Bentworth Middle School

Bentleyville, PA

Technical Report One

An analysis of ASHRAE Standard 62.1-2007
and ASHRAE Standard 90.1-2007

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Executive Summary

The purpose of this report is to determine whether Bentworth Middle School complies with ASHRAE Standard 62.1-2007 and ASHRAE Standard 90.1-2007.

The newly built Bentworth Middle School is located Bentleyville, PA. The school is considered a state-of-the-art facility and just opened its doors to students grades five through eight in January 2009. Ensuring that the students and staff were provided with a comfortable and functional learning and working environment was a priority.   Directly related to this is air quality and energy efficiency of the building as clean, fresh air is ideal in any environment and schools are always looking to save money on energy expenditure in order to provide more money allowance to go into furthering student education. Therefore, ASHRAE Standards 62.1 and 90.1 are very relevant design parameters.

The evaluation of ASHRAE Standard 62.1-2007 showed that the building just fell short of complete compliance with the standard. The two primary sections of this standard that were evaluated were *Section 5 Systems and Equipment* and *Section 6 Procedures*. Bentworth Middle School complied with all parts of Section 5, displaying the school's excellence in system design and equipment use. However, when the school's ventilation rates were studied under the procedures outlined in Section 6 a discrepancy was found. It appeared that one of the rooftop heat pumps was not capable of providing the required amount of ventilation air. Since this rooftop unit is providing outdoor air to the heat pumps in the classroom wing, it is believed that it will still be able to provide adequate ventilation air to spaces as it is very unlikely that all of the spaces will require peak ventilation air rates at the same time. It is also believed that ASHRAE assumed a higher number of occupants in some of the spaces than what was actually designed for.

It was also determined that Bentworth Middle School was just shy of compliance with ASHRAE Standard 90.1-2007. The two primary areas where the building fell short were *Fan Power Limitation* and the flooring U-value. It was also difficult to differentiate whether or not the building's heat pumps met the minimum efficiency requirements outlined in this standard because the entering water temperatures ASHRAE used to determine the minimum COP and EER values were different than the design entering water temperatures at Bentworth Middle School.

Although Bentworth Middle School did not achieve complete compliance with either of the standards this report shows that the school's design was still incredibly accurate and energy efficient. If some additional considerations had been given to ASHRAE Standards 62.1 and 90.1 early on in the design process or if a few minor alterations are made to the building, Bentworth Middle School would easily be in accordance with the standards.

ASHRAE Standard 62.1-2007 Evaluation

Section 5 Compliance – Systems and Equipment

5.1 Natural Ventilation
Although many of the spaces are designed to include operable double hung windows, they were not intended to be the sole source for fresh air. However, many of the spaces, such as the classrooms, are capable of being naturally ventilated given the right outdoor air conditions as the amount of openable window area is at least 4% of the floor area and is within 25 feet of the space.

5.2 Ventilation Air Distribution
The specifications state that the various mechanical equipment responsible for providing ventilation have controls able to maintain an adjustable minimum ventilation rate under any load condition as required by Section 6 of ASHRAE 62.1. A full analysis of Section 6 can be found in this report.

5.3 Exhaust Duct Location
Spaces that contain potentially harmful contaminants are equipped with exhaust fans. Each of these fans exhaust air at high speeds of over 1000 fpm. Such speeds will create a negative pressure in the duct relative to the room, ensuring that the space is not polluted by the contaminant. Furthermore, all ducts are sealed in accordance with SMACNA standards.

5.4 Ventilation System Controls
The mechanical ventilation of the building is mainly provided by six rooftop heat pumps. Two of these rooftop units simply provide ventilation air to the heat pumps serving the classrooms, library, and office area. When any of these zones are in an occupied mode, the rooftop units will energize and operate to provide tempered ventilation air as required. This requirement is determined by a static pressure sensor installed in the ductwork which will increase the variable frequency drive supply and return fans' speed when the static pressure in the duct decreases or it will decrease the fans' speed if the static pressure increases. The remaining four rooftop units provide air to large spaces and use a demand controlled ventilation sequence which is dictated by CO_2 sensor in the space. This sensor measures the differential CO_2 level between the outdoor and indoor environments. If this differential rises above 700 ppm, then the outdoor air damper will modulate open as needed to maintain a differential below 700 ppm. As the differential CO_2 level drops below 700 ppm the outdoor air damper will close. As an energy saving feature, the enthalpy economizer controls are able to override the demand controlled ventilation controls if economizer cooling is available.

5.5 Airstream Surfaces
The specifications for basic mechanical requirements state that all product materials must be UL listed and the duct specifications require that all ductwork fabrication and support must be in accordance with

SMACNA HVAC Duct Construction Standards. These standards state that a minimum resistance to mold growth and erosion must be met, satisfying this section.

5.6 Outdoor Air Intakes

All air intakes are located either in the mechanical mezzanine or on the roof and abide by the minimum separation distance. Both the wall louvers and mechanically operated dampers comply with AMCA 500. The wall louvers also have bird screens conforming to this section. This is all the information pertaining to this section available at this time.

5.7 Local Capture of Contaminants

Any equipment that produces building contaminants is equipped with an exhaust fan which routes the exhaust direct out of the building through the roof.

5.8 Combustion Air

All combustion equipment is provided with sufficient combustion air and is adequately exhausted. Specifically, the natural gas fired emergency generator was provided with a wall louver by the general contractor and it is specified that it was to be provided with a Schedule 40 black steel pipe exhaust.

5.9 Particulate Matter Removal

The rooftop heat pumps have pleated air filters with an atmospheric efficiency between 25% and 30% located upstream of their cooling coils. This is equivalent to a MERV 6 or MERV 7 filter and is therefore in compliance.

5.10 Dehumidification

The heat pumps are equipped with humidity sensors that maintain a relative humidity within the space at 60% or less. Additionally, a pressure sensor ensures that the room pressure remains at +0.05 in wg relative to the outdoor pressure in order to prevent infiltration.

5.11 Drain Pans

It is specified that all rooftop heat pumps be constructed of 20-guage stainless steel, sloped, and positioned under the evaporator coil and meet all requirements of ASHRAE 62.1.

5.12 Finned-Tube Coils and Heat Exchangers

Drain pans have been provided as necessary and in compliance with 5.11 and there are no finned-tube coils in series.

5.13 Humidifiers and Water-Spray Systems

No humidifiers or water-spray systems are used in the building so this section is not applicable.

5.14 Access for Inspection, Cleaning, and Maintenance

Appropriate clearances to allow unobstructed access to all equipment doors and panels as indicated in this section have been specified for the purposes of inspection, cleaning, and maintenance.

5.15 Building Envelope and Interior Surfaces

In order to prevent moisture penetration of the foundation, both a modified bituminous membrane sheet waterproofing and cold towel-applied asphalt bituminous dampproofing were used. A vapor barrier below the slab on grade is also provided. Within the exterior wall assembly there is 1 ½ inch rigid insulation board applied to the block in full bed mastic which acts as the vapor barrier. All exterior and interior joints and openings have been specified to be sealed or caulked.

All duct and pipe surfaces within the building that may fall to a temperature capable of producing condensation on their surface have been properly insulated in order to prevent moisture collection both on the exposed surface and within the insulating material.

5.16 Buildings with Attached Parking Garages

This section is not applicable as there is no parking garage attached to Bentworth Middle School.

5.17 Air Classification and Recirculation

All building air has a Class 1 designation which allows it to be recirculated or transferred to any space. The only exception to this would be the kitchen air, which is simply exhausted to the exterior of the building through the kitchen hood.

5.18 Requirements for Buildings Containing ETS Areas and ETS-Free Areas

The property on which Bentworth Middle School is located is designated a tobacco free zone. Therefore, this section does not apply.

Section 6 Compliance – Procedures

Summary of Section 6

The purpose of ASHRAE Standard 62.1 Section 6 is to outline the proper procedure for calculating the outdoor air intake rates based on "space type/application, occupancy level, and floor area." This calculation procedure is very stringent and involves many considerations and equations. Therefore, the procedure for the calculations for Bentworth Middle School are outlined on the next page.

Breathing Zone Outdoor Airflow

$V_{bz} = R_p * P_z + R_a * A_z$ (Equation 6-1)

where: $A_z =$ *zone floor area:* the net occupiable floor area of the zone (ft^2)

$P_z =$ *zone population:* the largest number of people expected to occupy the zone during typical usage. If the number of people expected to occupy the zone fluctuate, P_z may be estimated bases on averaging approaches described in Section 6.2.6.2. If P_z cannot be accurately predicted during design, it shall be an estimated value based on the zone floor area and the default occupant density listed in Table 6-1.

$R_p =$ outdoor airflow rate required per person as determined from Table 6-1

$R_a =$ outdoor airflow rate required per unit area as determined from Table 6-1

Zone Air Distribution Effectiveness

$E_z = 1$ as determined by Table 6-2 of ASHRAE Standard 62.1

Zone Outdoor Airflow

$V_{oz} = V_{bz} / E_z$ (Equation 6-2)

Single-Zone Systems

$V_{ot} = V_{oz}$ (Equation 6-3)

100% Outdoor Air Systems

$V_{ot} = \sum_{\text{all zones}} V_{oz}$ (Equation 6-4)

Primary Outdoor Air Fraction

$Z_p = V_{oz} / V_{pz}$ (Equation 6-5)

System Ventilation Efficiency

E_v shall be determined using Table 6-3 of ASHRAE Standard 62.1 which is shown on the next page.

