Ventilation In HAP

There are many questions regarding how to input ventilation rates and how to interpret the HAP results and impacts of those inputs. There is a hierarchy employed by the software to determine the amount of outside air needed by the system. Understanding this is the key. To this end, the various areas of inputs that have an effect on the ventilation rate will be examined in this article, and the relationship of these inputs and the resultant ventilation rates will be discussed.

Space Inputs

The first area for ventilation inputs is the space. Previous versions of HAP did not have ventilation as a space input but in the system. This causes some confusion with long time users and those who naturally think of ventilation as a "system" Input. The optional ASHRAE 62 calculation procedure needs to determine the critical ventilation zone. In HAP, the zone is a system input. A zone is comprised of one or more spaces. Hence, the current starting point for ventilation airflow rate determination is in the space definition.

Space Usage

Choose one of the space usage types to default outdoor air requirements based on ASHRAE Standard 62 values (Figure 1) or select "User-Defined" (Figure 2) to define your own requirements.

When complying with Standard 62, you can select one of these space usage types and the corresponding ventilation requirement will be defaulted automatically.

When complying with a different ventilation standard or code or entering specific values, choose the "User-Defined" usage type.

One or two outdoor air requirements can be defined for the space: OA Requirement 1 and 2. Define a value and the units of measure for each.

Example: 20 CFM/person. Units of measure options in English are CFM, CFM/ft^2, CFM/person and percentage of supply air.
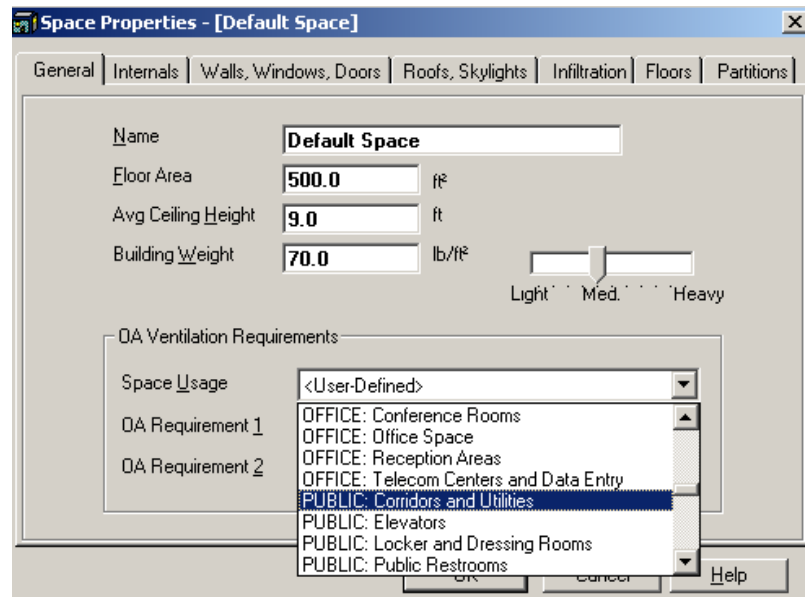

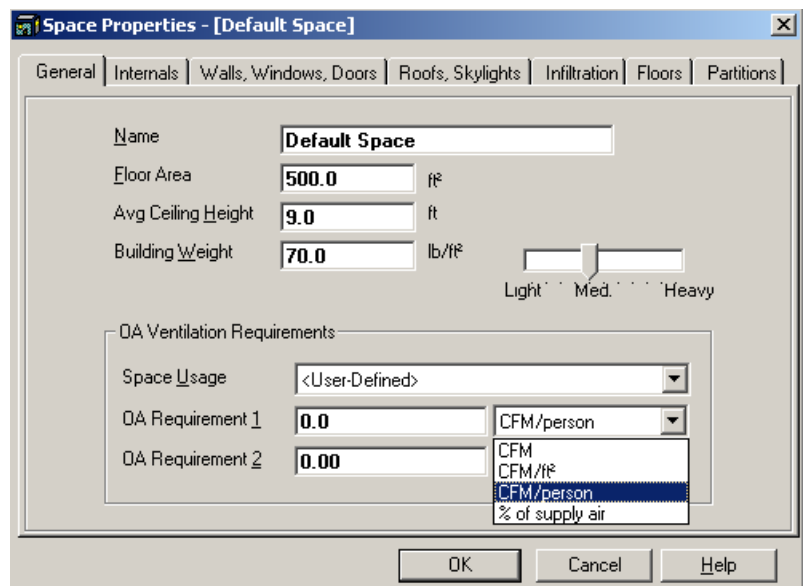**Figure 1 - Ventilation Space Usage**

Figure 2 - Space OA Requirements

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If the ventilation standard or code being used defines only one outdoor requirement, specify it and leave the second outdoor air requirement value as zero.

