Public Works Canada
Design and Construction
Technology

ABC PROGRAM:
USER'S MANUAL

Version 3.0
March 1980

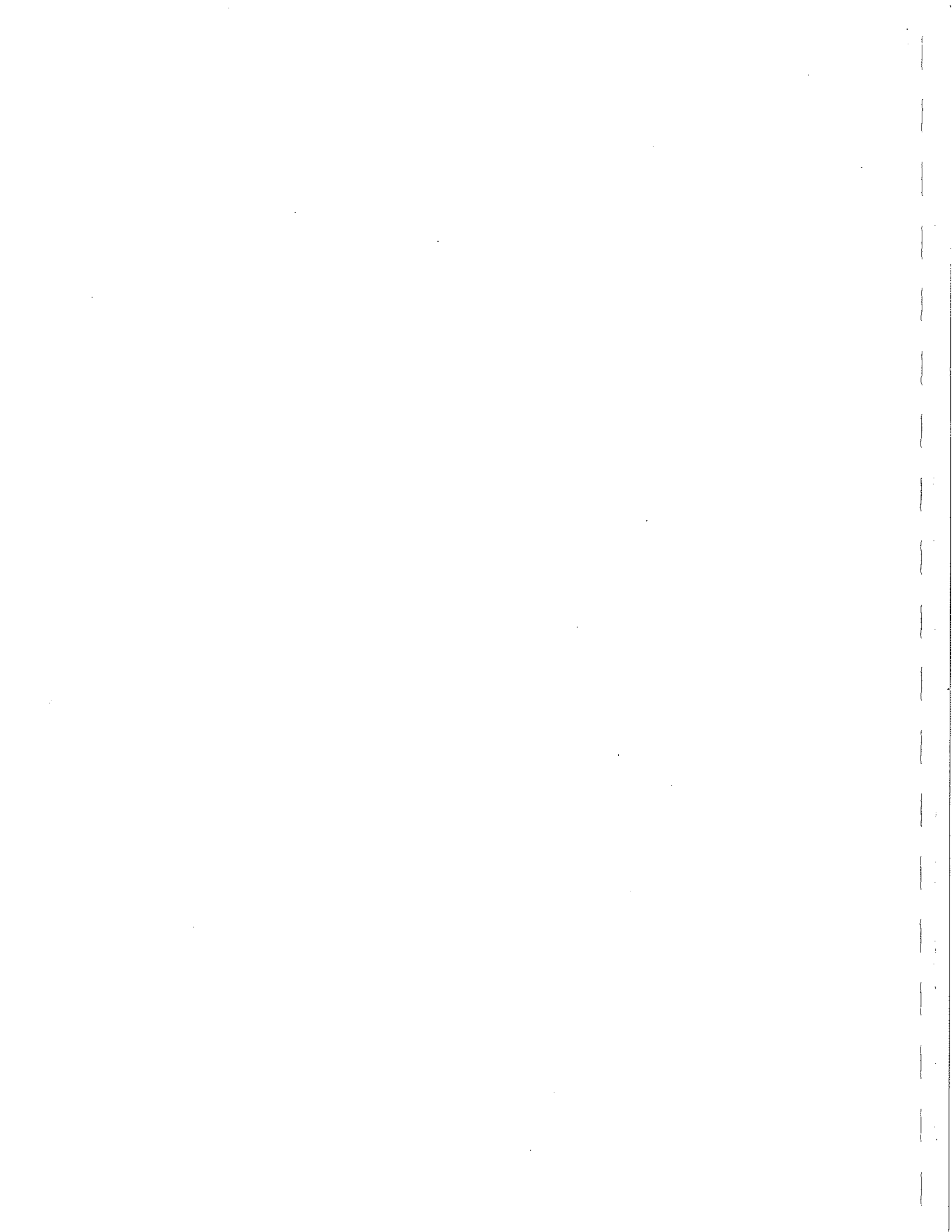Computer-Aided Design (CAD)

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1. PURPOSE

This program provides a fast easy-to-use tool to aid in the evaluation of architectural building concepts. The program estimates the effect on annual heating/cooling energy requirements of architectural factors such as shape and size of building, orientation, amount and type of glass, amount of insulation, lighting level, and infiltration.