Uncorrected Outdoor Air Intake

$V_{ou} = D\sum_{\text{all zones}}(R_p * P_z) + \sum_{\text{all zones}}(R_a * A_z)$ (Equation 6-6)

where: $D =$ $P_s / \sum_{\text{all zones}} P_z$ (Equation 6-7)

$P_s =$ *system population:* is the total population in the area served by the system

Outdoor Air Intake

$V_{ot} = V_{ou} / E_v$

TABLE 6-3   System Ventilation Efficiency

Max (Z_P)	E_v
≤0.15	1.0
≤0.25	0.9
≤0.35	0.8
≤0.45	0.7
≤0.55	0.6
>0.55	Use Appendix A

1. "Max Z_p" refers to the largest value of Z_p, calculated using Equation 6-5, among all the zones served by the system.
2. For values of Z_p between 0.15 and 0.55, one may determine the corresponding value of E_v by interpolating the values in the table.
3. The values of E_v in this table are based on a 0.15 average outdoor air fraction for the system (i.e., the ratio of the *uncorrected outdoor air intake* V_{ou} to the total *zone primary airflow* for all the zones served by the air handler). For systems with higher values of the average outdoor air fraction, this table may result in unrealistically low values of E_v and the use of Appendix A may yield more practical results.

Seven units provide ventilation air to Bentworth Middle School including six rooftop heat pump units and one energy recovery ventilator (ERV). However, for this analysis only five of the rooftop heat pump units were seen as critical pieces of ventilation equipment and therefore were considered to evaluate the building's compliance with Section 6. The ERV was not considered because it only provides a small amount of outdoor air (1300 cfm) to the locker room areas and ASHRAE Standard 62.1 does not specifically outline ventilation rates for this type of space. Rooftop heat pump B5 was also not considered because it only provides make-up air for the kitchen hood and does not actually ventilate the space.

Section 6 Compliance Results
An Excel spreadsheet was used to determine whether or not Bentworth Middle School's ventilation rates met ASHRAE's Standard 62.1 Section 6 expectations. This Excel spreadsheet uses the equations outlined above and user input values for a space's square footage, room occupancy type, and supply air. The complete results of these calculations are located in Appendix A, but below is a table summarizing the building's compliance.

As can be seen on the next page, not all of the rooftop heat pumps meet the ventilation requirements of the zones that they are supplying. It is worrisome that RTHP-A1 seems to be grossly undersized, but there could be reasons behind this and there is only a small discrepancy between the design and required outdoor air values for RTHP-B3 so this is not very bothersome as the unit should still be able to do its job.

Table 1 – Summary of Ventilation Rate Calculations

RTHP	Design Max CFM	Design OA CFM	ASHRAE 62.1 Min OA	Compliance?
A1	11,500	11,500	18,487	No
B1	3,500	3,500	3,175	Yes
B2	6,000	4,110	3,538	Yes
B3	2,100	1,110	1,176	No
B4	10,000	8,000	4,791	Yes

ASHRAE 62.1-2007 Summary

The design of Bentworth Middle School is completely compliant with Section 5 of ASHRAE 62.1 but one of the rooftop heat pumps appears to not meet its peak ventilation requirements as outlined by Section 6. This is troubling, further investigation will have to be done to see why this is. Perhaps, it is because it is unlikely that all of the spaces served by RTHP-A1 with require peak ventilation at the same time and that the average number of people that ASHRAE assumes to be the space is larger than what the building spaces were actually designed for.

ASHRAE Standard 90.1-2007 Evaluation

Section 5 Building Envelope

5.1.4 Climate

Using Figure B-1 from ASHRAE 90.1, shown below, it was determined that Bentworth Middle School, located in Bentleyville, PA, is in climate Zone 5A.
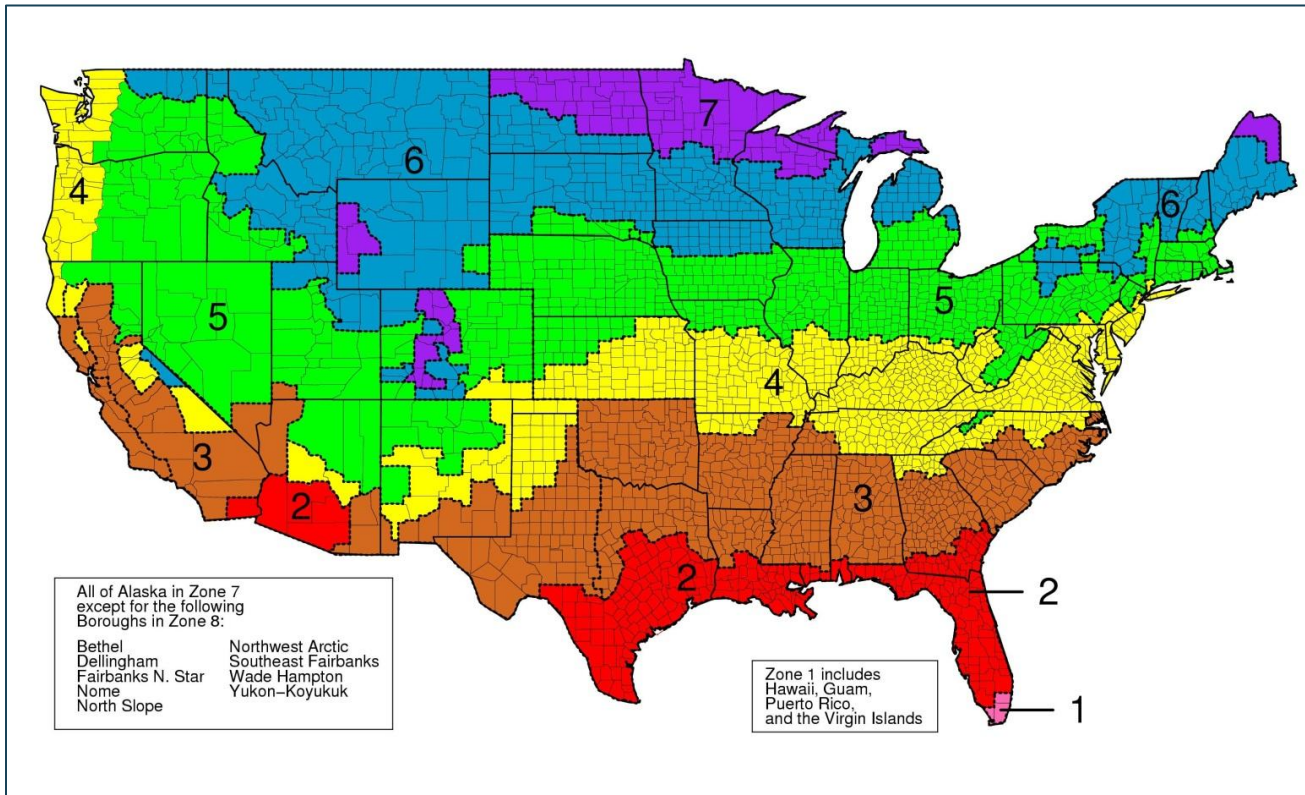
Figure B-1

5.4 Mandatory Provisions

The building is specified to have all joints, seams, fenestrations, and all other openings sealed or caulked. The main entrance to the building has a vestibule where the exterior and interior doors are separated by a distance of 20 feet. This distance is greater than the 7 foot minimum requirement. Bentworth Middle School has no cargo or loading dock doors.

5.5 Prescriptive Building Envelope Option

There are two ways to achieve compliance for the building envelope. The prescriptive path option was chosen over the trade-off path for this analysis. The two primary parameters that must be followed for this path are meeting the minimum building envelope requirements and having no more than the allowable 40% fenestration area. Both of these requirements were met. A summary of the necessary calculations needed to reach this conclusion are below in Table 2 and Table 3.

Table 2 – Minimum Building Envelope Requirements

Area	Construction Method	Prescribed Nonresidential		Designed Assemblies		Compliance?
		Assembly Maximum	Insulation Minimum	Assembly Maximum	Insulation Minimum	
Roof	Attic	U-0.027	R-38.0	U-0.025	R-40	Yes
Walls Above Grade	Mass	U-0.090	R-11.4	0.076	R-13.2	Yes
Walls Below Grade	Below-Grade Wall	C-0.119	R-7.5	C-0.121	R-8.3	Yes
Floors	Mass	U-0.074	R-10.4	U-0.45	R-2.2	No
Slab on Grade Floors	Unheated	F-0.730	NR	F-0.721	NR	Yes
Fenestration	Metal Framing (storefront)	U-0.45	SHGC-0.40	U-0.42	SHGC-0.36	Yes
	Metal Framing (all other)	U-0.55	SHGC-0.40	U-0.51	SHGC-0.34	Yes

Table 3 – Building Fenestration Percentage Calculation

Fenestration Area	Wall Area	Percent Fenestration	Compliance?
5,800 ft^2	35,080 ft^2	16.5%	Yes

Section 6 Heating, Ventilating, and Air Conditioning

6.2 Compliance Path

There are two compliance paths that may be followed. For this analysis the Mandatory Provisions path shall be used as Bentworth Middle School is more than two stories and over 25,000 ft^2.

6.4 Mandatory Provisions

The primary mechanical equipment used in Bentworth Middle School is heat pumps, which are governed by this section. Although COP's and EER's were given for the heat pumps, without having the manufacturer information for these pieces of equipment it is hard to differentiate whether they satisfy this section or not. Table 6.8.1B of ASHRAE 90.1 mandates that all ground source heat pumps in cooling mode with an entering water temperature of 59 ℉ have an EER of 16.2 and while in heating mode with an entering water temperature of 32 ℉ have COP of 3.1. Bentworth Middle School's design is based on entering water temperatures of 75 ℉ and 42 ℉ for cooling and heating respectively. Nonetheless, at the design temperatures most of the given COP's for each of the heat pumps meet the set standard of 3.1, while very few of the heat pumps achieved an EER of 16.2.

Bentworth Middle School's rooftop heat pumps would be considered packaged terminal heat pump units which are also regulated by this section. Table 6.8.1D requires that these units have a minimum EER of 9.1. Unfortunately, the EER's for these units are unavailable at this time.
It is specified that there be a 5 ℉ dead band as well as the appropriate amount of insulation be applied to all ductwork, plenums, and piping. The motorized dampers for all vents and air intakes have the appropriate controls as outlined in this section.

