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## Obtaining Consistent Results Using HAP and the ASHRAE 62MZ Ventilation Rate Procedure Spreadsheet

A key task in commercial building Heating, Ventilation, and Air Conditioning (HVAC) design is determining outdoor ventilation airflow rates. In most jurisdictions in the United States, ventilation airflow rates must comply with local building code requirements, and for many applications those codes typically reference American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 62.1, *Ventilation for Acceptable Indoor Air Quality*. Engineers have a number of tools at their disposal to calculate Standard 62.1-required airflows for a building project.

One tool is Carrier's Hourly Analysis Program (HAP), a full service HVAC system design tool in which the ventilation airflow calculation is just one of many design calculations being performed. Another tool is the ASHRAE 62MZ Ventilation Rate Procedure spreadsheet, a tool focused solely on the ventilation airflow calculation.

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# Obtaining Consistent Results Using HAP and the ASHRAE 62MZ Ventilation Rate Procedure Spreadsheet

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For some projects, designers are required to submit ventilation airflow rate calculations using the ASHRAE 62MZ Spreadsheet. This creates a situation where HAP is used to design the full system, and ASHRAE 62MZ is used to submit documentation for the ventilation airflow calculations. Obtaining consistent results between the two tools is critical in these projects.

This article provides a concise summary of how consistent results can be obtained using HAP and the ASHRAE 62MZ Spreadsheet. A more detailed discussion presenting a step by step example for an 8-zone Variable Air Volume (VAV) system is available in the companion eHelp ["Obtaining Consistent Results using HAP and the ASHRAE 62MZ Ventilation Rate Procedure Spreadsheet"](#)

## Using HAP for Standard 62.1 Ventilation Calculations for a VAV System:

### Step 1

For each space, assign an ASHRAE Standard 62.1 space type using the Space Usage drop down list under "OA Ventilation Requirements". This defaults Standard 62.1 CFM/person and CFM/sqft requirements for the space.

### Step 2

For each air system, specify the Ventilation Sizing Method as "ASHRAE Standard 62.1". This directs the program to use the Standard 62.1 Ventilation Rate Procedure to calculate airflow requirements.

### Step 3

Configure the VAV terminal type and the VAV terminal minimum supply airflow for each zone.

### Step 4

Run sizing calculations for the air system and request the Ventilation Sizing Summary report.

### Step 5

Interpret results on the Ventilation Sizing Summary Report.

## Using the ASHRAE 62MZ Spreadsheet for a VAV System

### Step 1

Enter project information into the spreadsheet.

### Step 2

Enter data in the "Inputs for System" section. This includes total floor area, population, and design supply airflow rate for the air system.

### Step 3

Enter data in the "Inputs for Potentially Critical Zones" section. This includes: zone floor area, number of occupants, and design supply airflow rate. If you know the critical zone to begin with, specify only those zones. Otherwise define all the zones served by the system so the spreadsheet can determine the critical zone for you.

### Step 4

Enter data in the "Inputs for Operating Condition Analyzed" section. Specify data for the design cooling condition. For VAV systems, this involves specifying the % of design supply airflow at minimum VAV terminal airflow and an "air distribution type" for supply of cool air.

### Step 5

Review spreadsheet calculation results to obtain required ventilation airflow for the cooling condition.

### Step 6

Make a copy of the spreadsheet and repeat steps 1 through 5 above, this time for the design heating condition. Using a copy of the original cooling analysis, data for Steps 1, 2 and 3 above will not require any changes. However, Step 4 must be modified to specify the "air distribution type" for supply of warm air. Then review spreadsheet calculation results to obtain required ventilation airflow for the heating condition.

### Step 7

Your ventilation airflow requirement will be the larger of the results from Step 5 and Step 6.



If the input data entered in the 62MZ Spreadsheet matches your inputs in HAP, both methods will yield the same outdoor ventilation airflow requirement. It is important to note:

**1.** HAP collects the information needed for the Standard 62.1 Ventilation Rate Procedure (VRP) calculation from the data you enter as a normal course of creating your building and system models. This includes floor area, number of occupants, air terminal types and supply temperatures. HAP automatically calculates the Standard 62.1 VRP for both cooling and heating conditions. It automatically determines the critical zone for ventilation purposes for each case. Ultimately it reports the worst case result as the ventilation requirement for the system.