The program is intended to aid in making decisions about these architectural concepts at the early design stage, when the design alternatives are little more than rough sketches. Since little consideration is given to HVAC system design at this stage, it assumes the use of 'ideal' HVAC systems.

The assumptions contained in the ABC program are adequate for a "first-cut" design tool. This program should be used to compare the relative energy consumption of design options, not as an estimate of the absolute value of building energy consumption. A more detailed energy analysis program, which can account for the many building and system variables, should be used at later stages of design in order to obtain a more accurate estimate of absolute energy consumption.

2. DESCRIPTION

This program provides estimates of annual building heating/cooling energy requirements. It uses a table lookup interpolation method based on a database created using hourly calculations (basically the same algorithms and weather data as used by the Meriwether ERE program). The results are equivalent to those obtained using ERE with the following assumptions:

- standard weather and solar data.
- building thermal mass effects are neglected.
- room temperature maintained as stated on database file. (Normally heating to 72°F, and cooling to 78°F.)
- internal load profiles restricted to one value for occupied periods, and another value for unoccupied periods.
- ventilation and infiltration similarly assumed to have one constant value for occupied periods, and another constant value for unoccupied periods. (Infiltration is not a function of outdoor temperature.)
- the system without economizer is one which provides the heating or cooling required. The only outside air provided is that specified for ventilation + infiltration. (This system is the equivalent of Meriwether's Type 3 system. It provides only sensible cooling, and never reheats.)
- the system using economizer is an ideal VAV system supplying the required quantity of air at a temperature of 60°F and dewpoint of 57°F. The minimum on the supply air flow is equal to the ventilation + infiltration.

This program (like Meriwether's ERE) analyses only one zone or thermal block at a time. A thermal block is defined as an area which is thermally homogeneous. That is, each part of the area 'sees' the same thermal loads (e.g. lights, people, solar, transmission, etc.). An additional restriction of ABC is that all windows of a zone must face in the same direction. A building is usually divided into an interior zone, plus one perimeter zone facing each direction. The depth of the perimeter is normally 12-20 feet.

Version 3.0 of the ABC program provides the capability of summing a number of zones together to obtain a building total.

3.   HARDWARE AND DISK REQUIREMENTS

The ABC program will operate on an IM/70 minicomputer with three floppy disk drives, a video terminal, and a printer. The program is contained on one floppy disk; the database is contained on a separate disk.

Two data base disks are currently available, both for 72-78°F thermostat setting:

1) Calgary, Halifax, Montreal, Ottawa, Saskatoon, Toronto, Vancouver.

2) Victoria, Quebec City, Winnipeg, Edmonton, Regina, Kamloops, Whitehorse.

(Note: You must terminate each input by hitting carriage return.)

- 'Power-up' the minicomputer as described in 'An Introduction to Running Fortran Programs Under FOS 4.1'.
- Install the 'ABC program' disk into floppy drive no. 1.
- Install an 'ABC Data' disk into floppy drive no. 2. (Two data disks are provided. Choose the disk which contains data for the location of the building you wish to analyse. At present data is available for 14 cities.)
- Type /BA F1.ABC1 (if you don't have a line printer, type /BA F1.ABC0).
- A list of the locations contained on the data disk will be displayed.
- You must specify one of these locations for your analysis.
- There will be a brief pause while the files are readied.
- The program will then ask which system of units you wish to use:
     Reply: IM If you wish imperial units
             SI If you wish SI units.
- The program will ask for a project title. This title (maximum of 72 characters) will appear on each page of program output.
- The program will then ask a series of questions pertaining to zone input data. This input data is summarized in Table I. A further description of the input data is given in Section 5.
- Although defaults are provided for most of the inputs it is good practice to enter values at this time (most of the default values are zero).
- If you make an error in input, and notice it before hitting RETURN, you may "backspace" (←) and then enter the correct input. If you notice an error after hitting RETURN, don't worry; proceed to complete the input, after which you may easily correct the error using the editing capability described in Section 5.
- When all input has been provided the program will compute and display the annual heating and cooling requirements.
- The program will then prompt with COMMAND? To obtain a list of valid responses to this prompt, type HELP.
- You may now either change the input data using edit instructions described in Section 5, or you may issue commands to the program as described in Section 6.