6.5 Prescriptive Path

Economizers are required on cooling equipment over 135,000 Btu/h in climate zone 5A. However, there are no economizers on the rooftop heat pumps which are over the specified cooling rate, but there are water economizers on the heat pumps serving the classroom spaces despite them being under the specified cooling rate.

All rooftop heat pumps are equipped with an enthalpy wheel for energy recovery from exhausted air. This is in compliance with this section of ASHRAE 90.1. It is also specified that all heat pumps have the capability to switch off their compressor should the refrigerant pressure drop below a safe operating point.

Table 4, below, shows how Bentworth Middle School meets ASHRAE 90.1's *Fan System Power Limitation*. Six out of the 13 analyzed fans do not comply with this section of ASHRAE's 90.1.

Table 4 – Fan System Power Limitation Calculations

Equipment	HP	CFM	CFM*0.0011	Compliance?
RTHP-A1 Supply	15	11,500	12.56	No
RTHP-A1 Exhaust	15	11,500	12.56	No
RTHP-B1 Supply	3	3,500	3.85	Yes
RTHP-B1 Exhaust	3	3,500	3.85	Yes
RTHP-B2 Supply	5	6,000	6.60	Yes
RTHP-B2 Exhaust	5	6,000	6.60	Yes
RTHP-B3 Supply	5	2,100	2.31	No
RTHP-B3 Exhaust	3	2,100	2.31	No
RTHP-B4 Supply	15	10,000	11.00	No
RTHP-B4 Exhaust	10	10,000	11.00	Yes
RTHP-B5 Supply	15	4,270	4.70	No
EF-A1	1.5	3,800	4.18	Yes
EF-B3	3	4,500	4.95	Yes

6.7 Submittals

All building drawings and manuals were provided to the building owner within the required 90 days and it is specified that all HVAC systems were to be balanced.

Section 7 Service Water Heating

Four gas-fired storage water heaters provide domestic hot water to Bentworth Middle School. Each of the water heaters has an efficiency of 90% or more which exceeds this section's minimum requirement of an efficiency of 80%. The water heaters are also equipped with a thermostat with adjustable temperature range from 110 ℉ to 180 ℉. The service hot-water piping is specified to be insulated with a minimum of one inch of insulation which is the same amount that is required by this section.

Section 8 Power

No information pertaining to the maximum voltage drop for the feeders or branch circuits is available at this time. All design documents were submitted to the building owner within the specified amount of time in this section.

Section 9 Lighting

This section outlines the requirement for both interior and exterior lighting. There are two separate ways in which the interior lighting system can achieve compliance through lighting power density. In this analysis, the building area method is used opposed to the space-by-space method. Table 5, on the next page, shows that the Bentworth Middle School has a lighting power density of 1.11 W/ft^2 which is in compliance as schools must have a lighting power density equal to or less than 1.2 W/ft^2. Let it also be known that most of the spaces are controlled with both a wall switch and occupancy sensor.

ASHRAE Standard 90.1-2007 Summary

Bentworth Middle School was largely compliant with ASHRAE Standard 90.1. The areas in which it did not meet the requirements of the standard were in fan power limitation and the overall U-value for the floors. Although it is obvious that the building designers were designing in an environmentally conscientious fashion, they were not trying to acquire any building accolades such as a LEED certification. Therefore, ASHRAE Standard 90.1 may have been overlooked during the design process, but with a few changes to the building's structural system and mechanical equipment, complete compliance should be easily attainable. Nonetheless, Bentworth Middle School's near compliance with ASHRAE Standard 90.1 further exemplifies the school as not only a great learning and working environment, but also as an energy efficient building.

Table 5 – Lighting Power Density Calculation

Fixture	Floor 1st	2nd	3rd	Watts/Fixture	Total Watts
A/70	0	8	0	70	560
A/100	0	5	0	100	500
B/70	11	14	11	70	2520
B/100	0	13	0	100	1300
B/140	0	1	0	140	140
C/70	27	68	13	70	7560
C/100	0	0	113	100	11300
D/70	0	5	0	70	350
E/70	0	45	0	70	3150
E/100	118	124	0	100	24200
G/35	2	4	2	35	280
G70	0	1	0	70	70
H/40	52	97	52	40	8040
H/70	4	4	4	70	840
I/70	31	12	7	70	3500
I/100	3	0	0	100	300
I/140	0	16	0	140	2240
J/375	0	8	0	375	3000
K/70	2	4	2	70	560
L/500	0	1	0	500	500
M/70	0	12	4	70	1120
M/105	0	46	4	105	5250
O/360	0	29	0	360	10440
P/70	0	26	0	70	1820
P/100	0	22	0	100	2200
Q/48	1	0	0	48	48
R/70	0	8	0	70	560
R/35	0	4	0	35	140
S/40	2	2	2	40	240
U/15	0	6	0	15	90
AA/50	0	1	0	50	50
Total Building Watts					92868
Building Square Footage					83800
Lighting Power Density					1.11

References

ANSI/ASHRAE. (2007). *Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality.* Atlanta, GA: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

ANSI/ASHRAE. (2007). *Standard 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential Buildings.* Atlanta, GA: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

Hayes Large Architects, LLP. Architectural Construction Documents. Hayes Large Architects, LLP., Altoona, PA.

Hayes Large Architects, LLP. Mechanical Construction Documents. Hayes Large Architects, LLP., Altoona, PA.

Hayes Large Architects, LLP. Electrical Construction Documents. Hayes Large Architects, LLP., Altoona, PA.

Hayes Large Architects, LLP. Architectural Specifications. Hayes Large Architects, LLP., Altoona, PA.

Hayes Large Architects, LLP. Mechanical Specifications. Hayes Large Architects, LLP., Altoona, PA.

Hayes Large Architects, LLP. Electrical Specifications. Hayes Large Architects, LLP., Altoona, PA.

Appendix A – Ventilation Load Calculations

Building: Bentworth Middle School
System Tag/Name: RTHP-A1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

	Name	Units	System		Science Classroom A103 Classrooms (age 9 plus)	Corridor A102 Corridors	Classroom A104 Classrooms (age 9 plus)	Classroom A105 Classrooms (age 9 plus)	Classroom A106 Classrooms (age 9 plus)
Inputs for System									
Floor area served by system	As	sf	33341						
Population of area served by system (including diversity)	Ps	P	872	100% diversity					
Design primary supply fan airflow rate	Vpsd	cfm	34,280						
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.11						
OA req'd per person for system area (Weighted average)	Rps	cfm/p	9.4						
Inputs for Potentially Critical zones									
Floor Area of Zone	Az	sf			883	780	766	766	766
Design population of zone	Pz	P			30.905	0	26.81	26.81	26.81
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			1.200	360	800	800	800
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?	Er								
Inputs for Operating Condition Analyzed									
Percent of total design airflow rate at conditioned analyzed	Ds	%	100%		100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed					CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00
Results									
Ventilation System Efficiency	Ev		0.83						
Outdoor air intake required for system	Vot	cfm	14184						
Outdoor air per unit floor area	Vot/As	cfm/sf	0.43						
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	16.3						
Outdoor air as a % of design primary supply air	Ypd	cfm	41%						
Detailed Calculations									
Initial Calculations for the System as a whole									
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	34280				
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	11752				
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.34				
Initial Calculations for individual zones									
OA rate per unit area for zone	Raz	cfm/sf			0.12	0.06	0.12	0.12	0.12
OA rate per person	Rpz	cfm/p			10.00	0.00	10.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			1200	360	800	800	800
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=	415.0	46.8	360.0	360.0	360.0
Unused OA requirement for zone	Voz		= Vbz/Ez	=	415	47	360	360	360
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	=	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	=	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	=	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	=	0.35	0.13	0.45	0.45	0.45
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	=	0.35	0.13	0.45	0.45	0.45
System Ventilation Efficiency									
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	=	1.00	1.21	0.89	0.89	0.89
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	= 0.83					
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	= 0.64					
Minimum outdoor air intake airflow									
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	= 14184					
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	= 0.41					
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	= 18487					
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	= 0.54					
OA Temp at which Min OA provides all cooling									
OAT below which Min OA intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTrf)	= 31					

Zone title turns purple italic for critical zone(s)

Building: Bentworth Middle School
System Tag/Name: RTHP-A1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units		System
Floor area served by system	As	sf		33341
Population of area served by system (including diversity)	Ps	P	100% diversity	872
Design primary supply fan airflow rate	Vpsd	cfm		34,280
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.11
OA req'd per person for system area (Weighted average)	Rps	cfm/p		9.4

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

			Learning Support	Computer Lab	IPC	Work Room	Corridor
Zone Name							
Zone Tag			A107	A109	A114	A117	A127
Space type		Select from pull-down list	Classrooms (age 9 plus)	Computer lab	Office space	Office space	Corridors
Floor Area of zone	Az	sf	766	820	433	155	780
Design population of zone	Pz	P (default value listed; may be overridden)	26.81	20.5	4	0.775	0
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm	800	1020	580	100	360
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					
Local recirc. air % representative of ave system return air	Er						

Inputs for Operating Condition Analyzed

Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez		1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep						

Results

Ventilation System Efficiency	Ev		0.83
Outdoor air intake required for system	Vot	cfm	14184
Outdoor air per unit floor area	Vot/As	cfm/sf	0.43
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	16.3
Outdoor air as a % of design primary supply air	Ypd	cfm	41%

Detailed Calculations

Initial Calculations for the System as a whole

Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	34280
Uncorrected OA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	11752
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.34

Initial Calculations for individual zones

				Learning Support	Computer Lab	IPC	Work Room	Corridor
OA rate per unit area for zone	Raz	cfm/sf		0.12	0.12	0.06	0.06	0.06
OA rate per person	Rpz	cfm/p		10.00	10.00	5.00	5.00	0.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm		800	1020	580	100	360
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	360.0	303.4	46.0	13.2	46.8
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	360	303	46	13	47
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	0.45	0.30	0.08	0.13	0.13
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	0.45	0.30	0.08	0.13	0.13

