Technical Report 1

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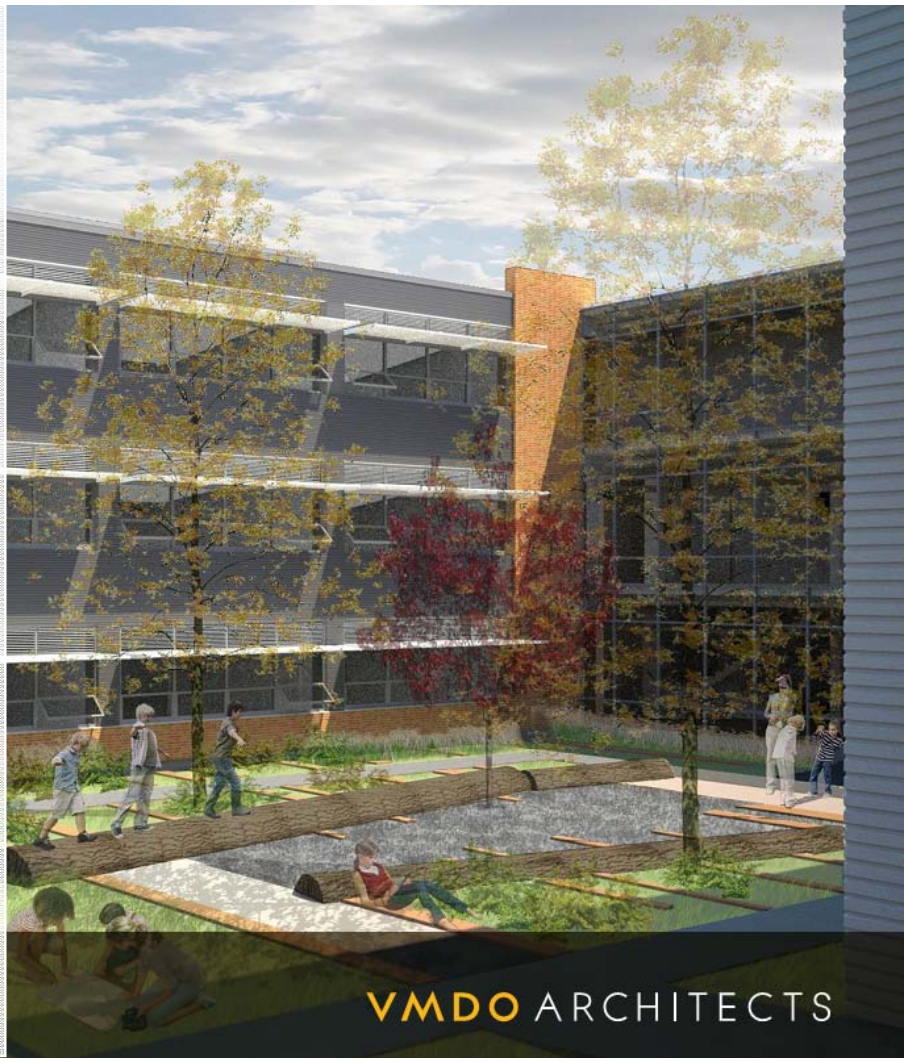

This document contains an analysis of ASHRAE Standard 62.1-2007 and ASHRAE Standard 90.1-2007 for the Manassas Park Elementary School, located in Manassas Park, VA.

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Executive Summary:

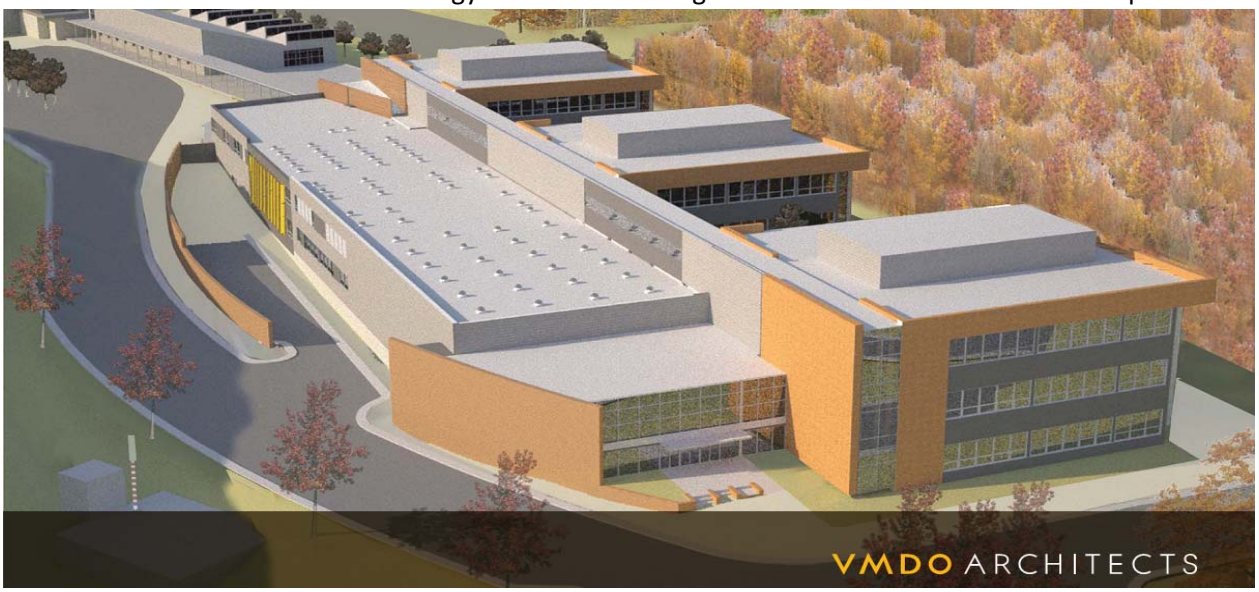
The purpose of this report is to determine if Manassas Park Elementary School (MPES) is in compliance with ASHRAE Standard 62.1-2007 and ASHRAE Standard 90.1-2007.

