoor air temperature, °F.
- Comment: This equation is useful with non-contact thermometers such as the Raytek® Raynger. Be careful of the effect of the sun and other sources of radiant heat. Also, be aware of thermal time lags.

Nugget-82

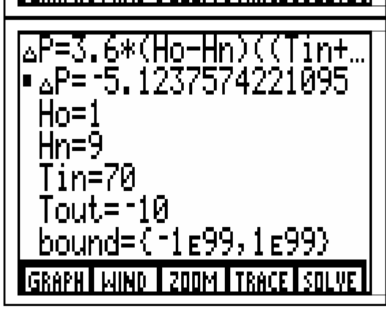


<u>ASERP</u> <u>(building-to-zone percentage of zone-to-outdoor leakage rate)</u>
BZpCent = building-to-zone percentage of zone-to-outdoor leakage rate (also building-to-duct as percentage of duct-to-outdoor leakage).
P2 = zone-to-outside (duct-to-outside) pressure difference, Pascals.
P1 = building-to-zone (building-to-duct) pressure difference, Pascals
- Comment: The example values indicate that the building-to-zone leakage is about 50% of the zone-to-outside leakage.

Nugget-83

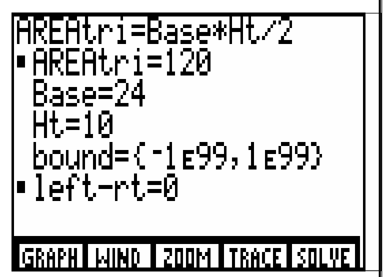
<u>ASIR</u> <u>(simple savings-to-investment ratio)</u>
SIR = simple savings-to-investment ratio.
SAVE = First-year savings due to energy-saving measure, dollars.
COST = Cost of energy-saving measure, dollars.
LIFE = Expected life of energy-saving measure, years.
- Comment: If the SIR is less than one, the energy-saving measure is not worth implementing; if it is more than one, it is worth implementing. The higher the "SIR," the better.

Nugget-84



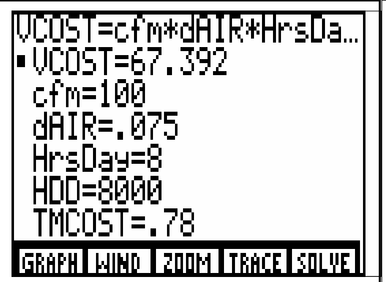
<u>ASTAK</u> <u>(building stack pressure at given height)</u>
ΔP = building stack pressure at a given height.
Ho = height at observation measurement, ft.
Hn = height of neutral pressure level, ft. **Tin =** temperature indoors, °F.
Tout = temperature outdoors, °F. For below zero temps., use "(-)" key.
- Comment: This equation <u>estimates</u> ΔP. The neutral pressure level is usually above mid-height for residential buildings. For tall buildings, it is from 0.3 to 0.7 of total building height. See *ASHRAE Fundamentals Handbook.*

Nugget-85



__**ATRIa**__ __(area of a triangle)__
AREAtri = area of a triangle, such as a gable end.
Base = the base dimension of the triangle.
Ht = the height of the triangle.

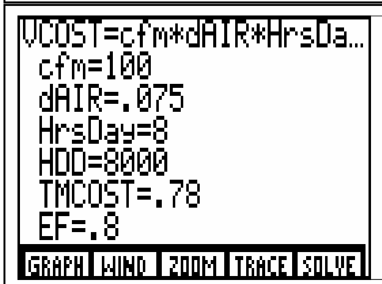
Nugget-86



__**AVNT1**__ __(space heating energy consumption for ventilation)__
VCOST = annual cost of space heating energy for ventilation. **cfm =** actual cubic feet per minute of exhaust fan(s). **dAIR =** density of air (at sea level 0.075 pounds/cubic foot) See air density correction factors on page 106.
HrsDay = hours of average daily running time of exhaust fan(s).
HDD = heating degree days, base 65°F.
TMCOST = therm cost of space heating fuel. Use Equation Nugget "AFUEL" to determine this value.

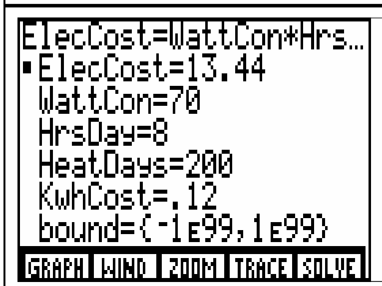
See next panel

Nugget-87



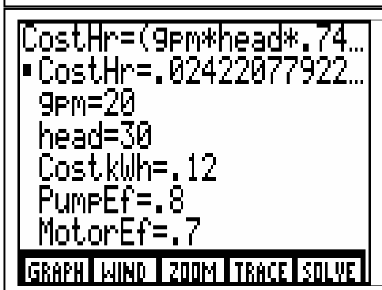
AVNT1, continued. (The screen has been scrolled up one line).
EF = __seasonal__ efficiency of the space heating unit. Include losses from distribution system. Note: seasonal efficiency is always less than steady-state efficiency (that which is calculated with a flue-gas analysis tester).
- Comment: This equation assumes that all make-up air for the exhaust ventilation flows directly from the outside. The value of "VCOST" is the energy required to heat the make-up air that replaces the exhausted ventilation air.