System Ventilation Efficiency

				Learning Support	Computer Lab	IPC	Work Room	Corridor
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	0.89	1.05	1.26	1.21	1.21
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =		0.83			
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =		0.64			

Minimum outdoor air intake airflow

Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	=	14184
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	0.41
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	=	18487
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	=	0.54

OA Temp at which Min OA provides all cooling

OAT below which OA intake flow is @ minimum		Deg F	= ((Tp-dTsf)-(1-Y)*(Tr+dTrf))	=	31

Building: Bentworth Middle School
System Tag/Name: RTHP-A1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units	System
Floor area served by system	As	sf	33341
Population of area served by system (including diversity)	Ps	P	872
Design primary supply fan airflow rate	Vpsd	cfm	34.280
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.11
OA req'd per person for system area (Weighted average)	Rps	cfm/p	9.4

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

Zone Name		Classroom	*Classroom*	Classroom	Science Classroom	Classroom
Zone Tag		A118	A124	A123	A126	A125
Space type		Classrooms (age 9 plus)	Classrooms (age 9 plus)	Classrooms (age 9 plus)	Classrooms (age 9 plus)	Classrooms (age 9 plus)
Floor Area of zone	Az	sf	766	766	766	883	766
Design population of zone	Pz	P	26.81	26.81	26.81	30.905	26.81
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm	800	700	800	1060	700
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A				
Local recirc. air % representative of ave system return air	Er						

Inputs for Operating Condition Analyzed

Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed			CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez		1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep						

Results

			System				
Ventilation System Efficiency	Ev		0.83				
Outdoor air intake required for system	Vot	cfm	14184				
Outdoor air per unit floor area	Vot/As	cfm/sf	0.43				
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	16.3				
Outdoor air as a % of design primary supply air	Ypd	cfm	41%				

Detailed Calculations

Initial Calculations for the System as a whole

Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	VpdDs	34280
Uncorrected OA requirement for system	Vou	cfm	=	Rps Ps + Ras As	11752
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	0.34

Initial Calculations for individual zones

					A118	A124	A123	A126	A125
OA rate per unit area for zone	Raz	cfm/sf			0.12	0.12	0.12	0.12	0.12
OA rate per person	Rpz	cfm/p			10.00	10.00	10.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			800	700	800	1060	700
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	360.0	360.0	360.0	415.0	360.0
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	360	360	360	415	360
Fraction of zone supply air to zone (primary plus diversity)	Fa		=	Ep + (1-Ep)Er	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply not directly recirc. from zone	Fb		=	Ep	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		=	Voz / Vdz	0.45	0.51	0.45	0.39	0.51
Unused OA fraction required in primary air to zone	Zp		=	Voz / Vpz	0.45	0.51	0.45	0.39	0.51

System Ventilation Efficiency

						A118	A124	A123	A126	A125
Zone Ventilation Efficiency (App A Method)	Evz		=	(Fa + FbXs - FcZ) / Fa		0.83	0.83	0.89	0.95	0.83
System Ventilation Efficiency (App A Method)	Ev		=	min (Evz)	0.83					
Ventilation System Efficiency (Table 6.3 Method)	Ev		=	Value from Table 6.3	0.64					

Minimum outdoor air intake airflow

Outdoor Air Intake Flow required to System	Vot	cfm	=	Vou / Ev	14184
OA intake req'd as a fraction of primary SA	Y		=	Vot / Vps	0.41
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	=	Vou / Ev	18487
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		=	Vot / Vps	0.54

OA Temp at which Min OA provides all cooling

OAT below which OA intake flow is @ minimum		Deg F	=	{(Tp-dTsf)-(1-Y)*(Tr+dTrf)	31

Building: Bentworth Middle School
System Tag/Name: RTHP-A1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units	System
Floor area served by system	As	sf	33341
Population of area served by system (including diversity)	Ps	P	872
Design primary supply fan airflow rate	Vpsd	cfm	34,280
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.11
OA req'd per person for system area (Weighted average)	Rps	cfm/p	9.4

(100% diversity)

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

			Storage	Corridor	Art CR	Art Storage	Kiln
Zone Name			Storage	Corridor	Art CR	Art Storage	Kiln
Zone Tag			A126A	A202	A203	A203A	A203B
Space type			Storage rooms	Corridors	Art classroom	Storage rooms	Storage rooms
Floor Area of zone	Az	sf	220	780	900	175	70
Design population of zone	Pz	P	0	0	18	0	0
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm	140	360	1040	120	220

Select from pull-down list (default value listed : may be overridden)
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan? — Select from pull-down list or leave blank if N/A
Local recirc. air % representative of ave system return air — Er

Inputs for Operating Condition Analyzed

Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed			CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez		1.00	1.00	1.00	1.00	1.00

Primary air fraction of supply air at conditioned analyzed — Ep

Results

	Name	Units	System
Ventilation System Efficiency	Ev		0.83
Outdoor air intake required for system	Vot	cfm	14184
Outdoor air per unit floor area	Vot/As	cfm/sf	0.43
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	16.3
Outdoor air as a % of design primary supply air	Ypd	cfm	41%

Detailed Calculations

Initial Calculations for the System as a whole

		Units			System
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	$VpdDs$	34280
Uncorrected OA requirement for system	Vou	cfm	=	$Rps\,Ps + Ras\,As$	11752
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	0.34

Initial Calculations for individual zones

		Units			A126A	A202	A203	A203A	A203B
OA rate per unit area for zone	Raz	cfm/sf			0.12	0.06	0.18	0.12	0.12
OA rate per person	Rpz	cfm/p			0.00	0.00	10.00	0.00	0.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			140	360	1040	120	220
Unused OA req'd to breathing zone	Vbz	cfm	=	$Rpz\,Pz + Raz\,Az$	26.4	46.8	342.0	21.0	8.4
Unused OA requirement for zone	Voz		=	Vbz/Ez	26	47	342	21	8
Fraction of zone supply not directly recirc. from zone	Fa		=	$Ep + (1-Ep)Er$	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		=	Ep	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		=	$1-(1-Ez)(1-Ep)(1-Er)$	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA required in supply air to zone	Zd		=	Voz / Vdz	0.19	0.13	0.33	0.18	0.04
Unused OA fraction required in primary air to zone	Zp		=	Voz / Vpz	0.19	0.13	0.33	0.18	0.04

System Ventilation Efficiency

		Units			System
Zone Ventilation Efficiency (App A Method)	Evz		=	$(Fa + FbXs - FcZ) / Fa$	1.15 / 1.21 / 1.01 / 1.17 / 1.30
System Ventilation Efficiency (App A Method)	Ev		=	$\min(Evz)$	0.83
Ventilation System Efficiency (Table 6.3 Method)	Ev		=	Value from Table 6.3	0.64

Minimum outdoor air intake airflow

		Units			System
Outdoor Air Intake Flow required to System	Vot	cfm	=	Vou / Ev	14184
Outdoor air intake req'd as a fraction of primary SA	Y		=	Vot / Vps	0.41
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	=	Vou / Ev	18487
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		=	Vot / Vps	0.54

OA Temp at which Min OA provides all cooling

		Units			System
OAT below which OA Intake flow is @ minimum		Deg F	=	$((Tp-dTsf)-(1-Y)*(Tr+dTrf))$	31

Building: Bentworth Middle School
System Tag/Name: RTHP-A1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units	System
Floor area served by system	As	sf	33341
Population of area served by system (including diversity)	Ps	P	872
Design primary supply fan airflow rate	Vpsd	cfm	34,280
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.11
OA req'd per person for system area (Weighted average)	Rps	cfm/p	9.4

100% diversity

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

			Seminar	Seminar	Gifted	Seminar	Office
Zone Name			A204	A205	A206	A208	A233
Zone Tag			Conference/meeting	Conference/meeting	Classrooms (age 9 plus)	Conference/meeting	Office space
Space Type		Select from pull-down list					
Floor Area of zone	Az	sf	756	756	768	375	125
Design population of zone	Pz	P	37.8	37.8	26.53	18.75	0.625
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm	800	800	800	425	100
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					
Local recirc. air % representative of ave system return air	Er						

Inputs for Operating Condition Analyzed

				A204	A205	A206	A208	A233
Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list		CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez			1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep							

Results

Ventilation System Efficiency	Ev	cfm	0.83
Outdoor air intake required for system	Vot	cfm	14184
Outdoor air per unit floor area	Vot/As	cfm/sf	0.43
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	16.3
Outdoor air as a % of design primary supply air	Ypd	cfm/p	41%

Detailed Calculations

Initial Calculations for the System as a whole

Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	= 34280
Uncorrected OA requirement for system	Vou	cfm	= Rps Ps + Ras As	= 11752
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	= 0.34

Initial Calculations for individual zones

			Equation	A204	A205	A206	A208	A233
OA rate per unit area for zone	Raz	cfm/sf		0.06	0.06	0.12	0.06	0.06
OA rate per person	Rpz	cfm/p		5.00	5.00	10.00	5.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm		800	800	800	425	100
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	234.4	234.4	356.3	116.3	10.6
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	234	234	356	116	11
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	0.29	0.29	0.45	0.27	0.11
Unused OA fraction required in primary air to zone	Zp		= Voz / Vps	0.29	0.29	0.45	0.27	0.11

System Ventilation Efficiency

				A204	A205	A206	A208	A233
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	1.05	1.05	0.90	1.07	1.24
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	0.83				
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	0.64				

Minimum outdoor air intake airflow

Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	= 14184
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	= 0.41
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	= 18487
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	= 0.54

OA Temp at which Min OA provides all cooling

OAT below which OA intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)(Tr+dTrf)	= 31