TABLE I
ABC PROGRAM INPUT

LOCATION _____

UNITS   _____   IM   or   SI

PROJECT   _____

_____

ZONE: description _____

MULT: zone multiplier   _____

AREA: floor area   _____ ft^2 or m^2

DIRX: direction   _____

WALL: gross wall area   _____ ft^2 or m^2
        u-value   _____ $\frac{btu}{hr.ft^2{}^oF}$ or $\frac{watt}{m^2\,{}^oC}$

WIND: window area   _____ ft^2 or m^2
        u-value   _____ $\frac{btu}{hr.ft^2{}^oF}$ or $\frac{watt}{m^2\,{}^oC}$
        shading ceet.

ROOF: roof area   _____ ft^2 or m^2
        u-value   _____ $\frac{btu}{hr.ft^2{}^oF}$ or $\frac{watt}{m^2\,{}^oC}$

TIME: occupied - no. of days/week   _____
        unoccupied - no. of days/week _____

LITE: power to lights - occupied   _____ $\frac{watt}{ft^2}$ or $\frac{watt}{m^2}$
                        - unoccupied _____

PEOP: people density - occupied   _____ $\frac{ft^2}{person}$ or $\frac{m^2}{person}$
                       - unoccupied   _____

VENT: ventilation (min. O.A.) - occupied   _____ $\frac{cfm}{ft^2}$ or $\frac{1}{soc.m^2}$
                               - unoccupied _____
        infiltration   - occupied   _____
                        - unoccupied   _____

You may use the editing features to change your input
data. Input data is organized in groups called data-
groups. Each data-group has a 4-character identifier.
To edit data enter the identifier for the data-group
for which you wish to make a change. The program will
prompt you for input. If you do not wish to enter a
new value hit carriage return and the data will remain
unchanged. (The 'default' value is shown at the right
side of the screen.)

The data-groups are:

ZONE: This permits you to supply a label to identify
the zone. The label may be up to 80 characters
(one line).

MULT: It is sometimes convenient to specify the input
data on the basis of a module (for example a
typical floor). The zone multiplier is the
number of these modules which make up the zone.
In effect, this means that the areas specified
for floor area, wall, window and roof are
multiplied by the zone multiplier, (range 1. to
9999.9).

AREA: Enter floor area (range 1. to 999999999.).

DIRX: Enter the direction in which windows for this
zone face. Note that all windows must face in
the same direction. Valid directions are NORTH,
N.E., EAST, S.E., SOUTH, S.W., WEST and N.W.
(note that the program recognizes only the first
4 characters, and requires the periods in N.E.
etc.). Enter INTR to indicate that the zone is
an interior zone (i.e. one with no walls or
windows).

WALL: Enter gross wall area (range 0. to 999999999.).
This should be the total area of the wall
including window area. (The program subtracts
the window area to get the net opaque wall
area.)

The following is input only if wall area is not
zero:
– U-value of opaque wall (range 0. to 10.).

WIND: Window area may be expressed as either an absolute area or as a percentage of gross wall area.

Enter value for absolute area (range 0. to 999999999.). Enter value followed by % for percentage (range 0. to 100.). (Example 50%).

The following are input only if window area is not zero:
- U-value of window (range 0. to 10.).
- Shading coefficient of window (range 0. to 1.).

ROOF: Enter roof area (range 0. to 999999999.).

The following is input only if roof area is not zero:
- U-value of roof (range 0. to 10.).