Nugget-88



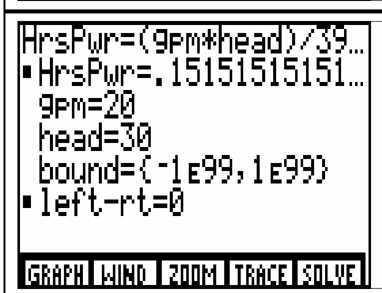
__**AVNT2**__ __(annual electrical consumption for ventilation)__
ElecCost = annual electrical cost to operate an exhaust fan.
WattCon = power consumption of fan, in Watts.
HrsDay = hours of average daily running time of exhaust fan(s).
HeatDay = heating days per year. A heating day is any day having an average outdoor temperature less that 65°F.
KwhCost = cost of electricity, per kWh.

Nugget-89



__**AWATC**__ __(cost to operate a water pump)__
CostHr = Cost per hour to operate a water pump.
gpm = gallons per minute moved by the pump.
head = the head in feet.
CostkWh = cost of electricity in kWh.
PumpEf = pump efficiency as a decimal.
MotorEf = pump motor efficiency as a decimal.

Nugget-90



__**AWATP**__ __(horsepower needed to pump water)__
HrsPwr = horse power of pump and motor required to pump water.
gpm = gallons per minute moved by the pump.
head = the head in feet.

•Press the **EXIT** key to exit the SOLVER feature.

SUPPORT INFORMATION

HEATING DEGREE DAY$_{65}$ CORRECTION FACTORS, C_D

QUALITY OF CONSTRUCTION AND RELATIVE USE OF ELECTRICAL APPLIANCES	NUMBER OF DEGREE DAYS (65°F)								
	1000	2000	3000	4000	5000	6000	7000	8000	9000
Well-Constructed House. Large quantities of insulation, tight fit on doors and windows, well sealed openings. Large use of electrical appliances. Large availability of solar energy at the house.	0.48	0.45	0.42	0.39	0.36	0.37	0.38	0.39	0.40
House of Average Construction. Average quantities of insulation, average fit on doors and windows, partially sealed openings. Average availability of solar energy at the house. Average use of electrical appliances.	0.80	0.76	0.70	0.65	0.60	0.61	0.62	0.69	0.67
Poorly Constructed House. Small quantities of insulation, poor fit on doors and windows, unsealed openings. Small use of electrical appliances. Small availability of solar energy at the house.	1.12	1.04	0.98	0.90	0.82	0.85	0.88	0.90	0.92

Source: ASHRAE

AIR DENSITY CORRECTION FACTORS

Altitude (ft)		Sea Level	1000	2000	3000	4000	5000	6000	7000	8000	9000	10,000
Barometer	(in.Hg)	29.92	28.86	27.82	26.82	25.84	24.90	23.98	23.09	22.22	21.39	20.58
	(in.w.g.)	407.5	392.8	378.6	365.0	351.7	338.9	326.4	314.3	302.1	291.1	280.1
Air Temp.	-40°	1.26	1.22	1.17	1.13	1.09	1.05	1.01	0.97	0.93	0.90	0.87
°F	0°	1.15	1.11	1.07	1.03	0.99	0.95	0.91	0.89	0.85	0.82	0.79
	40°	1.06	1.02	0.99	0.95	0.92	0.88	0.85	0.82	0.79	0.76	0.73
	70°	1.00	0.96	0.93	0.89	0.86	0.83	0.80	0.77	0.74	0.71	0.69
	100°	0.95	0.92	0.88	0.85	0.81	0.78	0.75	0.73	0.70	0.68	0.65
	150°	0.87	0.84	0.81	0.78	0.75	0.72	0.69	0.67	0.65	0.62	0.60
	200°	0.80	0.77	0.74	0.71	0.69	0.66	0.64	0.62	0.60	0.57	0.55
	250°	0.75	0.72	0.70	0.67	0.64	0.62	0.60	0.58	0.56	0.58	0.51
	300°	0.70	0.67	0.65	0.62	0.60	0.58	0.56	0.54	0.52	0.50	0.48
	350°	0.65	0.62	0.60	0.58	0.56	0.54	0.52	0.51	0.49	0.47	0.45
	400°	0.62	0.60	0.57	0.55	0.53	0.51	0.49	0.48	0.46	0.44	0.42
	450°	0.58	0.56	0.54	0.52	0.50	0.48	0.46	0.45	0.43	0.42	0.40
	500°	0.55	0.53	0.51	0.49	0.47	0.45	0.44	0.43	0.41	0.39	0.38
	550°	0.53	0.51	0.49	0.47	0.45	0.44	0.42	0.41	0.39	0.38	0.36
	600°	0.50	0.48	0.46	0.45	0.43	0.41	0.40	0.39	0.37	0.35	0.34
	700°	0.46	0.44	0.43	0.41	0.39	0.38	0.37	0.35	0.34	0.33	0.32
	800°	0.42	0.40	0.39	0.37	0.36	0.35	0.33	0.32	0.31	0.30	0.29
	900°	0.39	0.37	0.36	0.35	0.33	0.32	0.31	0.30	0.29	0.28	0.27
	1000°	0.36	0.35	0.33	0.32	0.31	0.30	0.29	0.28	0.27	0.26	0.25