**2.** With the 62MZ Spreadsheet it is important to understand the procedure for correct use of the spreadsheet. This includes the need to run separate calculations for both cooling and heating modes and choose the worst case result. It includes proper definition of percent of design airflow and the proper "air distribution type" for both cooling and heating mode calculations. And it requires correctly identifying the critical zones, or otherwise defining all of the zones to allow the spreadsheet to determine the critical zone.

With proper use of both tools, matching results can be obtained.

## Understanding the User-Defined Sizing Option for HAP Air Systems

Normally Carrier's Hourly Analysis Program (HAP) is used to automatically determine sizing requirements for HVAC systems such as supply and ventilation airflow rates, and coil capacities. However, there are applications where it is necessary to manually define this HVAC sizing data and then evaluate the resulting system performance at peak load conditions or for full year energy performance. This article describes how the "user-defined sizing" feature for air-side systems in HAP can be used for these applications.

**Typical Applications.** The following are two common applications for the "user-defined sizing" feature for air-side systems:

**1. Retrofits** - Suppose you're applying energy conservation measures, or replacing components and controls in an existing building and want to evaluate the effect on system energy performance. Therefore the HVAC system already exists and airflow rates and duct sizes are set.

**2. Troubleshooting** - Suppose you're working with an existing building in which you believe the HVAC system is either oversized or undersized. By specifying actual system airflow rates you can simulate system performance at peak load conditions to determine if the system is over- or under-sized, evaluate potential consequences, and evaluate corrective actions. Or you can determine the effect on annual energy performance of a right-sized system versus a mis-sized system.

**How it Works.** In the Air System Properties window, on the left side of the Sizing Tab inputs are provided for choosing "Computer-Generated" or "User-Defined" sizing for the system. If you select "Computer-Generated", HAP will automatically calculate all of the data in Table 1 applicable to your system based on peak load conditions and your system specifications. On the other hand, if you choose "User-Defined", HAP will require you to directly specify the data in Table 1 using inputs on the Air System Sizing and Zone Sizing data screens on the Sizing Tab.

If you select "User-Defined" sizing for an air system that was previously calculated, the initial calculation results will be preserved as defaults and you only need to modify the values needing adjustment. On the other hand, if you select "User Defined" for an air system not yet calculated, all the sizing values will initially be zero and you'll be responsible for defining all the values yourself.

Regardless of which option is selected, the sizing data in Table 2 is computer-generated by HAP. Note that there are separate options for manually specifying DX equipment capacities (see Air System Properties, Equipment Tab) and for hydronic equipment (see Plant Properties window) that relate to many of the Table 2 elements. In many situations the DX sizing options match 1 to 1 with coils in Table 2. For hydronic equipment, user-defined sizing is done on a plant level rather than a coil by coil level.

**Table 1. Sizing Data Affected by User-Defined Sizing Option**

Zone and system supply airflow rates. System outdoor ventilation airflow rate.
Zone-level outdoor ventilation airflow rates (Terminal systems - FCUs, WSHPs, VRF).
Zone-level primary airflow rates (Induction Beams, Active Chilled Beams).
Zone-level parallel fan powered mixing box fan airflows (parallel fan powered mixing box terminals only).
Terminal reheat coil capacities (CAV and VAV systems with reheat coils).
Supplemental zone heating unit capacities (baseboard and fan coil units).

**Table 2. Sizing Data Not Affected by User-Defined Sizing Option**

Space by space supply airflow rates.
Central cooling and heating coil capacities (CAV and VAV central systems).
Precool and preheat coil capacities (CAV and VAV central systems).
Ventilation cooling and heating coil capacities (Ventilation AHUs).
Terminal cooling and heating coil capacities (FCUs, WSHPs, VRF, Induction Beams, Active Chilled Beams).

**Consequences.** When selecting the “User-Defined” sizing option, it is important to understand resulting consequences for design and energy simulation calculations. Three of the key consequences are listed below.

**1. Sizing Calculations** - If you select “User-Defined” sizing, no sizing calculations will be done for data shown in Table 1. The most important consequence here is that the program will not perform any ASHRAE Standard 62.1 Ventilation Rate Procedure calculations. Instead it will directly use the ventilation airflow rates specified on the Air System Sizing or Zone Sizing data screens. Because no ventilation sizing calculations are done, no data will be available on the Ventilation Sizing Summary to assess ventilation performance on a space by space level.