TIME: Internal loads (as well as infiltration and ventilation) may vary with time. One value may be specified for occupied periods and another value for unoccupied periods. The occupied and unoccupied periods are defined in terms of 'days' (7AM-7PM) and 'nights' (7PM-7AM). For example a typical office building occupancy might be:
   Occupied for 5 days per week (weekdays)
          and 0 nights per week
   Unoccupied for 2 days per week (weekends)
          and 7 nights per week.

Note that input must be integer numbers (i.e. no decimal point) in the range of 0 to 7.

LITE: Enter power input to lights for occupied and unoccupied periods. This may also include miscellaneous electric loads such as office equipment, etc. (Range 0. to 99.).

PEOP: Enter people density expressed as floor area per person for occupied and unoccupied periods. Enter 0 to indicate that there are no people in the room. (Range 0. to 99999.).

VENT: Enter ventilation and infiltration rates for occupied and unoccupied periods (range 0. to 99.). Ventilation is the quantity of outside air supplied by the HVAC system (minimum outside air for system with economizer).

You may request the program to execute the following commands:

LIST: This command causes the input data contained in memory to be displayed on the screen. Input data is shown with the Data-group identifier used for editing data.

CALC: This command causes the annual heating/cooling corresponding to the input data in memory to be calculated and the result displayed on the screen.

PRIN: This command causes the input data contained in the memory to be printed on the line printer along with the computed heating/cooling corresponding to that input. This provides a permanent record of the analysis.

BEGI: This command causes the program to prompt you for all of the input data (using present values as defaults). This may be useful when a number of items of input are to be changed; it acts as a check to make sure you don't forget something.

STOP: This command causes the program to stop.

The following commands are used to sum a number of zones to obtain a building total:

ADD: This command causes the input data which is presently in memory to be "added" to the building file (a file containing the data for all the zones in the building). The next available zone number will be assigned to the data by the program; remember this zone number because you may wish to access this data later. The data in memory is unchanged by the ADD command.

SUM: This command causes the data for each zone on the building file to be read into memory and printed on the line printer along with the computed heating/cooling consumption corresponding to this input. This is followed by a printout of the building total which is the sum of the zones. Note that the data in memory is destroyed by the SUM command; it is replaced by the data for the last zone in the building file.

GET: This command is used to "get" the input data from a particular zone on the building file; this data replaces the input data presently in memory. The input data will be displayed on the screen.

REP: This command replaces the data for a particular zone in the building file with the data presently in memory.

DEL: This command is used to "delete" a zone from the building file. This means that this zone will no longer be included in the building total for a SUM command. Note that the data for a deleted zone is still present on the building file; it has simply been flagged as a deleted zone. You may still GET this data from the file. (In fact, you can "restore" the deleted file by GETting it and then REPlacing it.)

All input is checked for validity and allowable range:
should an error be detected a message will be displayed
on the screen and you will be prompted to re-enter the
data. Most of the error messages should be self-
explanatory.

(Take care to distinguish between the numeral 0 and the
letter O.)

**The following error messages may occur during execution
of the calculation phase of the program:**

-*** WINDOW AREA EXCEEDS GROSS WALL AREA

- Since gross wall area is the sum of opaque wall
  plus window area, this represents an impossible
  situation. Correct your input and try again.

-*** OUT OF RANGE OF DATABASE

- The database is defined for only a finite range
  of conditions. Input data in which both conduc-
  tion (U-value * area) and ventilation/infiltra-
  tion are very small, or internal heat gains
  (lights + people) are very large, may result in
  conditions which are outside this range. Check
  your input.

-*** FILE ERROR- CITY NAME

- This means that the city names on the database
  files do not match. This is a system error:
  the file may be faulty or a reading error may
  have occurred. Try again from the beginning.