Manassas Park Elementary School is a LEED® Gold elementary school that was built on existing school grounds in Manassas Park, Virginia. It houses students from third to fifth grade, and utilizes small classrooms to accommodate the schools progressive educations programs. It is particularly important that this building conform to minimum ventilation and performance requirements of the aforementioned standards, as they are prerequisites for LEED® Certification.

The ASHRAE Standard 62.1-2007 compliance analysis showed that the building is compliant with the standard in its entirety. Section 5 of the standard showed that MPES has a high quality indoor air environment, and Section 6 calculations proved that ventilation levels are more than acceptable for all occupied spaces in the building. Both of these building traits have recently been linked to increased productivity and decreased absence among students.

MPES also came very close to completely complying with ASHRAE Standard 90.1-2007. The equipment within the building that is non-compliant represented only a small portion of the total system, virtually rendering its nonconformity negligible with respect to the whole building efficiency. Although exact causes of non-compliance have yet to be determined, it is speculated that errors are due to miscalculations and/or specification errors conducted during the initial design. There is, however, a possibility that this analysis followed a different compliance path for specific requirements, and that the systems that were deemed *non-compliant* by this report are still reasonably acceptable with respect to the standard.

Because the MPES design team had a goal of achieving LEED® Gold certification, the cumulative modeled energy use of the system is less than that of a comparable school. Specifically, the use of light wells and natural daylighting practically eliminated the dependence on artificial light in most of the perimeter zones as well as select interior zones (throughout a specific range of weather conditions). Further information on modeled energy use of the building can be found in MPES Technical Report 2.



ASHRAE Standard 62.1-2007 Section 5 – *Systems & Equipment*:

Section 5.1 – Natural Ventilation

MPES takes advantage of the mild northern Virginia climate by utilizing an innovative natural ventilation system. All naturally ventilated spaces are permanently open to and within 25 feet of operable windows which have an openable area greater than 4% of the net occupied floor area.

The operable windows are of the horizontal axis crank type, which are manually opened by a readily accessible rotating handle located at the base of each window.

Section 5.2 – Ventilation Air Distribution

Specification 15950-3.7-A states that the air handling and distribution systems shall be adjusted to obtain minimum ventilation requirements for all specified spaces within the building. The ventilation air distribution system can be adjusted to achieve these minimum ventilation airflows under any load condition as required by Section 6 of ASHRAE Standard 62.1. A full analysis of Section 6 is contained within this report.

Section 5.3 – Exhaust Duct Location

All exhaust ducts that convey potentially harmful contaminants have been specified as being negatively pressurized, and are sealed in accordance with SMACNA Seal Class A. This sealing methodology is described in *HVAC Duct Construction Standards, Metal and Flexible, 2nd Edition (1995)*.

Section 5.4 – Ventilation System Controls

The mechanical ventilation of the building is typically supplied via 5 outside air units. Each of these units has a microprocessor-based controller which monitors and controls the unit as directed by a direct digital control building automation system. This system is automatically put into occupied operation during normal business hours, supplying sufficient ventilation air to all applicable spaces in conformance to section 5.4.

The building automation system also downloads hour by hour forecasted weather data from the National Weather Service before the beginning of each school day. If the forecasted weather is between 60 and 75 degrees Fahrenheit and it is predicted that there will be a 40% chance of precipitation or less for all hours between 8:00am and 3:00pm (adjustable), the building enters *green light occupied operation mode*. In this operation mode, 2 of the 5 outside air units are disabled, and appropriate dampers are closed to isolate specific perimeter classrooms from their respective outside air units. Teachers in these classrooms are notified of the operation change by way of a small green light, which is centrally located within each floor of each pod. When this light is illuminated, teachers are to open the operable windows of their respective classrooms, which in turn provides sufficient ventilation and conditioning to the space while minimizing energy consumption of the outside air units. Implications of this system are briefly discussed in the ASHRAE Standard 90.1 energy analysis section of this report.

Section 5.5 – Airstream Surfaces

Specifications section 15810-2.2-A states that duct fabrication shall be "in accordance with SMACNA HVAC Duct Construction Standards", which specifies an acceptable resistance to both mold growth and erosion. Also, section 15 specifications state that the insulation inside of energy recovery ventilators, ground source heat pumps, water source heat pumps, and make-up air units meets the air erosion and mold growth limits of UL-181.

Section 5.6 – Outdoor Air Intakes

All of the outdoor air intakes on the MPES (including operable windows) are located such that the shortest distance from the intake to any specific potential outdoor contaminant source is greater than the separation distance listed in Table 5-1 of ASHRAE Standard 62.1, shown below as Table 1.