**2. Design Supply Temperatures** - When “User-Defined” sizing is selected, the design supply air temperatures shown on the Sizing Tab will be used for system control instead of design supply air temperatures specified earlier on the System Components or Zone Components tabs. Therefore, if you modify the supply air temperatures on the Air System Sizing data screen, be aware these modified values become the basis for control of system supply air temperatures.

**3. Undersizing or Oversizing** - The user-specified sizing values are used in system calculations whether or not they are sufficient to meet cooling and heating demands in the building. For example if an airflow rate or coil capacity from Table 1 is not sufficient to meet a peak cooling or heating demand, temperature control in the conditioned zone will be lost and zone temperatures can rise to excessively warm values or fall to excessively cold values. In certain troubleshooting applications, this is the desired result since the objective of undersizing is to determine the effect on system control. Also note that this will likely result in large numbers of zone-temperature-out-of-range hours in the energy simulation.

# Frequently Asked Questions

## **Question 1: Can HAP handle diversity? If so where is that input to the program?**

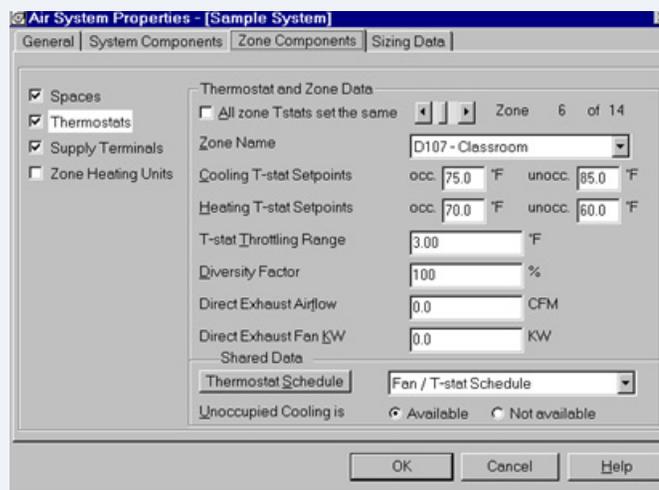
**Answer: Diversity can be handled at the air system level using the “diversity factor” input.**

The diversity factor is used to change lighting and occupant heat gains for the two stages of system design calculations. First, when calculating required zone airflow rates, HAP will calculate lighting and occupant loads according to the user’s original space and schedule specifications in order to obtain the peak load for the zone. Second, when calculating system operation to determine peak cooling and heating coil loads, the program adjusts lighting and people heat gains to lower levels if a diversity factor was specified. This is intended to account for situations where occupants move within the building so that all zones are not simultaneously at maximum occupancy. In these situations, calculating peak system coil loads with all zones at maximum occupancy would overestimate the coil load.

The input for diversity factor is found in the Air System Properties window, on the Zone Components tab, in the Thermostat data screen. A single diversity factor can be applied to all zones in a system using the “all zones the same” option, or separate diversity factors can be defined for each zone by unchecking the “all zones the same” option. A diversity factor of 100% means no diversity is considered. Values less than 100% indicate the percentage of total specified occupants and lights that will be considered for the coil sizing calculation.

In addition, ASHRAE Standard 62.1 ventilation sizing calculations are affected by the occupant diversity factor you specify. In the Standard 62.1 Ventilation Rate Procedure (VRP) the factor “D” is calculated as the ratio of (Total System Population) divided by (Sum of Peak Zone Populations). If you specify diversity factors of 100% in HAP (i.e., no diversity), the factor D in the 62.1 VRP calculation will be 1.0.

If you specify diversity factors less than 100% in HAP (i.e. diversity is present), the factor D in the 62.1 VRP calculation will be less than 1.0. That in turn will reduce  $V_{ot}$ , the required outdoor air intake flow rate.



## **Question 2: How do I configure exhaust air in HAP?**

**Answer: In HAP “direct exhaust air” can be configured at the air system level on the “Zone Components” tab, in the Thermostats data screen.**

Direct Exhaust Air refers to air directly exhausted from zones without first flowing through the return plenum or return duct. Direct exhaust can occur in a number of ways. Examples of forced direct exhaust include:

- laboratory fume hoods,
- kitchen exhaust hoods,
- toilet exhaust, and
- through-the-wall exhaust.

Examples of natural direct exhaust include:

- exfiltration through open loading dock doors, and
- exfiltration through open entry doors.

Direct exhaust is a significant detail when modeling building performance because where air leaves the building affects system thermal performance. Air leaving the zone directly will often be at a temperature different from air exhausted after flowing through a return plenum or return duct.