To illustrate the operation of the program assume a
very simple building consisting of two zones: a
perimeter zone for which the input data is given in
Table II(a), and an interior zone for which the input
data is given in Table II(b). Note that Table II(b)
shows only those values which are different than for
the perimeter zone. The procedure would then be:

- initiate the ABC program as described in Section 4
  and input the values given in Table II(a).
- LIST to check for input errors.
- CALC to see if results are reasonable.
- when satisfied that the perimeter zone has been
  properly input, ADD to building file.
- edit the input to form data for interior zone. This
  would involve ZONE, AREA, DIRX, ROOF and VENT.
- LIST to check for input errors.
- CALC to see if results are reasonable.
- when satisfied with interior zone, ADD to building
  file.
- SUM to obtain the building total. The resulting
  printout is shown on the following pages:

TABLE II(a)
ABC PROGRAM INPUT

LOCATION   Montreal

UNITS			IM	IM	or	SI

PROJECT   Example building

ZONE: description Perimeter zone-facing south east

MULT: zone multiplier   1

AREA:	floor area	1000	ft^2	or	m^2

DIRX: direction   S.E.

WALL:	gross wall area	950	ft^2	or	m^2
	u-value	0.13	$\frac{btu}{hr.ft^2{}^oF}$	or	$\frac{watt}{m^2{}^oC}$

WIND:	window area	45%	ft^2	or	m^2
	u-value	0.63	$\frac{btu}{hr.ft^2{}^oF}$	or	$\frac{watt}{m^2{}^oC}$
	shading ceet.	0.94			

ROOF:	roof area	500	ft^2	or	m^2
	u-value	0.085	$\frac{btu}{hr.ft^2{}^oF}$	or	$\frac{watt}{m^2{}^oC}$

TIME:	occupied - no. of days/week	5			
	unoccupied - no. of days/week	0			

LITE:	power to lights - occupied	3.0	$\frac{watt}{ft^2}$	or	$\frac{watt}{m^2}$
	- unoccupied	0.25			

PEOP:	people density - occupied	200	$\frac{ft^2}{person}$	or	$\frac{m^2}{person}$
	- unoccupied	0			

VENT:	ventilation (min. O.A.) - occupied	0.1	$\frac{cfm}{ft^2}$		$\frac{1}{soc.m^2}$
	- unoccupied	0			
	infiltration - occupied	0.05			
	- unoccupied	0.05			

TABLE II(a)

LOCATION   Montreal

UNITS   IM   IM   or   SI

PROJECT   Example building

ZONE: desciption Perimeter zone-facing south east

MULT: zone multiplier   1

AREA: floor area   1000 ft^2 or m^2

DIRX: direction   S.E.

WALL: gross wall area   950 ft^2 or m^2

        u-value   0.13 $\frac{btu}{hr.ft^2 {}^oF}$ or $\frac{watt}{m^2 {}^oC}$

WIND: window area   45% ft^2 or m^2

        u-value   0.63 $\frac{btu}{hr.ft^2 {}^oF}$ or $\frac{watt}{m^2 {}^oC}$

        shading ceet.   0.94

ROOF: roof area   500 ft^2 or m^2

        u-value   0.085 $\frac{btu}{hr.ft^2 {}^oF}$ or $\frac{watt}{m^2 {}^oC}$

TIME: occupied - no. of days/week   5

        unoccupied - no. of days/week 0

LITE: power to lights - occupied   3.0 $\frac{watt}{ft^2}$ or $\frac{watt}{m^2}$

                    - unoccupied   0.25

PEOP: people density - occupied   200 $\frac{ft^2}{person}$ or $\frac{m^2}{person}$

                  - unoccupied   0

VENT: ventilation (min. O.A.) - occupied   0.1 $\frac{cfm}{ft^2}$ or $\frac{1}{soc.m^2}$

                         - unoccupied   0

        infiltration   - occupied   0.05

                    - unoccupied   0.05

TABLE II(b)
ABC PROGRAM INPUT

LOCATION _____

UNITS _____ _____   IM   or   SI

PROJECT _____

ZONE: description <u>Interior zone</u> _____

MULT: zone multiplier _____

AREA: floor area ____1200____ ft^2 or m^2

DIRX: direction ____INTR____

WALL: gross wall area _____ ft^2 or m^2
       u-value _____ $\dfrac{btu}{hr.ft^2 {}^oF}$ or $\dfrac{watt}{m^2\ {}^oC}$