When values are specified for both outdoor air requirements they will be additive. Some standards or codes define two requirements per occupied space. One is typically on a per person basis to address CO_2 and people-generated pollutants or odors. The second is typically on a per floor area basis to address pollutants generated by materials in the space such as carpeting and furnishings. During sizing calculations, the program will sum the two ventilation requirements to obtain the total requirement for the space.

System Inputs

The Air System Properties has various input areas that impact the design ventilation air requirements. The first area is that of the ventilation air on the **System Components** tab**.** See Figure 3. Depending on the system type chosen, constant volume or variable volume, various Airflow Control choices are available.

Proportional Control models the use of uncontrolled or partially controlled ventilation air for variable air volume systems. With this control, the ventilation airflow rate varies as the supply airflow varies. Uncontrolled outdoor airflow tends to vary as a constant percentage of supply air. Thus, if the supply fan has throttled to 60% of its design flow rate, then the outdoor ventilation airflow is at 60% of the design outdoor airflow rate. This control option is offered only for VAV systems. The use of proportional control means there will be two different ventilation rates between which the system will vary. The system with all the VAV boxes wide open will have the maximum outside airflow rate and the system with all the VAV boxes with the primary air dampers at their minimum position will have the minimum OA quantity. HAP cooling design reports will show the OA quantity at the time of the peak coil load. At this time, not all the VAV box dampers may be in the full open

Figure 3 - Ventilation Airflow Control

position, so the HAP user will see a design cooling OA rate at some value less than at the full open design. For design heating sizing calculations, the VAV box primary air dampers are all set to their minimum positions. The amount of outside air will be proportional to the VAV box minimum settings. For example if the boxes were set to 25% minimum, the outside air quantity for design heating will be only 25% of system wide open value. Therefore, the user will see two different OA values in the HAP design load reports: one for peak cooling and one for peak heating.
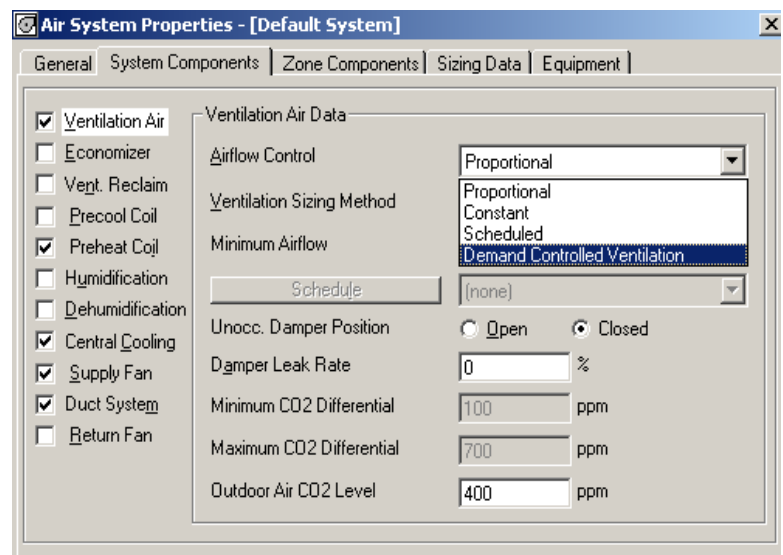
If the user must provide the "design" OA values at all times, proportional control should not be used.

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Constant Control specifies that outdoor ventilation will be maintained at the design CFM (or L/s) airflow value for all occupied period hours and for unoccupied period hours when the ventilation dampers are open. For constant volume systems, constant ventilation airflow can be maintained without special controls. For VAV systems, it is assumed special damper controls or booster fans are used to maintain a constant ventilation airflow rate as the supply airflow varies. If the supply airflow rate in a VAV system drops below the design ventilation flow rate, the system will operate with 100% outdoor air, but will be below the design ventilation specification.

