MIN-AIR-SCH

allows an hourly variation of the minimum outside air. Any fractional input defines the hourly value of the minimum outside air damper position as a ratio of design flowrate; it also enables the economizer. The two exceptions to this definition are when the schedule has a value of either zero or -999.0, in which case special meanings are assumed. When the value is zero, a no outside air situation with no movable dampers (economizer inactive if specified) is simulated. This usage is common for nighttime heating or a warmup cycle. If this schedule has a value of -999.0, the calculated or specified value for MIN-OUTSIDE-AIR (found on report SV-A for the SYSTEM or for each zone for zonal systems) is used as the minimum damper position for the current hour. If this value is zero, the discussion above for that special value applies. During a warmup period, this schedule is normally set to zero and can then be set to -999.0 during other hours to allow the specified or calculated ventilation minimum damper position to be used.

OA-CONTROL

Input for this keyword is the code-word for the type of outside air control strategy selected. See code-words below. This keyword must equal FIXED if you do *not* want an economizer; otherwise, it will default to TEMP, which will simulate a temperature-controlled economizer. If no outside air has been specified, no movable dampers are simulated, even if OA-CONTROL equals TEMP or ENTHALPY.

FIXED

No movable dampers. Outside air quantity is a fixed amount specified, calculated, or scheduled.

TEMP

Temperature-controlled economizer. In response to the mixed air temperature going above the controller setpoint (equal to the supply air setpoint for the hour), the outside air damper is opened. (This assumes a cooling mode and that the outside air is cooler than the return air.) The outside air quantity returns to its minimum (outside air dampers close but minimum outside air dampers remain open) when the outside air temperature is at or above the ECONO-LIMIT-T.

ENTHALPY

Enthalpy-controlled economizer. Same as TEMP above except that if the return air enthalpy is less than the outside air enthalpy, the dampers are forced to minimum outside air position.

RECOVERY-EFF

is applicable only to those systems provided with heat recovery coils (or other devices) for the exchange of heat between the air exhausted from the building (by the return air fan) and the fresh air supplied to the building. The input is the ratio

Note that the italicized words in the left column are *code-words*, not keywords.

(decimal fraction) of the energy actually exchanged to the total sensible energy that would be exchanged if the exhaust air were cooled to outside air temperature. The program uses this ratio (plus outside air and return air temperatures and return air flow rate) to calculate the energy that can be added to the outside air make-up. If the recoverable energy is greater than that needed by the supply air, the program will use the smaller quantity. If the outside air temperature is above the temperature setpoint of the mixed air, no energy is exchanged. If the difference between return and outside air temperatures is less than 10 degrees, no recovery is simulated.

Note: heat recovery can be simulated only when the return air is *warmer* than the outside air.

(If the heat recovery occurs through a single heat exchanger, i.e., heat pipe or thermal wheel, then RECOVERY-EFF is identical to the heat exchanger effectiveness. See Kays and London, *Compact Heat Exchangers*, 2nd edition, McGraw-Hill, 1964).

VENT-TEMP-SCH

accepts as input the u-name of a schedule giving the hourly minimum temperature setpoint for the natural venting algorithm. This keyword is appropriate to system type RESYS only. The hourly values that should be specified in the SCHEDULE referenced by VENT-TEMP-SCH are the indoor dry-bulb temperatures, cooled through natural ventilation in lieu of mechanical cooling. This hourly temperature is generally below the hourly temperature in the SCHEDULE referred to by COOL-TEMP-SCH. This latter schedule specifies the zone cooling thermostat setpoint. The windows are assumed to be closed if the temperature in the room falls below this point. If VENT-TEMP-SCH is not specified, all its hourly SCHEDULE values will default to the temperature at the top of the heating THROTTLING-RANGE as defined by HEAT-TEMP-SCH.

NATURAL-VENT-AC

is the peak number of air changes per hour due to natural ventilation through open windows. This value is constant and is not a function of wind speed. This keyword is appropriate only to system type RESYS.

NATURAL-VENT-SCH

is the u-name of a schedule which determines when the windows can be open vs. when they are always closed. The hourly values given in the SCHEDULE (and referenced by this keyword) are 0, 1, or -1. This keyword is appropriate only to system type RESYS.