WIND: window area _____ ft^2 or m^2
       u-value _____ $\dfrac{btu}{hr.ft^2 {}^oF}$ or $\dfrac{watt}{m^2\ {}^oC}$
       shading ceet. _____

ROOF: roof area ____600____ ft^2 or m^2
       u-value _____ $\dfrac{btu}{hr.ft^2 {}^oF}$ or $\dfrac{watt}{m^2\ {}^oC}$

TIME: occupied - no. of days/week _____
       unoccupied - no. of days/week _____

LITE: power to lights - occupied _____ $\dfrac{watt}{ft^2}$ or $\dfrac{watt}{m^2}$
                       - unoccupied _____

PEOP: people density - occupied _____ $\dfrac{ft^2}{person}$ or $\dfrac{m^2}{person}$
                       - unoccupied _____

VENT: ventilation (min. O.A.) - occupied _____ $\dfrac{cfm}{ft^2}$ or $\dfrac{1}{soc.m^2}$
                              - unoccupied _____
       infiltration - occupied ____0.____
                     - unoccupied ____0.____

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PROJECT:
EXAMPLE BUILDING

***ZONE NUMBER 1
ZONE: PERIMETER ZONE- FACING SOUTH EAST
MULT: ZONE MULTIPLIER=   1.0
AREA·   FLOOR AREA=   1000. (SQ-FT)
DIR::   DIRECTION=   S. E.
WALL: WALL AREA=   950. (SQ-FT) ; U-VALUE=   .130 (BTU/HR SQ-FT DEG-F)
WIND: WINDOW AREA= 45. %   ; U-VALUE=   .630 (BTU/HR SQ-FT DEG-F)
                                      ; SHADING COEF:= .94
ROOF: ROOF AREA=   500. (SQ-FT) ; U-VALUE=   .085 (BTU/HR SQ-FT DEG-F)
TIME: OCCUPIED PERIOD=   5 DAYS/WEEK ;   0 NIGHTS/WEEK
        UNOCCUPIED PERIOD=   2 DAYS/WEEK ;   7 NIGHTS/WEEK
LITE: OCCUPIED= 3.00 (WATT/SQ-FT)   ; UNOCCUPIED=   .25 (WATT/SQ-FT)
PEOP: OCCUPIED= 200. (SQ-FT/PERSON) ; UNOCCUPIED=   0. (SQ-FT/PERSON)
VENT: VENTILATION REQUIREMENTS:
        OCCUPIED= .100 (CFM/SQ-FT)   ; UNOCCUPIED= 0.000 (CFM/SQ-FT)
        INFILTRATION RATE
        OCCUPIED= .050 (CFM/SQ-FT)   ; UNOCCUPIED= 0.000 (CFM/SQ-FT)

***USING DATA FILE: MTL
    -MONTREAL REFERENCE YEAR, STANDARD SOLAR, TSTAT=72-78 F.

** ANNUAL REQUIREMENT **
ELECTRICITY (LIGHTS):   10794. (KWH)   ;   10.79 (KWH/SQ-FT)

** CONSTANT OPERATION **
HEATING: 57638. (MBTU) ;   57.64 (MBTU/SQ-FT)
COOLING:
-SYSTEM WITHOUT ECONOMIZER=   8452. (TON-HR);   8.45 (TON-HR/SQ-FT)
-SYSTEM WITH ECONOMIZER (VAV)=   2442. (TON-HR);   2.44 (TON-HR/SQ-FT)

** SETBACK (65 F.) WHEN UNOCCUPIED **
HEATING: 46892. (MBTU) ;   46.89 (MBTU/SQ-FT)
COOLING:
-SYSTEM WITHOUT ECONOMIZER=   6201. (TON-HR);   6.20 (TON-HR/SQ-FT)
-SYSTEM WITH ECONOMIZER (VAV)=   1842. (TON-HR);   1.84 (TON-HR/SQ-FT)