Table 1: Minimum Distances between Building Intakes as Pollutant Sources:

Object	Minimum Distance, ft (m)
Significantly contaminated exhaust (Note 1)	15 (5)
Noxious or dangerous exhaust (Notes 2 and 3)	30 (10)
Vents, chimneys, and flues from combustion appliances and equipment (Note 4)	15 (5)
Garage entry, automobile loading area, or drive-in queue (Note 5)	15 (5)
Truck loading area or dock, bus parking/idling area (Note 5)	25 (7.5)
Driveway, street, or parking place (Note 5)	5 (1.5)
Thoroughfare with high traffic volume	25 (7.5)
Roof, landscaped grade, or other surface directly below intake (Notes 6 and 7)	1 (0.30)
Garbage storage/pick-up area, dumpsters	15 (5)
Cooling tower intake or basin	15 (5)
Cooling tower exhaust	25 (7.5)

Note 1: Significantly contaminated exhaust is exhaust air with significant contaminant concentration, significant sensory-irritation intensity, or offensive odor.
Note 2: Laboratory fume hood exhaust air outlets shall be in compliance with NFPA 45-1991[3] and ANSI/AIHA Z9.5-1992.[4]
Note 3: Noxious or dangerous exhaust is exhaust air with highly objectionable fumes or gases and/or exhaust air with potentially dangerous particles, bioaerosols, or gases at concentrations high enough to be considered harmful. Information on separation criteria for industrial environments can be found in the ACGIH Industrial Ventilation Manual[5] and in the *ASHRAE Handbook—HVAC Applications*.[6]
Note 4: Shorter separation distances are permitted when determined in accordance with (a) Chapter 7 of ANSI Z223.1/NFPA 54-2002[7] for fuel gas burning appliances and equipment, (b) Chapter 6 of NFPA 31-2001[8] for oil burning appliances and equipment, or (c) Chapter 7 of NFPA 211-2003[9] for other combustion appliances and equipment.
Note 5: Distance measured to closest place that vehicle exhaust is likely to be located.
Note 6: No minimum separation distance applies to surfaces that are sloped more than 45 degrees from horizontal or that are less than 1 in. (3 cm) wide.
Note 7: Where snow accumulation is expected, distance listed shall be increased by the expected average snow depth.

The weather hoods on the make-up air units are specified as being constructed of G90 galvanized steel, and having a birdscreen mounted at the intake. Further information on water penetration levels and birdscreen thicknesses is not listed in the specification.

Birdscreens on outside air and exhaust air louvers are specified as having a "bird screen with 1/2-inch square mesh for exhaust and 3/4-inch [square mesh] for intake". This is not in compliance with ASHRAE Standard 62.1 section 5.6.5, however an aluminum mesh has been installed for insect protection, which would likely stop anything tangible object or creature that was able to pass through the 3/4-inch square mesh birdscreen.

Exterior packaged and split condenser 100% outside air units utilize a weather hood that is designed for a maximum air velocity of 450 feet per minute. Again, further information on water penetration levels are not listed in the specification.

Section 5.7 – Local Capture of Contaminants

MPES does not have any non-combustion equipment that produces contaminants, thus section 5.7 is inapplicable.

Section 5.8 – Combustion Air

All combustion producing processes are designed to consume the appropriate amount of combustion air, and are vented directly to the outdoors in compliance with section 5.8.

Section 5.9 – Particulate Matter Removal

100% synthetic particulate matter filters with a minimum efficiency reporting value of 7 have been placed upstream of the heat exchanger and coils in the packaged and split condenser 100% outside air units in compliance with section 5.9.

Section 5.10 – Dehumidification Systems

The building automation system is specified to enable the dehumidification mode to maintain the supply air relative humidity setpoint at 50%. The building will always be positively pressurized when the mechanical air-conditioning systems are in dehumidification mode in conformance with section 5.10.

Section 5.11 – Drain Pans

All drain pans are constructed of 304 stainless steel to inhibit corrosion. The corrosion protection system of these drain pans meets the stringent 1000 hour salt spray test per ASTM B117. All drain pans are fully insulated, and their outlets are located at the bottom of the pan such that drainage of condensate is complete and unobstructed. Further detail concerning the drain pains is currently unavailable.

Section 5.12 – Finned-Tube Coil Selection for Cleaning

A drain pan has been provided and correctly placed beneath all dehumidifying cooling coil assemblies and all condensate-producing heat exchangers. The distance between coils is 18 inches which is compliant with section 5.12.

Section 5.13 – Humidifiers and Water-Spray Systems

Section 5.13 is not applicable because MPES does not utilize any humidifiers or water-spray systems.

Section 5.14 – Access for Inspection, Cleaning, and Maintenance

Equipment access doors have been sized and located appropriately, and all of the proper equipment clearances have been met. These access doors and clearances provide unobstructed access for inspection, cleaning, and routine maintenance for all applicable equipment in conformance with section 5.14.

Section 5.15 – Building Envelope and Interior Surfaces

A sufficient number of coatings of dampproofing have been applied to the foundation, footings, etcetera of the structure as is noted in specification section 07115-3.3 to prevent detrimental moisture penetration into the subgrade building. Specific waterproofing methodologies included self-adhering sheet waterproofing, modified cement waterproofing, crystalline waterproofing, and bentonite waterproofing. The roof was waterproofed by thermoplastic polyolefin roofing, which is also compliant with section 5.15.

All interior pipes and ducts that have the ability to drop below the local dew point have been adequately insulated such that condensation will not occur on the exterior surfaces of the material.