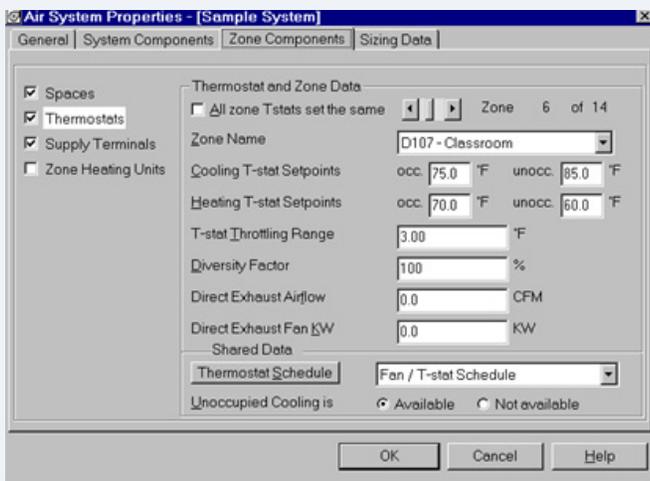
**Discussion.** The program assumes a steady state flow condition for all its system calculations. Therefore, any outdoor ventilation air entering the building will somehow be exhausted from the building. The question is where that exhaust occurs. If direct exhaust is specified, this airflow will be exhausted directly from the zone. If any remaining outdoor ventilation air must be exhausted, the program assumes it flows through the return plenum or duct before being exhausted at the air handling unit, or some other central location. Finally, for the situation in which direct exhaust air is not specified, the program automatically assumes all outdoor ventilation air is exhausted at the air handling unit after flowing through the return duct or plenum. No user specification of exhaust airflow is needed in this case - HAP calculates this automatically.

### Question 3: Does plant sizing consider diversity among air systems?

*"I am designing a central chiller plant which serves twelve air handling units. Looking at the Cooling Plant Sizing Summary I am wondering whether the peak chiller load is based on the sum of the peak loads for the 12 air systems or whether diversity is considered."*

**Answer: The peak chiller load is determined from the coincident peak load, not the sum of the peaks.**

Consider this example: Suppose we are designing a chiller plant which serves two air handlers. AHU-1 has a peak load of 100 tons at July 1300 while AHU-2 has a peak load of 150 tons at July 1800. Loads for these two air handlers are shown in the table below. Rather than size the chiller for the sum of the peaks (250 tons), the program finds the coincident peak load (212 tons at July 1500). This is the correct value to use because it is the maximum load imposed on the chiller.



Hour	AHU-1 Cooling Coil Load (Tons)	AHU-2 Cooling Coil Load (Tons)	Total Cooling Load Imposed on Chiller (Tons)
0600	43	31	74
0700	48	43	91
0800	55	51	106
0900	64	57	121
1000	78	64	142
1100	90	71	161
1200	96	82	178
1300	100	97	197
1400	98	110	208
1500	89	123	212
1600	72	138	210
1700	61	146	207
1800	565	150	206
1900	49	128	177

## 2014 Training Class Schedule

Location	Load Calculation for Commercial Buildings	Energy Simulation for Commercial Buildings	Energy Modeling for LEED® Energy & Atmosphere Credit 1	Advanced Modeling Techniques for HVAC Systems	Engineering Economic Analysis
Portland, OR	N/A	Apr 30	May 1	N/A	N/A
Houston, TX	May 12	May 13	May 14	May 15	May 16 (AM)
Montreal, QC	N/A	N/A	N/A	May 29	N/A
Toronto, ON	Jun 3	Jun 4	Jun 5	Jun 6	N/A
Washington, DC	Jun 17	Jun 18	Jun 19	Jun 20	N/A
Cincinnati, OH	Jul 8	Jul 9	Jul 10	Jul 11	N/A

Additional classes are being added.

### eDesign Suite Software Current Versions (North America)

Program Name	Current Version	Functionality
Hourly Analysis Program (HAP)	v4.80	Peak load calculation, system design, whole building energy modeling, LEED® analysis.
Building System Optimizer	v1.30	Whole building energy modeling for schematic design.
Block Load	v4.16	Peak load calculation, system design.
Engineering Economic Analysis	v3.05	Lifecycle cost analysis.
Refrigerant Piping Design	v4.00	Refrigerant line sizing.
System Design Load	v4.80	Peak load calculation, system design.



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