Standard Air Density, Sea Level, 70°F – 0.075 lb/cu ft at 29.92 in. Hg

Source: *HVAC Systems Duct Design*, SMACNA, 1981.

Air density, $d = 1.325\,(Pa/(460+T))$

where: Pa = barometric pressure, in Hg

T = temperature, °F

Multiply standard air density at Sea level of 0.075 by the correction factors in the table to get your air density.

The Equation Nuggets with Labels

1. ABMI (Body Mass Index)
   × BMI=(Wt*704)/Ht^2
2. ACFM (pressure created by exhaust devices)
   × cfm=(CFM50/50^.65)(¾P^.65)
3. ACFM1 (determination of vent fan size when house is "too tight")
   × VentFan=ð(((Btl/LBLn)^2)-((CFM50/LBLn)^2))
4. ACFMd (depressurization blower door result temperature adjusted)
   × CFMadDp=CFMnom*((Tout+459.7)/(Tin+459.7))^.5
5. ACFMp (pressurization blower door result temperature adjusted)
   × CFMadPr=CFMnom*((Tin+459.7)/(Tout+459.7))^.5

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6. ACH50 (air changes per hour at 50 Pascals building pressure from CMF$_{50}$)
   × ACH5o=CFM50*60/(FT2*CG)
7. ACHIL (equivalent wind chill temperature, 2001 version)
   × WCHILL=35.74+(0.6215*Tout)-(35.75*(SPEED^0.16))+(0.4275*Tout*(SPEED^0.16))
8. ACHN (building air change per hour at natural pressure)
   × ACH=CFM50*60/(LBLn*FT2*CG)
9. ACIRa (area of a circle)
   × AREAcir=.78539(dia^2)
10. ACIRc (circumference of a circle)
    × CIRcir=3.14159dia

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11. ACLG1 (annual cooling cost of air leakage)
    × ALCcost=((.026*CDD*KWHcost*CFM50)/(LBLn*SEER))
12. ACLG2 (cooling cost-effectiveness guideline for air sealing)
    × SAV100C=((.026*100*CDD*KWHcost)/(LBLn*SEER))*PBper
13. ACO2O (air-free carbon monoxide from as-measured carbon monoxide and carbon dioxide for a number 2 oil appliance)
    × COairFre=COppm(15.3/CO2)
14. ACOAR (air-free carbon monoxide from as-measured carbon monoxide and oxygen percentage in flue gas, any fuel)
    × COairFre=COppm(20.9/(20.9-Oxy2))
15. ACOLP (air-free carbon monoxide from as-measured carbon monoxide and carbon dioxide for a liquefied propane, LP, appliance)
    × COairFre=COppm(14/CO2)

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16. ACONG (air-free carbon monoxide from as-measured carbon monoxide and carbon dioxide for a natural gas appliance)
    × COairFre=COppm(12.2/CO2)
17. ACORM (for determining the carbon monoxide concentrations in a room from an unvented natural gas or propane appliance, such as a gas range/oven)
    × COppm=((COairFre*Vg*Gr)(1-(1/(2.713^(Nach*t)))))/(Nach*v)
18. ADEWP (dewpoint temperature determination)
    × DewPt=1.8*((ú4111/(ln (HuRa*101325/(HuRa+.62198))-23.7093)+35.45)-273)+32
19. ADUCT (round duct diameter to rectangular)
    × DuctDia=1.3((s1*s2)^.625)/(s1+s2)^.25)
20. AELA (effective leakage area from CFM$_4$)
    × ELAin2=.2835*CFM4