Building: Bentworth Middle School
System Tag/Name: RTHP-A1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units	System
Floor area served by system	As	sf	33341
Population of area served by system (including diversity)	Ps	P	872
Design primary supply fan airflow rate	Vpsd	cfm	34.280
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.11
OA req'd per person for system area (Weighted average)	Rps	cfm/p	9.4

100% diversity

Inputs for Potentially Critical Zones

Zone title turns purple italic for critical zone(s)

			Potentially Critical Zones				
			Work Room	AV Room	Computer Lab	IPC	Work Room
Zone Name							
Zone Tag			A212	A211	A213	A215	A218
Space type		Select from pull-down list	Office space	Storage rooms	Computer lab	Office space	Office space
Floor Area of zone	Az	sf	150	220	827	435	155
Design population of zone	Pz	P	0.75	0	20.675	4	0.775
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm	150	225	1020	680	100
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					
Local recirc. air % representative of ave system return air	Er						

Inputs for Operating Condition Analyzed

Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez		1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep						

100% (header row)

Results

Ventilation System Efficiency	Ev		0.83
Outdoor air intake required for system	Vot	cfm	14184
Outdoor air per unit floor area	Vot/As	cfm/sf	0.43
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	16.3
Outdoor air as a % of design primary supply air	Ypd		41%

Detailed Calculations

Initial Calculations for the System as a whole

Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	VpdDs	34280
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	11752
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	0.34

Initial Calculations for individual zones

					A212	A211	A213	A215	A218
OA rate per unit area for zone	Raz	cfm/sf			0.06	0.12	0.12	0.06	0.06
OA rate per person	Rpz	cfm/p			5.00	0.00	10.00	5.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	VpdDs	150	225	1020	680	100
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	12.8	26.4	306.0	46.1	13.2
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	13	26	306	46	13
Fraction of zone supply not directly recirc. from zone	Fa		=	Ep	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		=	Ep + (1-Ep)Er	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		=	Voz /Vdz	0.09	0.12	0.30	0.07	0.07
Unused OA fraction required in primary air to zone	Zp		=	Voz /Vpz	0.09	0.12	0.30	0.07	0.07

System Ventilation Efficiency

					A212	A211	A213	A215	A218
Zone Ventilation Efficiency (App A Method)	Evz		=	(Fa + FbXs - FcZ) / Fa	1.26	1.23	1.04	1.28	1.21
System Ventilation Efficiency (App A Method)	Ev		=	min (Evz)	0.83				
Ventilation System Efficiency (Table 6.3 Method)	Ev		=	Value from Table 6.3	0.64				

Minimum outdoor air intake airflow

Outdoor Air Intake Flow required to System	Vot	cfm	=	Vou / Ev	14184
OA intake req'd as a fraction of primary SA	Y		=	Vot / Vps	0.41
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	=	Vou / Ev	18487
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		=	Vot / Vps	0.54

OA Temp at which Min OA provides all cooling

OAT below which Min OA intake flow is @ minimum		Deg F	=	{(Tp-dTsf)-(1-Y)`(Tr+dTrf)}	31

(default value listed; may be overridden)
Select from pull-down list

Building: Bentworth Middle School
System Tag/Name: RTHP-A1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units	System
Floor area served by system	As	sf	33341
Population of area served by system (including diversity)	Ps	P	872
Design primary supply fan airflow rate	Vpsd	cfm	34,280
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.11
OA req'd per person for system area (Weighted average)	Rps	cfm/p	9.4

diversity: 100%

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

		A219 Emotional Support Classrooms (age 9 plus)	A227 Corridor Corridors	A224 CAD Computer lab	A225 Consumer ScienceClassroom Classrooms (age 9 plus)	A226 Construction Wood/metal shop
Floor Area of zone	Az (sf)	766	780	766	1190	766
Design population of zone	Pz (P)	26.81	0	19.15	41.65	15.32
Design total supply to zone (primary plus local recirculated)	Vdzd (cfm)	800	360	1020	1600	1490
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?						
Local recirc. air % representative of ave system return air	Er					

Inputs for Operating Condition Analyzed

		100%	A219	A227	A224	A225	A226
Percent of total design airflow rate at conditioned analyzed	Ds (%)	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed			CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez		1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep						

Results

Ventilation System Efficiency	Ev	0.83
Outdoor air intake required for system	Vot (cfm)	14184
Outdoor air per unit floor area	Vot/As (cfm/sf)	0.43
Outdoor air per person served by system (including diversity)	Vot/Ps (cfm/p)	16.3
Outdoor air as a % of design primary supply air	Ypd (cfm)	41%

Detailed Calculations

Initial Calculations for the System as a whole

Primary supply air flow to system at conditioned analyzed	Vps	$=$ VpdDs	34280
Uncorrected OA requirement for system	Vou	$=$ Rps Ps + Ras As	11752
Uncorrected OA req'd as a fraction of primary SA	Xs	$=$ Vou / Vps	0.34

Initial Calculations for individual zones

		Equation	A219	A227	A224	A225	A226
OA rate per unit area for zone	Raz (cfm/sf)		0.12	0.06	0.12	0.12	0.18
OA rate per person	Rpz (cfm/p)		10.00	0.00	10.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz (cfm)		800	360	1020	1600	1490
Unused OA req'd to breathing zone	Vbz (cfm)	$=$ Rpz Pz + Raz Az	360.0	46.8	283.4	559.3	291.1
Unused OA requirement for zone	Voz (cfm)	$=$ Vbz/Ez	360	47	283	559	291
Fraction of zone supply not directly recirc. from zone	Fa	$=$ Ep + (1-Ep)Er	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb	$=$ Ep	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc	$=$ 1-(1-Ez)(1-Ep)(1-Er)	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd	$=$ Voz / Vdz	0.45	0.13	0.28	0.35	0.20
Unused OA fraction required in primary air to zone	Zp	$=$ Voz / Vpz	0.45	0.13	0.28	0.35	0.20

System Ventilation Efficiency

		Equation	A219	A227	A224	A225	A226
Zone Ventilation Efficiency (App A Method)	Evz	$=$ (Fa + FbXs - FcZ) / Fa	0.89	1.21	1.06	0.99	1.15
System Ventilation Efficiency (App A Method)	Ev	$=$ min (Evz)	0.83				
Ventilation System Efficiency (Table 6.3 Method)	Ev	$=$ Value from Table 6.3	0.64				

Minimum outdoor air intake airflow

Outdoor Air intake Flow required to System	Vot (cfm)	$=$ Vou / Ev	14184
OA intake req'd as a fraction of primary SA	Y	$=$ Vot / Vps	0.41
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot (cfm)	$=$ Vou / Ev	18487
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y	$=$ Vot / Vps	0.54

OA Temp at which Min OA provides all cooling

OAT below which OA intake flow is @ minimum	Deg F	$= \{(Tp-dTsf)-(1-Y)\cdot(Tr-dTsf)\}$	31

Building: Bentworth Middle School
System Tag/Name: RTHP-A1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units	System	
Floor area served by system	As	sf	33341	
Population of area served by system (including diversity)	Ps	P	872	100% diversity
Design primary supply fan airflow rate	Vpsd	cfm	34,280	
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.11	
OA req'd per person for system area (Weighted average)	Rps	cfm/p	9.4	

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

			Storage	Science Classroom	Storage	Corridor	Classroom
Zone Name			Storage	Science Classroom	Storage	Corridor	Classroom
Zone Tag			A226A	A303	A303A	A302	A304
Space type		Select from pull-down list	Storage rooms	Classrooms (age 9 plus)	Storage rooms	Corridors	Classrooms (age 9 plus)
Floor Area of zone	Az	sf	205	883	220	780	766
Design population of zone	Pz	P	0	30.905	0	0	26.81
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm	110	920	100	360	800
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					
Local recirc. air % representative of ave system return air	Er						

Inputs for Operating Condition Analyzed

Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez		1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep						

Results

Ventilation System Efficiency	Ev		0.83
Outdoor air intake required for system	Vot	cfm	14184
Outdoor air per unit floor area	Vot/As	cfm/sf	0.43
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	16.3
Outdoor air as a % of design primary supply air	Ypd	cfm	41%

Detailed Calculations

Initial Calculations for the System as a whole

Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	34280	
Uncorrected OA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	11752	
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.34	

Initial Calculations for individual zones

			Equation	Storage A226A	Science A303	Storage A303A	Corridor A302	Classroom A304
OA rate per unit area for zone	Raz	cfm/sf		0.12	0.12	0.12	0.06	0.12
OA rate per person	Rpz	cfm/p		0.00	10.00	0.00	0.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm		110	920	100	360	800
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	24.6	415.0	26.4	46.8	360.0
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	25	415	26	47	360
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	0.22	0.45	0.26	0.13	0.45
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	0.22	0.45	0.26	0.13	0.45

System Ventilation Efficiency

Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	1.12	0.89	1.08	1.21	0.89
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	= 0.83				
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	= 0.64				

Minimum outdoor air intake airflow

Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	=	14184
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	0.41
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	=	18487
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	=	0.54

OA Temp at which Min OA provides all cooling

OAT below which OA intake flow is @ minimum		Deg F	= ((Tp-dTsf)-(1-Y)*(Tr+dTrf)	=	31

Building: Bentworth Middle School
System Tag/Name: RTHP-A1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units	System
Floor area served by system	As	sf	33341
Population of area served by system (including diversity)	Ps	P	872
Design primary supply fan airflow rate	Vpsd	cfm	34.280
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.11
OA req'd per person for system area (Weighted average)	Rps	cfm/p	9.4

100% diversity

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

			Classroom	Classroom	Learning Support	Computer Lab	Work room
Zone Name							
Zone Tag			A305	A306	A307	A309	A317
Space type			Classrooms (age 9 plus)	Classrooms (age 9 plus)	Classrooms (age 9 plus)	Computer lab	Office space
Floor Area of zone	Az	sf	766	766	766	820	155
Design population of zone	Pz	P	26.81	26.81	26.81	20.5	0.775
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm	800	800	800	1020	100
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?							
Local recirc. air % representative of ave system return air	Er						