A schedule value of zero (0) indicates that the windows are always closed for this hour.

A schedule value of one (1) indicates that the windows will be

opened, for part or all of this hour, only if this provides enough cooling to keep the zone temperature within or below the throttling range associated with COOL-TEMP-SCH. The zone may be cooled down to the hourly minimum value specified by VENT-TEMP-SCH. Note that this assumes the occupant will open the windows if the condition is met.

A schedule value of minus one (-1) indicates that the windows will be opened, for part or all of this hour, only if the condition for the value of one (1) is met (above) and also that the outside air enthalpy is lower than the inside air enthalpy. The zone may be cooled down to the hourly minimum value specified by VENT-TEMP-SCH. This assumes the occupant will open the windows if both the conditions are met.

To further illustrate, assume that the occupant arises at 6:00 a.m., goes to work at 8:00 a.m., returns from work at 5:00 p.m., and retires at 10:00 p.m. every day of the year. The DAY-SCHEDULE describing the window management would be:

```
VENT-DAY = DAY-SCHEDULE  (1,6) (0) (7,8) (1) (9,17) (0) (18,22) (-1) (23,24) (0)  ..
```

The schedule for the year becomes:

```
VENTING = SCHEDULE  THRU DEC 31 (ALL) VENT-DAY  ..
```

Having defined the schedule, the entry under the SYSTEM-AIR subcommand would be:

```
HOME-AIR = SYSTEM-AIR
                    .
                    .
                    .
     NATURAL-VENT-SCH = VENTING
                    .
                    .
                    .  ..
```

If the values in VENT-DAY during the sleeping hours were 1's, it would imply that the occupant got out of bed, as often as necessary, to open and close the windows, whenever the conditions called for it. If you want to specify "temperature limits" for cooling by natural ventilation, you should specify VENT-TEMP-SCH in the SYSTEM-AIR subcommand. For example, suppose this schedule describes the cooling setpoint of the mechanical system:

```
MECH-COOL-TEMP = SCHEDULE  THRU DEC 31 (ALL) (1,8) (78) (9,17) (90) (18,24) (78)  ..
```

The following schedule describes the minimum below which the windows will be closed.

```
MIN-VENT-TEMP = SCHEDULE  THRU DEC 31 (ALL) (1,6) (60) (7,22) (68) (23,24) (60)  ..
```

Then, under ZONE-CONTROL, you should specify COOL-TEMP-SCH = MECH-COOL-TEMP, while under SYSTEM-AIR, VENT-TEMP-SCH should be set to MIN-VENT-TEMP. The preceding example can be restated as the following:

SCHEDULE hours (clock time)	Temperature Range*
1,6 (midnight to 6 a.m.)	78°F max (provided by mechanical cooling)
7,8 (6 a.m. to 8 a.m.	78°F max (provided by mech cooling) 68°F min (provided by occupant operating windows)
9,17 (8 a.m. to 5 p.m.)	90°F max (provided by mechanical cooling)
18,22 (5 p.m. to 10 p.m.)	78°F max (provided by mechanical cooling) 68°F min (provided by occupant operating windows)
23,24 (10 p.m. to midnight)	78°F max (provided by mechanical cooling)

* Note that during the hours when the windows are constantly closed (10 p.m. to 6 a.m. and 8 a.m. to 5 p.m.), the temperatures referenced by VENT-TEMP-SCH are disabled. Note also that VENT-TEMP-SCH does not necessarily say that cooling by natural ventilation will be done satisfactorily. VENT-TEMP-SCH only sets the minimum indoor temperature limits for natural ventilation. The conditions specified in NATURAL-VENT-SCH, determine when, and if, cooling by natural ventilation is done.

SYSTEM–FANS

The function of the SYSTEM–FANS instruction is to provide information on supply and return fan operating schedules, control modes, static pressures, and efficiencies. In short, this instruction provides everything the program needs to know (with the exception of fan capacity and flow rate) for calculation of the energy consumed by and the heat input from these fans. The same type of information is provided for exhaust fans, if any, at the zone level (keywords EXHAUST–CFM, EXHAUST–STATIC, etc. in ZONE–AIR instruction). SYSTEM–FANS is a "subcommand" of SYSTEM and, as such, can be used to input a subset of data to SYSTEM.

u–name — is required.