Scheduled Control refers to special equipment and controls used to vary the outdoor ventilation air according to predetermined hourly and daily schedules. When this option is used, outdoor ventilation air is calculated using the design airflow value and a user-defined schedule.

Demand Controlled Ventilation (DCV) models the use of CO_2 sensors in each zone to control ventilation air. This is an energy savings part load control strategy and does not impact the design ventilation sizing.

The Ventilation Sizing Method in Figure 4 defines the procedure used to calculate the design outdoor ventilation airflow rate for the system. Three options are offered:

Sum of Space OA Airflows. This method calculates the design ventilation airflow by summing the space outdoor airflow requirements for all spaces served by the system. Certain ventilation standards and codes use this approach. This approach is also typically used when the building is not subject to a ventilation standard or code.

ASHRAE Standard 62-2001. This method calculates design ventilation airflow using the Ventilation Rate Procedure documented in section 6.1 of the Standard. When the system serves more than one space the multiple space equation, equation 6-1, is used. For VAV systems the program will calculate ventilation requirements at two conditions – with all VAV boxes full open, and with all VAV boxes at minimum position – and then choose the larger airflow as the design value for the system.
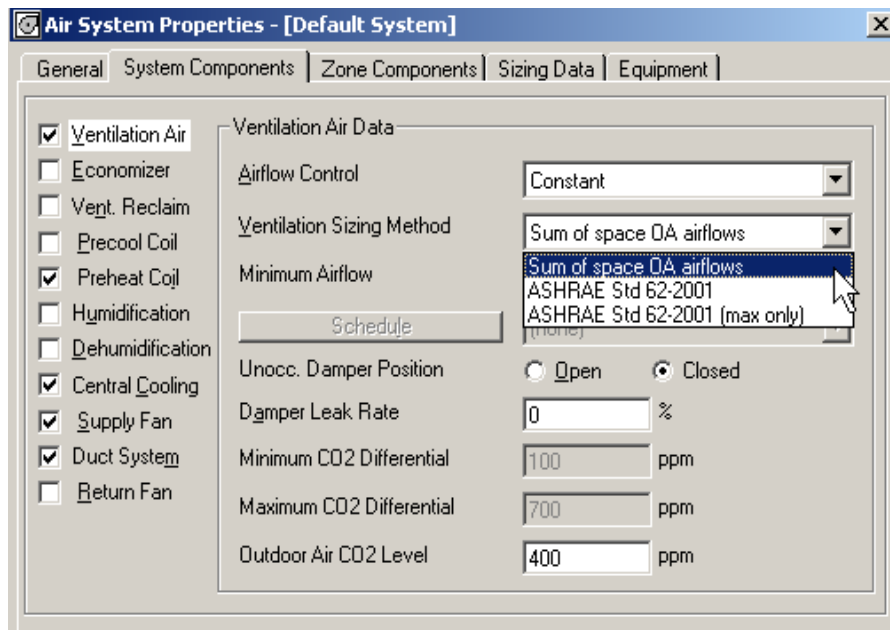

Figure 4 - Ventilation Sizing Method

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ASHRAE Standard 62-2001 (max only) – This option is only offered for VAV systems. It uses the same procedure as the previous item, except that only the condition with all VAV boxes full open is considered. Because the 2001 edition of Standard 62 is not specific about how the Standard should be applied to VAV systems, the use of the Standard for VAV systems requires engineering judgment. This option is offered for those who do now feel the minimum box condition should be considered, and for those who wish to compare sizing data using the max+min and max only scenarios.

Minimum Airflow in Figure 5 specifies whether special controls are used to prevent outdoor ventilation airflow from dropping to unacceptably low levels. The minimum airflow rate is defined as a percentage of the design ventilation airflow.

Example: The minimum is specified as 25% for a system with design ventilation airflow of 1000 CFM and a supply airflow rate of 5000 CFM. This means the ventilation airflow rate may not drop below 250 CFM. Without any minimum controls, ventilation airflow would be 200 CFM when the supply airflow rate dropped to 1000 CFM (20% of design). However, because a minimum airflow rate has been specified, the program will assume the necessary equipment and controls are present to maintain 250 CFM ventilation airflow for this condition.