Section 5.16 – Buildings with Attached Parking Garages

MPES does not have any attached parking garaged, thus section 5.16 is not applicable.

Section 5.17 – Air Classification and Recirculation

All of the spaces within the building (with the exception of the kitchen) are specified as being class 1 spaces. Class 1 air may be recirculated or transferred to any space as specified in section 5.17 of ASHRAE Standard 62.1. The kitchen exhaust air is exhausted directly from the building, thus the classification of the air is insignificant.

Section 5.18 – Requirements for Buildings containing ETS Areas and ETS-Free Areas

MPES is a non-smoking facility, and therefore does not have any environmental tobacco smoke areas. Being said, section 5.18 is not applicable.

ASHRAE Standard 62.1-2007 Section 6 – *Procedures*:

Section 6 of ASHRAE Standard 62.1 outlines what is known as the Ventilation Rate Procedure, which is used to design each ventilation system in a building. The Ventilation Rate Procedure is "a prescriptive procedure in which outdoor air intake rates are determined based on space type/application, occupancy level, and floor area", and is subject to a number of considerations and restrictions.

The entire mechanical ventilation system of MPES was looked at for this study. These ventilation systems include 5 outside air units, 1 makeup air unit, and 2 energy recovery ventilators. Natural ventilation considerations are compliant with Section 5.1, and will not be considered in this Section 6 analysis. Outdoor air quality at the site has been classified as acceptable in accordance to section 4. Air-cleaning devices for ozone do not need to be provided, as the second highest daily maximum one-hour average concentration does not exceed 0.160 ppm.

The following calculations come directly from Section 6 of ASHRAE Standard 62.1, and are used to calculate compliance with Section 6:

Breathing Zone Outdoor Airflow (V_{bz}):

$V_{bz} = R_p \cdot P_z + R_a \cdot A_z$

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

R_p = outdoor airflow rate required per person as determined from ASHRAE Standard 62.1 Table 6.1 (cfm/person)

R_a = outdoor airflow rate required per unit area as determined from ASHRAE Standard 62.1 Table 6.1 (cfm/ft^2)

Zone Air Distribution Effectiveness (E_z) as determined by ASHRAE Standard 62.1 Table 6.2:

$E_z = 1$

Zone Outdoor Airflow (V_{oz}):

$V_{oz} = V_{bz} / E_z$

Outdoor Air Intake Flow (V_{ot}) for makeup air units:

$V_{ot} = V_{oz}$

Outdoor Air Intake Flow (V_{ot}) for outside air units:

$V_{ot} = \sum_{all\ zones} V_{oz}$

Primary Outdoor Air Fraction (Z_p):

$Z_p = V_{oz} / V_{pz}$

where V_{pz} = zone primary airflow (mixed air). For VAV systems, V_{pz} is the minimum expected primary airflow for design purposes.

System Ventilation Efficiency (E_v) as determined using ASHRAE Standard 62.1 Table 6.3:

$E_v = 1$

The ASHRAE Standard 62.1 Users Manual includes a Microsoft Excel based spreadsheet that computes ASHRAE Standard 62.1 Section 6 compliance based on inputs including room square footage, room occupancy type, and room supply air. This spreadsheet was used to analyze MPES's ventilation system with the result that the school was Standard 62.1 Section 6 compliant. This calculation can be found in Appendix A.

ASHRAE Standard 62.1-2007 Conclusion:

Manassas Park Elementary School is 100% compliant with ASHRAE Standard 62.1 2007 Sections 5 and 6. This means that the ventilated environment within the school meets the standards set by the results of experiments conducted by engineering committees with decades of combined engineering experience. By complying with ASHRAE Standard 62.1, the designers of MPES have given a healthy working and learning environment to the current and future students and faculty of the school.

ASHRAE Standard 90.1-2007 Section 5 – *Building Envelope*:

MPES is a nonresidential conditioned space located in climate zone 4a as specified by section 5.1.2.1 and table B-1, respectively.

The school has a 32% vertical fenestration area and a 3% skylight fenestration area. Because these areas are less than 40% and 5%, respectively, the building is able to follow the Prescriptive Building Envelope Compliance Path specified in section 5.5 of Standard 90.1.

The Standard specifies that the envelope system of a nonresidential conditioned space located in climate zone 4a is compliant based on the fulfillment of individual requirements specified in sections 5.4, 5.5, 5.7, and 5.8 of ASHRAE Standard 90.1. The explicit specifications stated within these sections are listed in Table 5.5-4 of the Standard, shown in Appendix B. Table 2, below, summarizes MPESs compliance with the requirements specified in table 5.5-4 of the Standard.

Table 2: Section 5 Compliance Summary:

Value	Minimum Roof Insulation R-Value	Minimum Wall Insulation R-Value For Brick/CMU Walls	Non-Heated Slab on Grade Floor Minimum Insulation	Fenestration Assembly Maximum U-Value	Fenestration Maximum SHGC
Required	R-20	R-9.5	Not Required	0.55	0.40
Designed	R-30	R-10	Not Required	0.40	0.30
Compliance	Achieved	Achieved	Achieved	Achieved	Achieved

ASHRAE Standard 90.1-2007 Section 6 – *HVAC*:

Compliance with section 6 of ASHRAE Standard 90.1 will be determined according to section 6.4, Mandatory Provisions, and section 6.5, Prescriptive Path. Section 6.3, Simplified Approach Option for HVAC Systems will be neglected, as MPES is over two stories in height and has a gross floor area over 25,000 ft^2.