FAN–SCHEDULE — is the u-name of the SCHEDULE instruction giving the time periods (hours and days) during which this system's fans (supply, return, and exhaust) are operating and not operating. If the hourly values in the SCHEDULE that is referenced by FAN–SCHEDULE are positive, such as 1, the fans are on. If the hourly SCHEDULE values are 0, the fans are off but may be turned on by NIGHT–CYCLE–CTRL if ZONE temperatures warrant it. If the hourly SCHEDULE values are negative, such as -1, the fans are not permitted to be on for any reason. If you don't specify a SCHEDULE, the program will assume the fans run continuously. When the fans are scheduled to be off, baseboard units (if specified) can be operational.

FAN–CONTROL — equals a code-word that specifies the kind of flow reduction or control methods to be simulated. Listed below are the code-words and a brief description of the method each represents. The program calculates the part-load horsepower consumption for the supply fan and return fan (if any), on the basis of the part-load versus fan horsepower characteristics that are typical for the control mode selected (see Fig. 3.30). The program assumes that both supply and return fans have the same kind of flow control.

- *SPEED* — Variable speed motor (Curve #1 in Fig. 3.30). [For systems that have variable flow central air-handlers only.] Note, the PTGSD system defaults to SPEED control.
- *INLET* — Fan inlet vanes (Curve #2 in Fig. 3.30). [For systems that have variable flow central air-handlers only.]
- *DISCHARGE* — Damper in fan discharge (Curve #3 in Fig. 3.30). [For systems that have variable flow central air-handlers only.]
- *CYCLING* — Cycles on and off (Curve #4 in Fig. 3.30)

Note that the italicized words in the left column are *code-words*, not keywords.

TWO-SPEED High or low speed (for PTAC only - represented as 100% and another point lower on Curve #1)