The Unoccupied Damper Position in Figure 5 specifies whether outdoor air dampers are open during the unoccupied equipment-operating period. When the "Open" item is selected, ventilation airflow will be controlled in the same way it is in the occupied period whenever the system runs during unoccupied hours. When the "Closed" item is selected, dampers will be closed and only the specified damper leakage will occur when the system runs during unoccupied hours.

Damper Leak Rate defines how much air leaks through dampers when they are closed and the system is running. Leakage is defined as a percentage of the design outdoor ventilation airflow rate. If dampers are open during the unoccupied period, this input is not used.

Figure 5 - Damper Position and Leak Rate

Outdoor Air CO_2 Level defines the average concentration of carbon dioxide in outside air. It is not used in Proportional control calculations. However, the program performs a CO_2 balance calculation for all systems and displays the results on the System Psychrometrics report to allow users to examine CO_2 levels in the occupied zones. The Outdoor Air CO_2 Level is required for this calculation and therefore this input is required for all types of ventilation control. 400 parts per million (ppm) is

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a rule of thumb default for the outdoor CO_2 level. If you do not have actual data for the building site, we recommend using this default.

Direct Exhaust Airflow in Figure 6 defines the airflow rate for direct exhaust. This flow rate is assumed to occur for any hour in which the central supply fan is ON and the ventilation dampers are open. Direct exhaust airflow should be less than or equal to the outdoor ventilation rate for the system.

If direct exhaust airflow does not exist in the zone, specify a zero airflow rate. When this is done, the program will assume any outdoor ventilation air is exhausted after flowing through the return duct or plenum.

Please note! During system design calculations, if the direct exhaust airflow rate for zones in a system exceeds the outdoor ventilation airflow, the design ventilation airflow rate will be increased to equal the direct exhaust airflow rate.

During simulation of system operation using proportional, scheduled or demand controlled ventilation control, it is possible for ventilation airflow to fall below the direct exhaust airflow for zones in the system. In such a situation, direct exhaust airflow is reduced since total system exhaust cannot exceed ventilation.
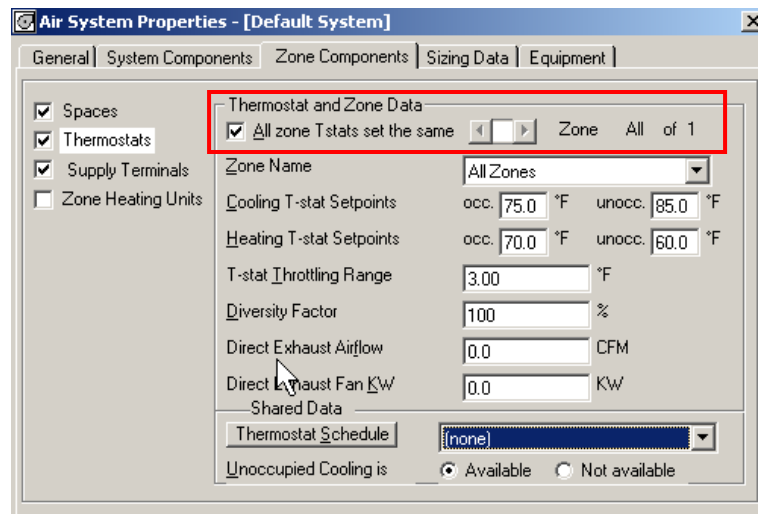

Figure 6 - Direct Exhaust Airflow

Also note that the box next to **All zone Tstats set the same** has been checked. See Figure 6.

This option applies to all items, including the direct exhaust airflow input value. In other words, if a 10 zone VAV system were input with a tick mark in this box and a value of 1,000 CFM of direct exhaust was used the total system direct exhaust would be 10,000 CFM. The system ventilation requirement would have to be equal to or greater than this amount if not the design ventilation airflow rate will be increased to equal the direct exhaust airflow rate of 10,000 CFM.

The zone Direct Exhaust Airflow rate also becomes one of the sizing criteria for the zone. The zone design airflow rate must be equal or greater than this value or the zone design airflow will be increased.