Heat Pumps:

MPES utilizes a myriad of different heat pump configurations manufactured by ClimateMaster. Table 3, below, shows the different models of heat pump used in the school.

Table 3: ClimateMaster Heat Pump Models Used in MPES:

Heat Pump Series	Model Number:
TSD	TSD018, TSD024, TSD030, TSD042, TSD048, TSD060
TSV	TSV042, TSV018, TSV030, TSV036, TSV048, TSV024
GLV	GLV200, GLV300
RE	RE07, RE20

Appendix C shows the energy efficiency of all TS-, GL-, and RE- models. All of the heat pump models specified in the MPES are compliant with ASHRAE Standard 90.1 2007 with the acception of the GLV300.

There is only 1 GLV300 in the building, and it is shown by the manufacturer specifications to have an EER of 12.7 with a 77˚F entering water temperature. The requirement set by ASHRAE Standard 90.1 2007 is an EER of 13.4 with an entering water temperature of 77˚F.

The 144,000 BTU/hr condensing unit has an EER of 9.8, as is shown on the mechanical equipment schedule of the mechanical drawing set. ASHRAE Standard 90.1 2007 requires condensing units of 135,000 BTU/h capacity or larger to have an EER of 10.1. This piece of equipment is not ASHRAE 90.1 2007 compliant.

MPES does not have any equipment that can be assessed according to the compliance tables for water chilling packages (chillers), Furnases, Boilers, or Heat Rejection Equipment. Heat generated in the school is rejected via a series of 200 geothermal wells, and climate heating is accomplished via electric heat pumps.

The mechanical equipment within MPES is covered by the U. S. National Appliance Energy Conservation Act of 1987, and thus does not need to have manufacturer installed labels stating that the given equipment complies with the requirements set forth in ASHRAE Standard 90.1. The equipment does, however, carry a perminant manufacturer installed label that shows specific equipment information from which ASHRAE Standard 90.1 compliance can be determined.

The HVAC system is automatically shut down in accordance to the direct digital control building automation system. This system places the buildings mechanical equipment on either occupied or unoccupied mode. When in occupied mode, the system can enter a third operation mode called *green light occupied operation mode*, as was discussed in the 62.1 analysis. This ventilation mode is being brought up in the 90.1 compliance section of this report because of section 6.4.3.3.1 of ASHRAE Standard 90.1, titled: Automatic Shutdown. This section states that “HVAC systems shall be equipped with [an automatic shutdown procedure]”. If natural ventilation were considered a ventilation *system*, then MPES *does not* comply with Standard 90.1, as the natural ventilation system cannot be automatically turned off. To reiterate, if the green light is on when the teachers leave the school for the day, their classroom windows remain open. Mechancial equipment may enter a heating mode where energy is pumped into classrooms that are open to the environment, causing emmense inefficiencies in the total building energy use model.

Section 6.5.1 of ASHRAE Standard 90.1 2007, Economizers, specifies that “Each cooling system that has a fan shall include either an air or water economizer meeting the requirements of Sections 6.5.1.1 through 6.5.1.4”. Table 6.5.1 of the Standard specifies that there is no economizer requirement for systems located in climate zone 4a. Because MPES is in climate zone 4a, it automatically complies with Section 6.5.1.

Section 6.5.2, *Zone Controls*: In compliance with Section 6.5.2, zone thermostatic controls are capable of “operating in sequence the supply of heating and cooling energy to the zone”. This allows certain heat pumps to utilize reheat after air is dehumidified by the condensing units. In most cases, this section is irrellavant due to the fact that the air is dehumidified via dessicant wheels.

Section 6.5.3.1, *Fan System Power Limitation*, specifies that system design conditions for supply fans, return/relief fans, and exhaust fans may not exceed the allowable fan system motor horsepower. This analysis is conducted in accordance with the calculations found within Table 6.5.4.1.1A of ASHRAE 90.1-2007, shown below as Table 4.

Table 4: Fan Efficiency Limitation Calculations:

	Limit	Constant Volume	Variable Volume
Option 1: Fan System Motor Nameplate hp	Allowable Nameplate Motor hp	$hp \le CFM_S \cdot 0.0011$	$hp \le CFM_S \cdot 0.0015$
Option 2: Fan System bhp	Allowable Fan System bhp	$bhp \le CFM_S \cdot 0.00094 + A$	$bhp \le CFM_S \cdot 0.0013 + A$

[a] where
CFM_S = the maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute
hp = the maximum combined motor nameplate horsepower
bhp = the maximum combined fan brake horsepower
A = sum of $(PD \times CFM_D/4131)$
where
PD = each applicable pressure drop adjustment from Table 6.5.3.1.1B in in. w.c.
CFM_D = the design airflow through each applicable device from Table 6.5.3.1.1B in cubic feet per minute

Through conducting the fan system power limitation analysis, it was determined that all but one fan (exhaust fan EF-7) were in compliance with Section 6.5.3.1 of ASHRAE 90.1-2007. Sample calculations are shown in Table 5, below, chosen to show the non-compliant equipment.