Inputs for Operating Condition Analyzed

Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed			CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez		1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep						

Results

Ventilation System Efficiency	Ev		0.83
Outdoor air intake required for system	Vot	cfm	14184
Outdoor air per unit floor area	Vot/As	cfm/sf	0.43
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	16.3
Outdoor air as a % of design primary supply air	Vot/Ps	cfm	41%

Detailed Calculations

Initial Calculations for the System as a whole

Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	34280
Uncorrected OA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	11752
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.34

Initial Calculations for individual zones

OA rate per unit area for zone	Raz	cfm/sf		0.12	0.12	0.12	0.12	0.06
OA rate per person	Rpz	cfm/p		10.00	10.00	10.00	10.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm		800	800	800	1020	100
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	360.0	360.0	360.0	303.4	13.2
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	360	360	360	303	13
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	0.45	0.45	0.45	0.30	0.13
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	0.45	0.45	0.45	0.30	0.13

System Ventilation Efficiency

Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	0.89	0.89	0.89	1.05	1.21
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=	0.83
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	=	0.64

Minimum outdoor air intake airflow

Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	=	14184
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	0.41
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	=	18487
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	=	0.54

OA Temp at which Min OA provides all cooling

OAT below which Min OA intake flow is @ minimum		Deg F	= ((Tp-dTsf)-(1-Y)*(Tr+dTrf)	=	31

Building: Bentworth Middle School
System Tag/Name: RTHP-A1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units	System
Floor area served by system	As	sf	33341
Population of area served by system (including diversity)	Ps	P	872
Design primary supply fan airflow rate	Vpsd	cfm	34,280
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.11
OA req'd per person for system area (Weighted average)	Rps	cfm/p	9.4

100% diversity

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

		IPC	Corridor	Learning Support	Classroom	Classroom
Zone Name						
Zone Tag		A314	A327	A318	A323	A324
Space type		Office space	Corridors	Classrooms (age 9 plus)	Classrooms (age 9 plus)	Classrooms (age 9 plus)
Floor Area of zone	Az	435	780	766	766	766
Design population of zone	Pz	4	0	26.81	26.81	26.81
Design total supply to zone (primary plus local recirculated)	Vdzd	580	360	800	800	800
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?						
Local recirc. air % representative of ave system return air	Er					

Inputs for Operating Condition Analyzed

		100%				
Percent of total design airflow rate at conditioned analyzed	Ds	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed	Ez	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ep	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed						

Results

Ventilation System Efficiency	Ev	0.83	
Outdoor air intake required for system	Vot	14184	cfm
Outdoor air per unit floor area	Vot/As	0.43	cfm/sf
Outdoor air per person served by system (including diversity)	Vot/Ps	16.3	cfm/p
Outdoor air as a % of design primary supply air	Ypd	41%	

Detailed Calculations

Initial Calculations for the System as a whole

Primary supply air flow to system at conditioned analyzed	Vps	= VpdDs	= 34280
UncorrectedOA requirement for system	Vou	= Rps Ps + Ras As	= 11752
Uncorrected OA req'd as a fraction of primary SA	Xs	= Vou / Vps	= 0.34

Initial Calculations for individual zones

			A314	A327	A318	A323	A324
OA rate per unit area for zone	Raz		0.06	0.06	0.06	0.06	0.12
OA rate per person	Rpz		5.00	0.00	10.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz		580	360	800	800	800.0
OA req'd to breathing zone	Vbz	= Rpz Pz + Raz Az	46.1	46.8	360.0	360.0	360.0
OA requirement for zone	Voz	= Vbz/Ez	46	47	360	360	360
Fraction of zone supply not directly recirc. from zone	Fa	= Ep + (1-Ep)Er	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb	= Ep	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc	= 1-(1-Ez)(1-Ep)(1-Er)	1.00	1.00	1.00	1.00	1.00
OA fraction required in supply air to zone	Zd	= Voz / Vdz	0.08	0.13	0.45	0.45	0.45
OA fraction required in primary air to zone	Zp	= Voz / Vpz	0.08	0.13	0.45	0.45	0.45

System Ventilation Efficiency

Zone Ventilation Efficiency (App A Method)	Evz	= (Fa + FbXs - FcZ) / Fa	1.26	1.21	0.89	0.89	0.89
System Ventilation Efficiency (App A Method)	Ev	= min (Evz)	0.83				
Ventilation System Efficiency (Table 6.3 Method)	Ev	= Value from Table 6.3	0.64				

Minimum outdoor air intake airflow

Outdoor Air Intake Flow required to System	Vot	= Vou / Ev	14184	cfm
OA intake req'd as a fraction of primary SA	Y	= Vot / Vps	0.41	
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	= Vou / Ev	18487	cfm
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y	= Vot / Vps	0.54	

OA Temp at which Min OA provides all cooling

OAT below which OA intake flow is @ minimum		= ((Tp-dTsf)-(1-Y)·(Tr+dTrf)	31	Deg F

Building: Bentworth Middle School
System Tag/Name: RTHP-A1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units	System
Floor area served by system	As	sf	33341
Population of area served by system (including diversity)	Ps	P	872
Design primary supply fan airflow rate	Vpsd	cfm	34,280
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.11
OA req'd per person for system area (Weighted average)	Rps	cfm/p	9.4

(100% diversity)

Inputs for Potentially Critical zones

Zone title turns purple Italic for critical zone(s)

	Name	Units	Classroom	Science Classroom	Storage
Zone Name			Classroom	Science Classroom	Storage
Zone Tag			A325	A326	A326A
Space type			Classrooms (age 9 plus)	Classrooms (age 9 plus)	Storage rooms
Floor Area of zone	Az	sf	766	883	220
Design population of zone	Pz	P	26.81	30.905	0
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm	800	1060	140
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?					
Local recirc. air % representative of ave system return air	Er				

Inputs for Operating Condition Analyzed

	Name	Units		Classroom	Science Classroom	Storage
Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100%	100%	100%
Air distribution type at conditioned analyzed				CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez			1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep					

Results

	Name	Units	System
Ventilation System Efficiency	Ev		0.83
Outdoor air intake required for system	Vot	cfm	14184
Outdoor air per unit floor area	Vot/As	cfm/sf	0.43
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	16.3
Outdoor air as a % of design primary supply air	Ypd	cfm	41%

Detailed Calculations

Initial Calculations for the System as a whole

		Units				
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	$VpdDs$	=	34280
Uncorrected OA requirement for system	Vou	cfm	=	$Rps\,Ps + Ras\,As$	=	11752
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.34

Initial Calculations for individual zones

		Units			Classroom	Science Classroom	Storage
OA rate per unit area for zone	Raz	cfm/sf			0.12	0.12	0.12
OA rate per person	Rpz	cfm/p			10.00	10.00	0.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			800.0	1060	140
Unused OA req'd to breathing zone	Vbz	cfm	=	$Rpz\,Pz + Raz\,Az$	360.0	415.0	26.4
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	360	415	26
Fraction of zone supply air not directly recirc. from zone	Fa		=	$Ep + (1-Ep)Er$	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		=	Ep	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		=	$1-(1-Ez)(1-Ep)(1-Er)$	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		=	Voz / Vdz	0.45	0.39	0.19
Unused OA fraction required in primary air to zone	Zp		=	Voz / Vpz	0.45	0.39	0.19

System Ventilation Efficiency

		Units			Classroom	Science Classroom	Storage
Zone Ventilation Efficiency (App A Method)	Evz		=	$(Fa + FbXs - FcZ) / Fa$	0.89	0.95	1.15
System Ventilation Efficiency (App A Method)	Ev		=	$\min(Evz)$	0.83		
Ventilation System Efficiency (Table 6.3 Method)	Ev		=	Value from Table 6.3	0.64		

Minimum outdoor air intake airflow

		Units			
Outdoor Air Intake Flow required to System	Vot	cfm	=	Vou / Ev	14184
OA intake req'd as fraction of primary SA	Y		=	Vot / Vps	0.41
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	=	Vou / Ev	18487
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		=	Vot / Vps	0.54

OA Temp at which Min OA provides all cooling

		Units			
OAT below which Min OA Intake flow is @ minimum		Deg F	=	$((Tp-dTsf)-(1-Y)(Tr+dTrf)$	31

Notes from input cells:
- Az — Select from pull-down list
- Pz — sf
- Vdzd — P / (default value listed; may be overridden)
- Induction Terminal... — cfm / Select from pull-down list or leave blank if N/A
- Ds — Select from pull-down list

Building: Bentworth Middle School
System Tag/Name: RTHP-B1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

Name	Units		System
Floor area served by system	As	sf	9220
Population of area served by system (including diversity)	Ps	P	172
Design primary supply fan airflow rate	Vpsd	cfm	10,110
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.08
OA req'd per person for system area (Weighted average)	Rps	cfm/p	8.0

100% diversity

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

		Units	*Health Classroom*	*Music Classroom*	Office	Storage	Instrument Repair	Concession	Instrument Practice
Zone Name			*Health Classroom*	*Music Classroom*	Office	Storage	Instrument Repair	Concession	Instrument Practice
Zone Tag			B217	B215	B214F	B214E	B214D	B212	B214A
Space type			Classrooms (age 9 plus)	Classrooms (age 9 plus)	Office space	Storage rooms	Office space	Cafeteria/fast-food dining	Office space
Floor Area of zone	Az	sf	823	823	109	92	64	95	29
Design population of zone	Pz	P	28.805	28.805	0.545	0	0.32	4	0.145
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm	800	800	125	75	50	165	50
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?									
Local recirc. air % representative of ave system return air	Er								

(default value listed, may be overridden)

Inputs for Operating Condition Analyzed

		Units	Health	Music	Office	Storage	Instrument Repair	Concession	Instrument Practice
Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed			CS	CS	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep								