The Equation Nuggets with Labels
(continued)

21. AEQLA (equivalent leakage area from CFM_{10})
× `EQLAin=.2939*CFM10`

22. AFCOM (payments on loan, interest, principle, periods)
× `PI=PRIN(i(1+i)^per)/(((1+i)^per)-1)`

23. AFUEL (per therm cost of fuel)
× `TMCOST=(UTCOST*100000)/(BTUUNIT*EF)`

24. AH2O (annual domestic water heating energy consumption)
× `H2Oerg=GALyr*(Tout-Tin)*8.33/(EF*BTUUNIT)`

25. AHET1 (annual space heating cost)
× `FUELCOST=DHL*HDD*CD*24(UTCOST/(BTUUNIT*EF))/¾T`

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26. AHET2 (savings from heating system efficiency improvements)
× `SAVE=QUAN*((E2-E1)/E2)*OSF`

27. AHET3 (annual heating costs of air leakage)
× `ALHcost=(26*HDD*(UTCOST/BTUUNIT)*CFM50/(LBLn*EF)).6`

28. AHET4 (heating cost-effectiveness guideline for air sealing)
× `SAV100H=(26*100*HDD*(UTCOST/BTUUNIT)/(LBLn*EF)).6*PBper`

29. AHET5 (transmission heat transfer through a surface)
× `BTU=Area*HDD*24*U`

30. AHET6 (air leakage heat loss per year)
× `BTU=FT2*CG*ACH*.0182*HDD*24`

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31. AHET7 (analysis for heating system replacement)
× `SIR=((LIFE*OSF*FUELCOST)/COST)((E2-E1)/E2)`

32. AHI (heat index or apparent temperature)
× `HI=(ú42.379)+(2.04901523(Tout))+(10.14333127(RH))-(.22475541 (Tout)(RH))-(6.83783(10^ú3)(Tout^2))-(5.481717(10^ú2)(RH^2))+ (1.22874(10^ú3)(Tout^2)(RH))+(8.5282(10^ú4)(Tout)(RH^2))-(1.99 (10^ú6)(Tout^2)(RH^2))`

33. AHRAT (humidity ratio)
× `HuRa=.62198*RH*.01/((e^(ú23.7093+(4111/((.5555*(Tin-32)+273)-35.45)))*101325)-RH*.01)`

34. AIREQ (building air flow rate, air equation)
× `Q=HC*¾P^Fx`

35. AIRSF (air speed in units of feet per minute)
× `AirSpd=255.9ðVelPr`

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36. AIRSP (air speed in units of miles per hour)
× `AirSpd=2.91ðVelPr`

37. AMLR (Minneapolis leakage ratio)
× `Mlr=CFM50/AGSarea`

38. APYTH (Pythagorean theorem)
× `HYP^2=s1^2+s2^2`

39. AREFR (Savings-to-Investment Ratio for refrigerator replacement)
× `SIR=((((kWhyrOld*(1+((AAAT-PAT)*.025)))-(kWhyrNew*(1+((AAAT-70) *.025))))*CostkWh)*LIF)/CostNew`

40. ARISR (sensible to total capacity ratio of air-to-air cooling equipment)
× `SHR=.82+(.0002*cfm)+(ú.0475*EWB)+(.0325*EDB)+(.0025*OAT)`

The Equation Nuggets with Labels
(continued)

41. ARITC (total capacity of air-to-air cooling equipment)
× TC=KK+(3.33*cfm)+(500*EWB)+(ú225*OAT)

42. ARVAL (determine R-value with non-contact thermometer)
× RvalU=(WALLiT-WALLoT)/(1.4(AIRiT-WALLiT))

43. ASERP (building-to-zone percentage of zone-to-outdoor leakage rate)
× BZpCent=100*((P2/P1)^.65

44. ASIR (simple savings-to-investment ratio)
× SIR=(SAVE/COST)(LIFE)

45. ASTAK (building stack pressure at given height)
× ¾P=3.6*(Ho-Hn)((Tin+459.67)-(Tout+459.67))/(Tout+459.67)

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46. ATRIa (area of a triangle)
× AREAtri=Base*Ht/2

47. AVNT1 (space heating energy consumption for ventilation)
× VCOST=cfm*dAIR*HrsDay*.24*HDD*TMCOST(.0006/EF)

48. AVNT2 (annual electrical consumption for ventilation)
× ElecCost=WattCon*HrsDay*HeatDays*KwhCost*.001

49. AWATC (cost to operate a water pump)
× CostHr=(gpm*head*.746*CostkWh)/(3960*PumpEf*MotorEf)

50. AWATP (horsepower needed to pump water)
× HrsPwr=(gpm*head)/3960

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