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In a VAV system, the amount of ventilation air at the design heating point is also a function of the minimum setting on the primary air valve. See Figure 7.

If the minimum primary air valve setting is less than the ventilation requirement, the system cannot deliver the required amount.

The minimum setting may need adjustment. If the ventilation airflow control is proportional (see Figure 3), the design ventilation air rate may not be achievable at the minimum box valve setting unless constant control is chosen.

The final input that will impact the design ventilation rate is in on the Air System Properties Sizing Data tab as shown in Figure 8.

Figure 7 - Air Valve Minimum Flow

By checking the box for **System Sizing** and then choosing **Sizing Data is User Defined**, the design value for the Ventilation Airflow rate can be changed and defined directly by the user. The user-defined value for the Ventilation Airflow Rate will be used and no other space or system input will be considered that directly or indirectly impacts the determination of the design ventilation rate.

The determination of the design ventilation rate by the HAP software is not always a simple straightforward process. The goal of the software is to assist you in your system design not just perform a simple load calculation. To this end, an understanding of the system and how it operates and the inner workings of the software is necessary to achieve an understanding of the reported results.
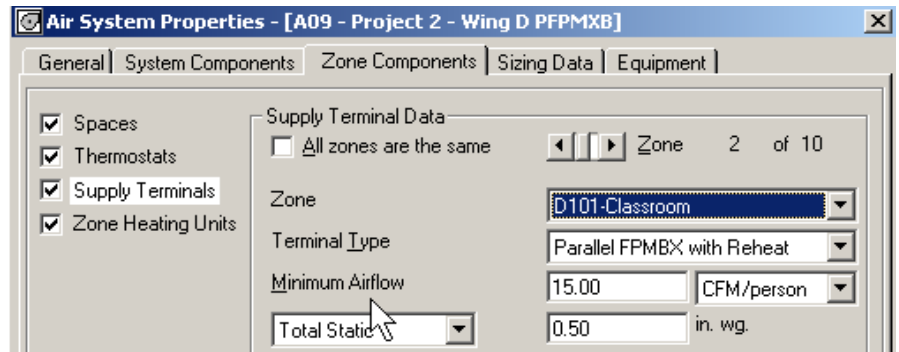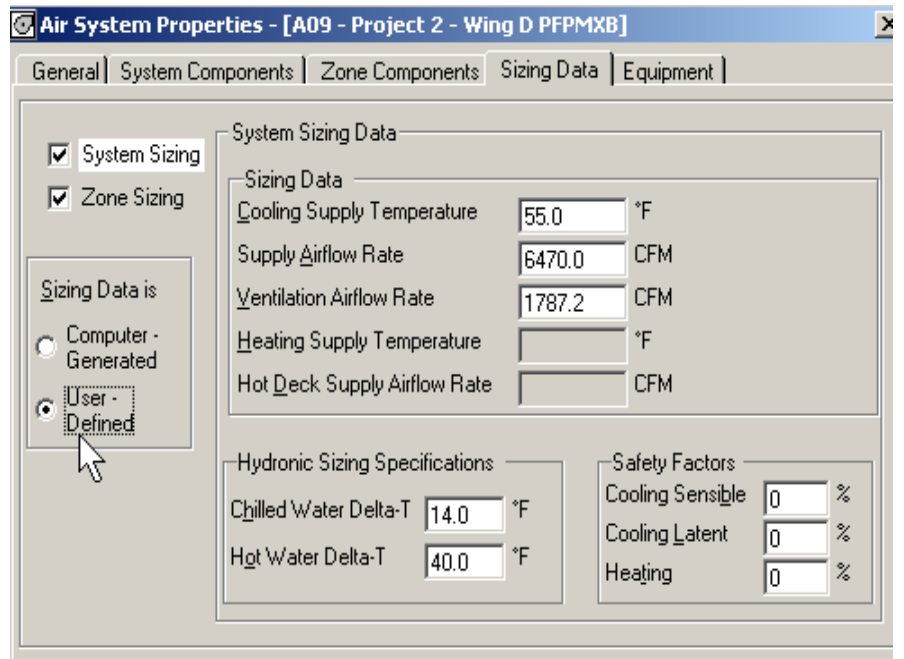

Figure 8 - User-Defined Ventilation Airflow