CONSTANT-VOLUME Volume kept constant

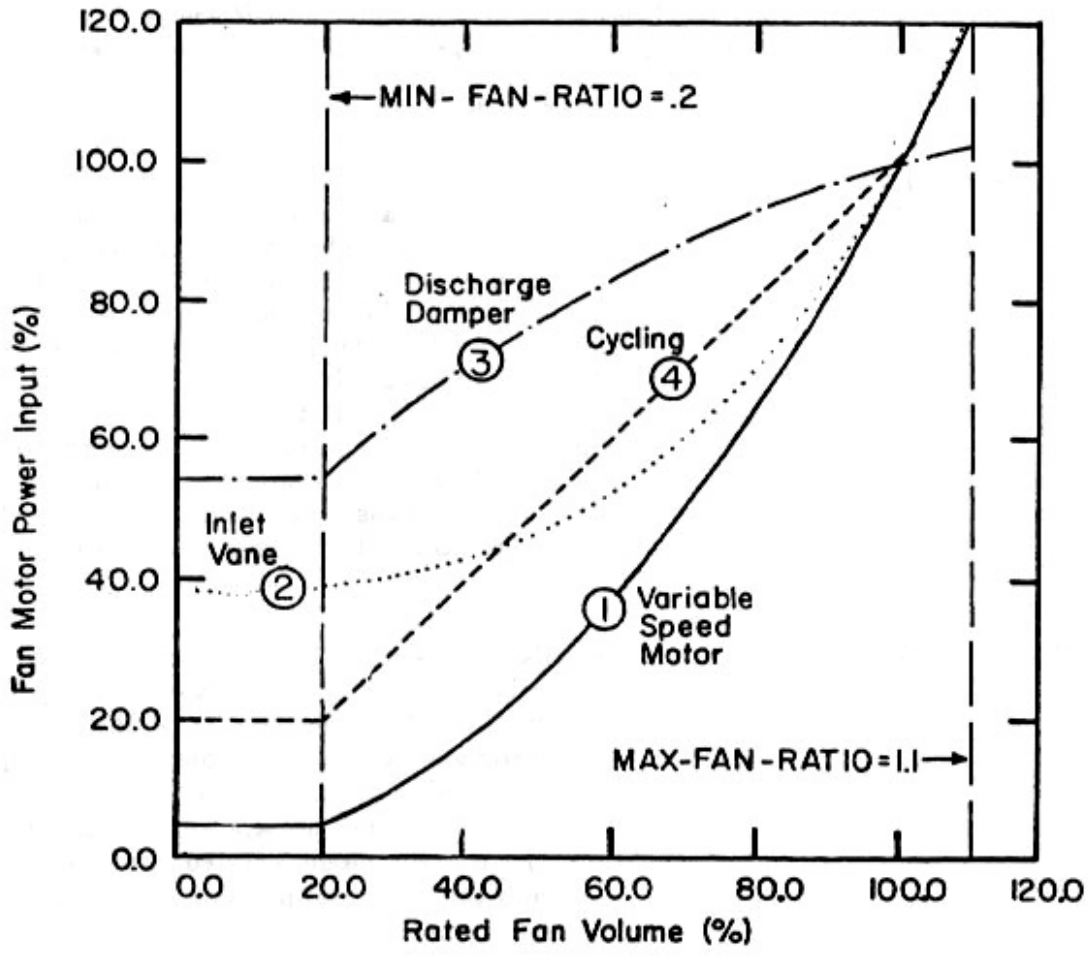

Figure 3.30: Typical power requirements at part-load operation for four different methods of capacity control (Note that with the CYCLING code-word, the MIN-FAN-RATIO is meaningless for those hours when the fan is off.)

SUPPLY-DELTA-T is used in conjunction with SUPPLY-KW. It is the temperature rise in the air stream across the supply fan. It is expressed in °F and its default value can be found in Table 3.1, based on SYSTEM-TYPE.

SUPPLY-KW is used in conjunction with SUPPLY-DELTA-T. It is the design full load power consumption of the supply fan per unit of supply air moved for one hour. It is expressed in kW/cfm at sea level (or kW/standard cfm) and its default value can be found in Table 3.1, based on SYSTEM-TYPE.

TABLE 3.1

Default Value for SYSTEM-TYPE	Effective Default Value for SUPPLY-DELTA-T (°F)	Default Value for Total SUPPLY-KW (kW/std. cfm)	Effective Default Value for FAN-STATIC* (inches, W.G.)	FAN-EFFICIENCY* (fraction)
SZRH	2.42	.000783	4	.6
RHFS	3.11	.00101	6	.7
MZS	2.723	.00088	4.5	.6
DDS	3.37	.00109	6.5	.7
VAVS	3.37	.00109	6.5	.7
PIU	3.37	.00109	6.5	.7
TPFC	.218	.00007	.3	.5
FPFC	.218	.00007	.3	.5
RESYS	.396	.000128	.6	.55
PSZ	1.815	.000587	3	.6
PMZS	2.117	.000685	3.5	.6
PVAVS	2.117	.000685	3.5	.6
PTAC	.218	.00007	.3	.5
PTGSD	1.2	*	*	*
UHT	.218	.00007	.3	.5
UVT	.182	.000059	.3	.6

* Not applicable as supply fan and pump energy are included in a fixed Electric-Input of .098 w/CFM for this system at full load.

RETURN-DELTA-T — is used in conjunction with RETURN-KW. It is the temperature rise in the air stream across the return air fan. It is expressed in °F and its default value is zero.

RETURN-KW — is used in conjunction with RETURN-DELTA-T. It is the design full load power consumption of the return fan per unit of return air moved for one hour. It is expressed in kW/cfm at sea level (or kW/standard cfm) and its default value is zero. You must enter a value in order for the program to simulate a return fan.

NIGHT-CYCLE-CTRL — Input for this keyword is the code-word that specifies the behavior of the system fans when the FAN-SCHEDULE is off. The fans are off when the hourly values in the SCHEDULE that is referenced by FAN-SCHEDULE are equal to 0. If the hourly SCHEDULE values are positive, the fans are on and if the hourly SCHEDULE values are negative, the fans are not permitted to be on under any circumstances.

NIGHT-CYCLE-CTRL also cycles fans on when the temperature goes above the COOL-TEMP-SCH's throttling range. To lock out this feature you must input a -1 in the FAN-SCHEDULE for the summer (cooling) period.