Results

		Units	System
Ventilation System Efficiency	Ev		0.73
Outdoor air intake required for system	Vot	cfm	2916
Outdoor air per unit floor area	Vot/As	cfm/sf	0.32
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	16.9
Outdoor air as a % of design primary supply air	Ypd	cfm	29%

Detailed Calculations

Initial Calculations for the System as a whole

		Units			System
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	10110
Uncorrected OA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	2116
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.21

Initial Calculations for individual zones

		Units	Equation	Health	Music	Office	Storage	Instrument Repair	Concession	Instrument Practice
OA rate per unit area for zone	Raz	cfm/sf		0.12	0.12	0.06	0.12	0.06	0.18	0.06
OA rate per person	Rpz	cfm/p		10.00	10.00	5.00	0.00	5.00	7.50	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm		800	800	125	75	50	165	50
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	386.8	386.8	9.3	11.0	5.4	47.1	2.5
Unused OA requirement for zone	Voz		= Vbz/Ez	387	387	9	11	5	47	2
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	0.48	0.48	0.07	0.15	0.11	0.29	0.05
Unused OA fraction required in primary air to zone	Zp		= Voz / Vps	0.48	0.48	0.07	0.15	0.11	0.29	0.05

System Ventilation Efficiency

		Units	Equation	Health	Music	Office	Storage	Instrument Repair	Concession	Instrument Practice
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs – FcZ) / Fa	0.73	0.73	1.14	1.06	1.10	0.92	1.16
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=	0.73
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	=	0.67

Minimum outdoor air intake airflow

		Units	Equation		System
Outdoor Air intake Flow required to System	Vot	cfm	= Vou / Ev	=	2916
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	0.29
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	=	3175
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	=	0.31

OA Temp at which Min OA provides all cooling

		Units	Equation		System
OAT below which Min OA Intake flow is @ minimum		Deg F	= ((Tp-dTsf)×(1-Y)×(Tr+dTr1	=	13

Building: Bentworth Middle School
System Tag/Name: RTHP-B1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units	System
Floor area served by system	As	sf	9220
Population of area served by system (including diversity)	Ps	P	172
Design primary supply fan airflow rate	Vpsd	cfm	10,110
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.08
OA req'd per person for system area (Weighted average)	Rps	cfm/p	8.0

100% diversity

Inputs for Potentially Critical zones

			Instrument Practice	Band	Corridor	Office space	Office space	Lobby	Library
Zone Name			B214C	B214	B204	B211A	B205A	A230	A232
Zone Tag			Office space	Music/theater/dance	Corridors	Office space	Office space	Main entry lobbies	Libraries
Space type		Select from pull-down list							
Floor Area of zone	Az	sf	80	1246	500	86	85	2060	1020
Design population of zone	Pz	P	0.4	43.61	0	0.43	0.425	20.6	10.2
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm	60	1360	450	100	100	1840	2200
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A							
Local recirc. air % representative of ave system return air	Er								

Inputs for Operating Condition Analyzed

	Name	Units		B214C	B214	B204	B211A	B205A	A230	A232
Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list		CS	CS	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez			1.00	1.00	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep									

Results

	Name	Units	System
Ventilation System Efficiency	Ev		0.73
Outdoor air intake required for system	Vot	cfm	2916
Outdoor air per unit floor area	Vot/As	cfm/sf	0.32
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	16.9
Outdoor air as a % of design primary supply air	Ypd	cfm	29%

Detailed Calculations

Initial Calculations for the System as a whole

	Name	Units		Equation		Value
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	$VpdDs$	=	10110
Uncorrected OA requirement for system	Vou	cfm	=	$Rps\,Ps + Ras\,As$	=	2116
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.21

Initial Calculations for individual zones

	Name	Units	Equation	B214C	B214	B204	B211A	B205A	A230	A232
OA rate per unit area for zone	Raz	cfm/sf		0.06	0.06	0.06	0.06	0.06	0.06	0.12
OA rate per person	Rpz	cfm/p		5.00	10.00	0.00	5.00	5.00	5.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	= $Rpz\,Pz + Raz\,Az$	60	1360	450	100	100	1840	2200
Unused OA req'd to breathing zone	Vbz	cfm	= Vbz/Ez	6.8	510.9	30.0	7.3	7.2	226.6	173.4
OA requirement for zone	Voz	cfm	= Vbz/Ez	7	511	30	7	7	227	173
Fraction of zone supply not directly recirc. from zone	Fa		= $Ep + (1-Ep)Er$	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= $1-(1-Ez)(1-Ep)(1-Er)$	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	0.11	0.38	0.07	0.07	0.07	0.12	0.08
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	0.11	0.38	0.07	0.07	0.07	0.12	0.08

System Ventilation Efficiency

	Name	Units	Equation	B214C	B214	B204	B211A	B205A	A230	A232	System
Zone Ventilation Efficiency (App A Method)	Evz		= $(Fa + FbXs - FcZ)/Fa$	1.10	0.83	1.14	1.14	1.14	1.09	1.13	
System Ventilation Efficiency (App A Method)	Ev		= $min\,(Evz)$								0.73
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3								0.67

Minimum outdoor air intake airflow

	Name	Units	Equation	System
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	2916
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	0.29
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	3175
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	0.31

OA Temp at which Min OA provides all cooling

	Name	Units	Equation	Value
OAT below which Min OA intake flow is @ minimum		Deg F	= $((Tp-dTsf)-(1+Y)*Tr+dTrf)$	13

Zone title turns purple italic for critical zone(s)

(default value listed; may be overridden)

Building: Bentworth Middle School
System Tag/Name: RTHP-B1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units	System
Floor area served by system	As	sf	9220
Population of area served by system (including diversity)	Ps	P	172
Design primary supply fan airflow rate	Vpsd	cfm	10,110
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.08
OA req'd per person for system area (Weighted average)	Rps	cfm/p	8.0

100% diversity

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

		Office space	Storage	Exam	Health	Cots	Corridor	File Room
Zone Name		Office space	Storage	Exam	Health	Cots	Corridor	File Room
Zone Tag		B203E	B203D	B203C	B203	B203A	B202D	B202B
Space type		Office space	Storage rooms	Office space	Office space	Office space	Corridors	Storage rooms
Floor Area of zone	Az (sf)	70	48	83	175	176	214	84
Design population of zone	Pz (P)	0.35	0.00	0.415	2	3	0	0
Design total supply to zone (primary plus local recirculated)	Vdzd (cfm)	100	50	50	100	85	170	50

(default value listed; may be overridden)
Select from pull-down list or leave blank if N/A

Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?
Local recirc. air % representative of ave system return air — Er

Inputs for Operating Condition Analyzed

		Office space	Storage	Exam	Health	Cots	Corridor	File Room
Percent of total design airflow rate at conditioned analyzed	Ds (%)	100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		CS	CS	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep							

Ds — Select from pull-down list

Results

		Units	
Ventilation System Efficiency	Ev		0.73
Outdoor air intake required for system	Vot	cfm	2916
Outdoor air per unit floor area	Vot/As	cfm/sf	0.32
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	16.9
Outdoor air as a % of design primary supply air	Ypd	cfm	29%

Detailed Calculations

Initial Calculations for the System as a whole

			Equation		
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	10110
Uncorrected OA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	2116
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.21

Initial Calculations for individual zones

		Units	Equation	B203E	B203D	B203C	B203	B203A	B202D	B202B
OA rate per unit area for zone	Raz	cfm/sf		0.06	0.12	0.06	0.06	0.06	0.06	0.06
OA rate per person	Rpz	cfm/p		5.00	0.00	5.00	5.00	5.00	0.00	0.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm		100	50	50	100	85	170	50
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	6.0	5.8	7.1	20.5	25.6	12.8	10.1
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	6	6	7	21	26	13	10
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	0.06	0.12	0.14	0.21	0.30	0.08	0.20
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	0.06	0.12	0.14	0.21	0.30	0.08	0.20

System Ventilation Efficiency

		Units	Equation	B203E	B203D	B203C	B203	B203A	B202D	B202B
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ)/Fa	1.15	1.09	1.07	1.00	0.91	1.13	1.01

			Equation		
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=	0.73
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	=	0.67

Minimum outdoor air intake airflow

		Units	Equation		
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	=	2916
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	0.29
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	=	3175
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	=	0.31

OA Temp at which Min OA provides all cooling

		Units	Equation		
OAT below which OA intake flow is @ minimum		Deg F	= ((Tp-dTsf)-(1-Y)(Tr+dTr))	=	13

Building: Bentworth Middle School
System Tag/Name: RTHP-B1
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units	System
Floor area served by system	As	sf	9220
Population of area served by system (including diversity)	Ps	P	172
Design primary supply fan airflow rate	Vpsd	cfm	10,110
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.08
OA req'd per person for system area (Weighted average)	Rps	cfm/p	8.0

100% diversity

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

		Work Room	Office	Office	Conference	Reception
Zone Name						
Zone Tag		B202A	B202G	B202F	B202E	B201
Space type		Office space	Office space	Office space	Conference/meeting	Reception areas
Floor Area of zone	Az	sf	140	223	182	213	500
Design population of zone	Pz	P	0.7	1.115	0.91	10.65	15
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm	100	250	250	330	400
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		*Select from pull-down list or leave blank if N/A*					
Local recirc. air % representative of ave system return air	Er						

Inputs for Operating Condition Analyzed

Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		*Select from pull-down list*	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez		1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep						

Results

Ventilation System Efficiency	Ev		0.73
Outdoor air intake required for system	Vot	cfm	2916
Outdoor air per unit floor area	Vot/As	cfm/sf	0.32
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	16.9
Outdoor air as a % of design primary supply air	Ypd	cfm	29%

Detailed Calculations

Initial Calculations for the System as a whole

Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	VpdDs	10110
Uncorrected OA requirement for system	Vou	cfm	=	Rps Ps + Ras As	2116
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	0.21