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PROJECT:
EXAMPLE BUILDING

***ZONE NUMBER 2
ZONE: INTERIOR ZONE
MULT: ZONE MULTIPLIER=   1.0
AREA: FLOOR AREA=   1200. (SQ-FT)
DIRX: DIRECTION=   INTR
ROOF: ROOF AREA=   600. (SQ-FT) ;U-VALUE= .085 (BTU/HR SQ-FT DEG-F)
TIME: OCCUPIED PERIOD=   5 DAYS/WEEK ;   0 NIGHTS/WEEK
        UNOCCUPIED PERIOD=   2 DAYS/WEEK ;   7 NIGHTS/WEEK
LITE: OCCUPIED= 3.00 (WATT/SQ-FT)   ;UNOCCUPIED=   .25 (WATT/SQ-FT)
PEOP: OCCUPIED= 200. (SQ-FT/PERSON) ;UNOCCUPIED=   0. (SQ-FT/PERSON)
VENT: VENTILATION REQUIREMENTS:
        OCCUPIED= .100 (CFM/SQ-FT)   ;UNOCCUPIED= 0.000 (CFM/SQ-FT)
        INFILTRATION RATE
        OCCUPIED= 0.000 (CFM/SQ-FT)   ;UNOCCUPIED= 0.000 (CFM/SQ-FT)

***USING DATA FILE: MTL
     -MONTREAL REFERENCE YEAR, STANDARD SOLAR, TSTAT=72-78 F.

** ANNUAL REQUIREMENT **
ELECTRICITY (LIGHTS):   12952. (KWH)   ;   10.79 (KWH/SQ-FT)

** CONSTANT OPERATION **
HEATING: 3963. (MBTU)   ;   3.30 (MBTU/SQ-FT)
COOLING:
-SYSTEM WITHOUT ECONOMIZER=   2095. (TON-HR);   1.75 (TON-HR/SQ-FT)
-SYSTEM WITH ECONOMIZER (VAV)=   748. (TON-HR);   .62 (TON-HR/SQ-FT)

** SETBACK (65 F.) WHEN UNOCCUPIED **
HEATING: 2807. (MBTU)   ;   2.34 (MBTU/SQ-FT)
COOLING:
-SYSTEM WITHOUT ECONOMIZER=   2033. (TON-HR);   1.69 (TON-HR/SQ-FT)
-SYSTEM WITH ECONOMIZER (VAV)=   701. (TON-HR);   .58 (TON-HR/SQ-FT)

PROJECT:
EXAMPLE BUILDING

*** BUILDING TOTAL- SUM OF ZONES ***

\# 1 PERIMETER ZONE- FACING SOUTH EAST
\# 2 INTERIOR ZONE

***USING DATA FILE: MTL
    -MONTREAL REFERENCE YEAR, STANDARD SOLAR, TSTAT=72-78 F.

** ANNUAL REQUIREMENT **
ELECTRICITY (LIGHTS):   23746. (KWH)   ;   10.79 (KWH/SQ-FT)

** CONSTANT OPERATION **
HEATING: 61602. (MBTU) ;   28.00 (MBTU/SQ-FT)
COOLING:
-SYSTEM WITHOUT ECONOMIZER=   10548. (TON-HR);   4.79 (TON-HR/SQ-FT)
-SYSTEM WITH ECONOMIZER (VAV)=   3190. (TON-HR);   1.45 (TON-HR/SQ-FT)

** SETBACK (65 F.) WHEN UNOCCUPIED **
HEATING: 49700. (MBTU) ;   22.59 (MBTU/SQ-FT)
COOLING:
-SYSTEM WITHOUT ECONOMIZER=   8233. (TON-HR);   3.74 (TON-HR/SQ-FT)
-SYSTEM WITH ECONOMIZER (VAV)=   2543. (TON-HR);   1.16 (TON-HR/SQ-FT)

FOR FURTHER INFORMATION AND ASSISTANCE CONTACT:
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