Table 5: Sample Calculations of Minimum Fan Efficiencies:

Mark	HP	W	CFM	CFM•0.0011	Compliant?
EF-1	0.44	328	750	0.825	Yes
EF-2	0.07	50	75	0.083	Yes
EF-3	0.06	48	200	0.220	Yes
EF-4	2.00	1491	12670	13.937	Yes
EF-5	0.19	144	370	0.407	Yes
EF-6	0.23	168	140	0.154	No
EF-7*	0.06	45	50	0.075	Yes
EF-DW	0.25	186	600	0.660	Yes
EF-MAU-1	3.00	2237	5690	6.259	Yes

*Note: EF-7 is a variable speed motor, and compliance equations within this table have been modified to reflect such.

Section 6.5.3.2, *VAV Fan Control (Including Systems Using Series Fan Power Boxes)*, details variable air volume terminal box requirements within a building system. Because MPES does not utilize variable air volume terminal boxes, it is not subject to the requirements specified within Section 6.5.3.2.

Section 6.5.4 of the standard, *Hydronic System Design and Control*, specifies that "HVAC hydronic systems having a total *pump system power* exceeding 10hp shall meet provisions of Sections 6.5.4.1 through 6.5.4.4".

Section 6.5.4.1, *Hydronic Variable Flow Systems*, states that "HVAC pumping systems that include control valves designed to modulate… shall be capable of reducing pump flow rates to 50% or less of the

design flow rate". Table 6, below, shows that the MPES ground source heat pump motors are both over 50 hp, and thus are subject to the requirements set forth in Section 6.5.4.1.

Table 6: Heat Pump Motor Efficiencies:

Mark	Service	Efficiency	GPM	Head (ft)	HP
HLP-1	Heat Pump Loop	83.3%	962	150	50
HLP-2	Heat Pump Loop	83.3%	962	150	50

Section 15265-2.1-D-23 of the building specifications states that the variable frequency drive used by the heat pumps (HLP-1 & HLP-2) has a current limit adjustment of "0-100 percent of rated [amperage]". This meets the requirements specified in section 6.5.4.1 of ASHRAE Standard 90.1-2007.

Section 6.5.4.2, *Pump Isolation*: This section is only applicable if a building has more than one chiller. Because MPES does not have any chillers, it is exempt from the requirements of Section 6.5.4.2.

Section 6.5.4.3, *Chilled- and Hot-Water Temperature Reset Controls*, requires systems with a design capacity exceeding 300,000 BTU/hr to "include controls that automatically reset supply water temperatures by representative building loads or *outdoor air* temperature". Specification section 15730-2.3-A-4-i specifies the heat pump control systems as having an automatic intelligent reset as one of its primary features. However, this reset feature was not ultimately required by Section 6.5.4.3 due to the following prescribed exception: "Hydronic systems… that used variable flow to reduce pumping energy [are exempt]".

Section 6.5.4.4, *Hydronic Heat Pump Systems*, specifies that "each hydronic heat pump shall have a two-position automatic valve interlocked to shut off water flow when the compressor is off". Specification section 15730-2.3-A-4-m states that a motorized water valve cycles wich the compressor such that water flow is shut off when the compressor is off.

Section 6.5.5.2 of the Standard, *Fan Speed Control*, specifies that "each fan powered by a motor of 7.5 hp or larger shall have the capability to operate that fan at two-thirds of full speed or less and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device". The heat pumps (which ultimately exchange heat with the ground) specified for MPES all have duel voltage capabilities in compliance with this section.

Section 6.5.6.2 of Standard 90.1, *Heat Recovery for Service Water Heating,* states that "condenser heat recovery systems shall be installed for heating or preheating of service hot water" if the implied building has a specific set of charactoristics. Among these defined charactoristics is that the building must be a 24-hour facility. Because MPES is not open 24 hours a day, it is exempt from this section of the standard.

Section 6.5.7.1, *Kitchen Exhaust Hoods*, requires that "individual kitchen exhaust hoods larger than 5000 cfm shall be provided with makeup air sized for at least 50% of exhaust air volume" EF-MAU-1 is a roof mounted upblast type kitchen exhaust fan that removes kitchen air at a rate of 5690 cfm. Because 5690 is greater than 5000, requirements specified in Section 6.5.7.1 apply. MPES utilizes a make-up air unit

(MAU-1) to account for the air exhausted by EF-MAU-1. This unit provides 3985 cfm of constant volume make-up air via an energy efficient EPACT and NEMA 1210 compliant motor, more than satisfying the requirements set forth in Section 6.5.7.1.

Section 6.5.7.2, *Fume Hoods*, applies to buildings with "fume hood systems having a total exhaust rate greater than 15,000 cfm". MPES is exempt from the requirements within this section, as the cumulative fume hood rate within the building is only 5,690 cfm.

Section 6.5.8, *Radiant Heating Systems*, does not apply to MPES due to the schools absence of radiant heating systems.

Section 6.5.9, *Hot Gas Bypass Limitation*, does not apply to MPES due to the schools absence of equipment utilizing hot gas bypass.

ASHRAE Standard 90.1-2007 Section 7 – *Water Heating*:

Domestic hot water in MPES is supplied by a variety of different heaters. These heater types include vertical storage gas fired heaters, vertical storage electric heaters, and electric instant heaters. The specific water heater types are listed in table 7, below.