Initial Calculations for individual zones

						Work Room	Office	Office	Conference	Reception
OA rate per unit area for zone	Raz	cfm/sf				0.06	0.06	0.06	0.06	0.06
OA rate per person	Rpz	cfm/p				5.00	5.00	5.00	5.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Rpz Pz + Raz Az		100	250	250	330	400
Unused OA req'd to breathing zone	Vbz	cfm	=	Vbz/Ez		11.9	19.0	15.5	66.0	105.0
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez		12	19	15	66	105
Fraction of zone supply not directly recirc. from zone	Fa		=	Ep + (1-Ep)Er		1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		=	Ep		1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)		1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		=	Voz / Vdz		0.12	0.08	0.06	0.20	0.26
Unused OA fraction required in primary air to zone	Zp		=	Voz / Vpz		0.12	0.08	0.06	0.20	0.26

System Ventilation Efficiency

						Work Room	Office	Office	Conference	Reception
Zone Ventilation Efficiency (App A Method)	Evz		=	(Fa + FbXs - FcZ) / Fa		1.09	1.13	1.15	1.01	0.95
System Ventilation Efficiency (App A Method)	Ev		=	min (Evz)	0.73					
Ventilation System Efficiency (Table 6.3 Method)	Ev		=	Value from Table 6.3	0.67					

Minimum outdoor air intake airflow

Outdoor Air Intake Flow required to System	Vot	cfm	=	Vou / Ev	2916
OA intake req'd as a fraction of primary SA	Y		=	Vot / Vps	0.29
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	=	Vou / Ev	3175
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		=	Vot / Vps	0.31

OA Temp at which Min OA provides all cooling

OAT below which OA intake flow is @ minimum		Deg F	=	{(Tp-dTsf)-(1-Y)*Tr}+dTrl	13

Building: Bentworth Middle School
System Tag/Name: RTHP-B2
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units	System
Floor area served by system	As	sf	4059
Population of area served by system (including diversity)	Ps	P	219 (100% diversity)
Design primary supply fan airflow rate	Vpsd	cfm	5,600
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf	0.18
OA req'd per person for system area (Weighted average)	Rps	cfm/p	7.5

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

			Potentially Critical Zones		
			Cafeteria	Kitchen	Office
Zone Name			B219	B232	B230
Zone Tag			Cafeteria/fast-food dining	Cafeteria/fast-food dining	Office space
Space type		Select from pull-down list			
Floor Area of zone	Az	sf	2,090	1800	169
Design population of zone	Pz	P	209	9	0.845
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm	4,000	1500	100
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A		
Local recirc. air % representative of ave system return air	Er				

Inputs for Operating Condition Analyzed

Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100%	100%	100%
Air distribution type at conditioned analyzed			Select from pull-down list			
Zone air distribution effectiveness at conditioned analyzed	Ez		CS	CS	CS	
Primary air fraction of supply air at conditioned analyzed	Ep		1.00	1.00	1.00	

Results

		Units	
Ventilation System Efficiency	Ev		0.93
Outdoor air intake required for system	Vot	cfm	2517
Outdoor air per unit floor area	Vot/As	cfm/sf	0.62
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	11.5
Outdoor air as a % of design primary supply air	Ypd	cfm	4.5%

Detailed Calculations

Initial Calculations for the System as a whole

		Units			
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	5600	
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	2350	
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	0.42	

Initial Calculations for individual zones

		Units		Cafeteria	Kitchen	Office
OA rate per unit area for zone	Raz	cfm/sf		0.18	0.18	0.06
OA rate per person	Rpz	cfm/p		7.50	7.50	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm		4000	1500	100
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	1943.7	391.5	14.4
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	1944	392	14
Fraction of zone supply air not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	0.49	0.26	0.14
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	0.49	0.26	0.14

System Ventilation Efficiency

		Units				
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	0.93	1.16	1.28
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	0.93		
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	0.66		

Minimum outdoor air intake airflow

		Units		
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	2517
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	0.45
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	3538
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	0.63

OA Temp at which Min OA provides all cooling

		Units		
OAT below which Min OA Intake flow is @ minimum		Deg F	= $\{(Tp\text{-}dTsf)\text{-}(1\text{-}Y)*(Tr+dTrf\}$	34

Building: Bentworth Middle School
System Tag/Name: RTHP-B3
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

Inputs for System

	Name	Units		System
Floor area served by system	As	sf		1,548
Population of area served by system (including diversity)	Ps	P		108
Design primary supply fan airflow rate	Vpsd	cfm	100% diversity	2,100
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.06
OA req'd per person for system area (Weighted average)	Rps	cfm/p		10.0

Zone title turns purple italic for critical zone(s)

Inputs for Potentially Critical zones

Potentially Critical Zones

				Stage enter tag	new zone New zone ID
Zone Name				Stages, studios	Restaurant dining rooms
Zone Tag			Select from pull-down list		
Space type			Select from pull-down list		
Floor Area of zone	Az	sf		1,548	0
Design population of zone	Pz	P	(default value listed; may be overridden)	108.36	
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm		2,100	
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A		
Local recirc. air % representative of ave system return air	Er				

Inputs for Operating Condition Analyzed

Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%
Air distribution type at conditioned analyzed			Select from pull-down list	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez			1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep				

Results

Ventilation System Efficiency	Ev			1.00
Outdoor air intake required for system	Vot	cfm		1176
Outdoor air per unit floor area	Vot/As	cfm/sf		0.76
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		10.9
Outdoor air as a % of design primary supply air	Ypd	cfm		56%

Detailed Calculations

Initial Calculations for the System as a whole

Primary supply air flow to system at conditioned analyzed	Vps	cfm	$= VpdDs$	2100
UncorrectedOA requirement for system	Vou	cfm	$= Rps\,Ps + Ras\,As$	1176
Uncorrected OA req'd as a fraction of primary SA	Xs		$= Vou / Vps$	0.56

Initial Calculations for individual zones

OA rate per unit area for zone	Raz	cfm/sf		0.06
OA rate per person	Rpz	cfm/p		10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm		2100
Unused OA req'd to breathing zone	Vbz	cfm	$= Rpz\,Pz + Raz\,Az$	1176.5
Unused OA requirement for zone	Voz	cfm	$= Vbz/Ez$	1176
Fraction of zone supply air not directly recirc. from zone	Fa		$= Ep + (1-Ep)Er$	1.00
Fraction of zone supply from fully mixed primary air	Fb		$= Ep$	1.00
Fraction of zone OA not directly recirc. from zone	Fc		$= 1-(1-Ez)(1-Ep)(1-Er)$	1.00
Unused OA fraction required in supply air to zone	Zd		$= Voz / Vdz$	0.56
Unused OA fraction required in primary air to zone	Zp		$= Voz / Vpz$	0.56

System Ventilation Efficiency

Zone Ventilation Efficiency (App A Method)	Evz		$= (Fa + FbXs - FcZ) / Fa$	1.00
System Ventilation Efficiency (App A Method)	Ev		$= min (Evz)$	1.00
Ventilation System Efficiency (Table 6.3 Method)	Ev		$=$ Value from Table 6.3	n/a

Minimum outdoor air intake airflow

Outdoor Air Intake Flow required to System	Vot	cfm	$= Vou / Ev$	1176
OA intake req'd as a fraction of primary SA	Y		$= Vot / Vps$	0.56
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	$= Vou / Ev$	n/a
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		$= Vot / Vps$	n/a

OA Temp at which Min OA provides all cooling

OAT below which OA intake flow is @ minimum		Deg F	$= \{(Tp-dTsf)-(1-Y)*(Tr+dTr)\}$	42

Building: Bentworth Middle School
System Tag/Name: RTHP-B4
Operating Condition Description: Occupied Operation Mode
Units (select from pull-down list): IP

	Name	Units		System
Inputs for System				
Floor area served by system	As	sf		6,809
Population of area served by system (including diversity)	Ps	P	100% diversity	410
Design primary supply fan airflow rate	Vpsd	cfm		10,000
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.24
OA req'd per person for system area (Weighted average)	Rps	cfm/p		4.7

Inputs for Potentially Critical zones
Zone title turns purple italic for critical zone(s)

				Potentially Critical Zones	
				Gym Floor 1	***Bleachers*** 2
Zone Name				Gym, stadium (play area)	Spectator areas
Zone Tag					
Space type			Select from pull-down list		
Floor Area of zone	Az	sf		5,093	1716
Design population of zone	Pz	P		152.79	257.4
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm	(default value listed; may be overridden)	5,000	5000
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A		
Local recirc. air % representative of ave system return air	Er				

Inputs for Operating Condition Analyzed					
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%
Air distribution type at conditioned analyzed			Select from pull-down list	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez			1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep				

Results				
Ventilation System Efficiency	Ev			0.95
Outdoor air intake required for system	Vot	cfm		3751
Outdoor air per unit floor area	Vot/As	cfm/sf		0.55
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		9.1
Outdoor air as a % of design primary supply air	Ypd	cfm		38%

Detailed Calculations

Initial Calculations for the System as a whole

						System
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=		10000
Uncorrected OA requirement for system	Vou	cfm	= Rps Ps + Ras As	=		3561
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=		0.36

Initial Calculations for individual zones

						Gym Floor	Bleachers
OA rate per unit area for zone	Raz	cfm/sf			=	0.30	0.06
OA rate per person	Rpz	cfm/p			=	0.00	7.50
Total supply air to zone (at condition being analyzed)	Vdz	cfm			=	5000	5000
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az		=	1527.9	2033.5
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez		=	1528	2033
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er		=	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep		=	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)		=	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz		=	0.31	0.41
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz		=	0.31	0.41

System Ventilation Efficiency

Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	=		0.95 / 1.05
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=		0.95
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	=		0.74

Minimum outdoor air intake airflow

Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	=		3751
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=		0.38
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	=		4791
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	=		0.48

OA Temp at which Min OA provides all cooling

OAT below which OA intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTr)}	=		27