NIGHT-CYCLE-CTRL only affects the fan operation. Once the fans have cycled on, the availability of heating or cooling is controlled by the HEATING SCHEDULE and COOLING-SCHEDULE.
The code-words for NIGHT-CYCLE-CTRL are:

STAY-OFF indicates that regardless of conditions, the fans are to stay off (default value).

CYCLE-ON-ANY means that if the temperature in *any* ZONE in the SYSTEM falls below the THROTTLING-RANGE for heating, the fans are cycled on for that hour.

CYCLE-ON-FIRST indicates that if the temperature in the *first*, or control, ZONE in the SYSTEM falls below the THROTTLING-RANGE for heating, the fans are cycled on for that hour.

ZONE-FANS-ONLY applies only to PIU. If input, the main or central system PIU fan will remain off; however, the individual zone terminal fans will cycle on separately to satisfy the heating setback temperature for each zone.

Note that the italicized words in the left column are *code-words*, not keywords.

SYSTEM

The SYSTEM instruction gives specifications for the secondary HVAC distribution system. The information provided includes system type, size, zones served, optional components, operating schedules, temperature and humidity limits, control strategies, outside air requirements, and fan static pressures and efficiencies. In addition, you may reference "subcommands" (SYSTEM–CONTROL, SYSTEM–AIR and SYSTEM–FANS) that contain the needed information.

u–name — required input for SYSTEM

SYSTEM–TYPE — identifies the type of system to be simulated. You must select one of 16 types of commonly used energy distribution systems. A discussion of the features of each system and a "suggested minimal input" for each system type can be found on p.3.10ff.

Code-word	Description of System Type	Generic Type
SZRH	Single Zone Fan System with Optional Subzone Reheat	built-up/central
RHFS	Constant Volume Reheat Fan System	built-up/central
MZS	Multizone Fan System	built-up/central
DDS	Dual Duct Fan System	built-up/central
VAVS	Variable Volume Fan System with Optional reheat	built-up/central
PIU	Powered Induction Unit	built-up/central
TPFC	Two Pipe Fan Coil System	built-up/zonal
FPFC	Four Pipe Fan Coil System	built-up/zonal
RESYS	Residential System	packaged/central
PSZ	Packaged Single Zone Air Conditioner with Optional Heating and Subzone Reheat	packaged/central
PMZS	Packaged Multizone Fan System	packaged/central
PVAVS	Packaged Variable Air Volume System	packaged/central
PTAC	Package Terminal Air Conditioner	packaged/zonal
PTGSD	Package Total Gas Solid Desiccant	packaged/central
UHT	Unit Heater	built-up/zonal
UVT	Unit Ventilator	built-up/zonal

SYSTEM–CONTROL — references the u-name of a previously assigned SYSTEM–CONTROL instruction.

SYSTEM–AIR — references the u-name of a previously assigned SYSTEM–AIR instruction.

SYSTEM–FANS — references the u-name of a previously assigned SYSTEM–FANS instruction.

HEAT-SOURCE

is the keyword that identifies the heat source for the distribution system for heating coils. This is the appropriate keyword for UHT, UVT, TPFC, FPFC and PTAC zone heating coils since they are all served by a central distribution system. HEAT-SOURCE defaults to GAS-HYDRONIC for the Packaged Total Gas Solid Desiccant (PTGSD) system; it should not be changed nor applied to any other system type.

The following HEAT-SOURCE code-words also apply to ZONE-HEAT-SOURCE, PREHEAT-SOURCE, and BASEBOARD-SOURCE.

ELECTRIC — The source of heat is an electric resistance element. This code-word is appropriate for central heating coils, preheat coils, baseboard heaters, and zone heating coils.

FURNACE — The source of heat is a furnace, which will be simulated in SYSTEMS.

GAS-HYDRONIC — Applies to BASEBOARD-SOURCE and HEAT-SOURCE for PTGSD system only. The source in this case is a gas-fired hot water generator.

HEAT-PUMP — The source of heat is an electric air-to-air heat pump. Note: This code-word is appropriate only as a HEAT-SOURCE for the RESYS, PSZ, and PTAC systems. It should not be used for any other system types.

HOT-WATER — The source of heat is hot-water, provided by conventional equipment specified in the PLANT program. This code-word is appropriate for central heating coils, preheat coils, baseboard heaters, and zone heating coils.