Table 7: Water Heaters in Manassas Park Elementary School:

Mark	Type	Fuel	Input (btu/hr, kW)	Storage Capacity (Gal)	Compliance
DWH.1A, 1B	Vertical Storage	Natural Gas	199000	100	Achieved
DWH.2	Vertical Storage	Electric	24	80	Achieved
DWH.3	Instant	Electric	10	0	Achieved
DWH.4	Vertical Storage	Electric	9	80	Achieved
DWH.5	Vertical Storage	Electric	18	80	Achieved
DWH.6	Instant	Electric	3.5	0	Achieved

Section 7 of ASHRAE Standard 90.1-2007 specifies minimum efficiencies for water heating equipment as being 80%. The 199,000 BTU/hr natural gas fired vertical storage water heater is specified as being 98% efficient in the plumbing equipment schedule found on the plumbing drawings; this efficiency is well within the 80% requirement set forth by Standard 90.1. Because the direct efficiency of electrical heaters is assumed to be 100%, they will be ignored from this analysis.

ASHRAE Standard 90.1-2007 Section 8 – *Power*:

Section 8 of ASHRAE Standard 90.1-2007 specifies that feeder conductors must have a maximum voltage drop of 2% at the design load, and branch circuits most have a maximum voltage drop of 3% at the design load. The electrical designer used Standard 90.1 2004 as the design constraints. After cross-

checking the 2004/2007 power requirements, it was determined that the requirements perscribed in Section 8 have been met.

ASHRAE Standard 90.1-2007 Section 9 – *Lighting*:

Section 9, *Lighting*, applies to all interior and exterior lighting systems of MPES.

Section 9.4.1.1, *Automatic Lighting Shutoff*, states that "interior lighiting in buildings larger than 5000 ft^2 shall be controlled with an automatic control device to shut off building lighting in all spaces". Specification section 17030-3.9-A states that "the BAS shall control individual lighting circuits (as indicated on the plans) via relay(s) with contacts rated for 20A at 277V. Each relay shall have its own operating schedule according to school programming. Exterior lighting shall be controlled by its own operating schedule and the BAS astronomical clock." This specification satisfies the requirements set forth in Section 9.4.1.1.

Section 9.4.2.2, *Space Control*, states that "Each space enclosed by ceiling-height partitions shall have at least one control device to independently control the general lighting within the space. Each manual device shall be readily accessible and located so that the occupants can see the controlled lighting". The spaces within MPES are all compliant with section 9.4.2.2. Most of the systems in the school consist of pendant type dual lamp dimmable 32 Watt T-8 fixtures connected to both photocells and occupancy sensors. The occupancy sensors turn the lights off after no motion is detected for 10 minutes; however, occupants have the ability to manually shut the lights off at their discretion. The photocells allow the pendant fixtures to provide no more than the required amount of light to each space. When a large amount of natural light pours into the building from its many windows, artificial lights are automatically dimmed to provide the appropriate amount of light to each space. All of these controls are clearly visible and in an obvious location, with the exception of the photocells, which are not meant for occupant manipulation.

In both the gym and the library, the school utilizes light tunnels with motorized dimming controls available to the occupants. These light tunnels provide bright, natural light to students and teachers alike, and can be easily dimmed via zone switches located by the main entrances of both the library and the gym. When the light from these tunnels is insufficient, the gym and library are brightened by halogen and fluorescent lamps, respectively. Because these light tunnels are located in the buildings largest spaces, the lighting power density of the entire building is drastically reduced, easily placing the school in the compliant region of ASHRAE Standard 90.1-2007, Section 9.

ASHRAE Standard 90.1-2007 Conclusion:

The MPES was largely compliant with Standard 90.1-2007. The non-compliant systems make up a very small portion of the entire building, virtually rendering their effects negligible to the entire efficiency of the building system. The reasons for non-compliance have not yet been exposed, but are most likely due to calculation errors and/or equipment specification errors. There is also a possibility that the

methodologies conducted within this analysis differed from the strategies used for the initial system design, and that both methods are reasonable.

Because the MPES design team had a goal of achieving LEED® Gold certification, the cumulative modeled energy use of the system is less than that of a comparable school. Specifically, the use of light wells and natural daylighting practically eliminated the dependence on artificial light in most of the perimeter zones as well as select interior zones. Further information on modeled energy use of the building can be found in Technical Report 2.

References:

ASHRAE Standard 62.1-2004
ASHRAE Standard 62.1-2007
ASHRAE Standard 62.1-2004 Users Manual
ASHRAE Standard 90.1-2004
ASHRAE Standard 90.1-2007
ASHRAE Standard 90.1-2004 Users Manual
ASHRAE Handbook of Fundamentals
ASHRAE Handbook of HVAC Systems and Equipment

James Gawthrop
Gregory Smithmyer

Building:						**Manassas Park Elementary School**						
System Tag/Name:						**Ventilation System**						
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				76,051						
System population (including diversity)	Ps	P				2,710						
Design primary supply fan airflow rate	Vpsd	cfm				77,970						
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf				0.13						
Average outdoor airflow rate per person for the system	Rps	cfm/p				8.5						
Inputs for Potentially Critical Zones												
Zone Name							**Classroom**	**Classroom**	**Classroom**	**Resource Room**	**Classroom**	**Classroom**
		Zone title turns purple italic for critical zone(s)										
Zone Tag							**1101**	**1102**	**1103**	**1104**	**1105**	**1106**
Space type							**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**
		Select from pull-down list										
Floor Area of zone	Az	sf					783	788	786	405	788	783
Design population of zone	Pz	P	(default value listed; may be overridden)				27.405	27.58	27.51	14.175	27.58	27.405
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm					840	840	840	500	700	700
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er						0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%				100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list					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
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
System Ventilation Efficiency	Ev					**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm				**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf				**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p				**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%				**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm				**32975**						
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	=	77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.42						
Initial Calculations for individual zones												
OA rate per unit area for zone	Ra	cfm/sf					0.12	0.12	0.12	0.12	0.12	0.12
OA rate per person for zone	Rp	cfm/p					10.00	10.00	10.00	10.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds			840	840	840	500	700	700
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		368.0	370.4	369.4	190.4	370.4	368.0
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		368	370	369	190	370	368
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=		0.44	0.44	0.44	0.38	0.53	0.53
System Ventilation Efficiency												
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=		0.98	0.98	0.98	1.04	0.89	0.90
System Ventilation Efficiency	Ev		=	min (Evz)	=	**0.43**						

Building:						**Manassas Park Elementary School**						
System Tag/Name:						**Ventilation System**						
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				76,051						
System population (including diversity)	Ps	P				2,710						
Design primary supply fan airflow rate	Vpsd	cfm				77,970						
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf				0.13						
Average outdoor airflow rate per person for the system	Rps	cfm/p				8.5						
Inputs for Potentially Critical Zones												
Zone Name		*Zone title turns purple italic for critical zone(s)*					**Classroom**	**Classroom**	**Classroom**	**Resource Room**	**Classroom**	**Classroom**
Zone Tag							**1201**	**1202**	**1203**	**1204**	**1205**	**1206**
Space type		Select from pull-down list					**Classrooms (age 9 plus)**	**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					783	788	786	405	788	783
Design population of zone	Pz	P (default value listed; may be overridden)					27.405	27.58	27.51	14.175	27.58	27.405
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm					840	840	840	500	700	700
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er						0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%				100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list					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
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
System Ventilation Efficiency	Ev					**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm				**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf				**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p				**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%				**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm				**32975**						
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	=	77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.42						
Initial Calculations for individual zones												
OA rate per unit area for zone	Ra	cfm/sf					0.12	0.12	0.12	0.12	0.12	0.12
OA rate per person for zone	Rp	cfm/p					10.00	10.00	10.00	10.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds			840	840	840	500	700	700
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		368.0	370.4	369.4	190.4	370.4	368.0
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		368	370	369	190	370	368
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=		0.44	0.44	0.44	0.38	0.53	0.53
System Ventilation Efficiency												
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=		0.98	0.98	0.98	1.04	0.89	0.90
System Ventilation Efficiency	Ev		=	min (Evz)	=	**0.43**						

Building:						**Manassas Park Elementary School**						
System Tag/Name:						**Ventilation System**						
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				76,051						
System population (including diversity)	Ps	P				2,710						
Design primary supply fan airflow rate	Vpsd	cfm				77,970						
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf				0.13						
Average outdoor airflow rate per person for the system	Rps	cfm/p				8.5						
Inputs for Potentially Critical Zones												
Zone Name							**Classroom**	**Classroom**	**Classroom**	**Resource Room**	**Classroom**	**Classroom**
		Zone title turns purple italic for critical zone(s)										
Zone Tag							**1301**	**1302**	**1303**	**1304**	**1305**	**1306**
Space type							**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**
		Select from pull-down list										
Floor Area of zone	Az	sf					783	788	786	405	788	783
Design population of zone	Pz	P (default value listed; may be overridden)					27.405	27.58	27.51	14.175	27.58	27.405
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm					840	840	840	500	700	700
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er						0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%				100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list					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
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
System Ventilation Efficiency	Ev					**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm				**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf				**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p				**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%				**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm				**32975**						
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	=	77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.42						
Initial Calculations for individual zones												
OA rate per unit area for zone	Ra	cfm/sf					0.12	0.12	0.12	0.12	0.12	0.12
OA rate per person for zone	Rp	cfm/p					10.00	10.00	10.00	10.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds			840	840	840	500	700	700
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		368.0	370.4	369.4	190.4	370.4	368.0
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		368	370	369	190	370	368
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=		0.44	0.44	0.44	0.38	0.53	0.53
System Ventilation Efficiency												
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=		0.98	0.98	0.98	1.04	0.89	0.90
System Ventilation Efficiency	Ev		=	min (Evz)	=	**0.43**						

Building:						**Manassas Park Elementary School**						
System Tag/Name:						**Ventilation System**						
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				76,051						
System population (including diversity)	Ps	P				2,710						
Design primary supply fan airflow rate	Vpsd	cfm				77,970						
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf				0.13						
Average outdoor airflow rate per person for the system	Rps	cfm/p				8.5						
Inputs for Potentially Critical Zones												
Zone Name							**Band**	**Band**	**Commons**	**Gymnasium**	**Raised Platform**	**Teacher's Room**
						Zone title turns purple italic for critical zone(s)						
Zone Tag							**1420**	**1422**	**1430**	**1410**	**1400**	**1107**
Space type							**Music/theater/ dance**	**Music/theater/ dance**	**Cafeteria/fast food dining**	**Gym, stadium (play area)**	**Stages, studios**	**Office space**
						Select from pull-down list						
Floor Area of zone	Az	sf					1,020	1,234	4,249	6,399	1,944	173
Design population of zone	Pz	P	(default value listed; may be overridden)				35.7	43.19	424.9	191.97	136.08	0.865
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm					820	1370	5400	6000	2200	500
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er						0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%				100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list					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
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
System Ventilation Efficiency	Ev					**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm				**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf				**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p				**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%				**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm				**32975**						
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	=	77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.42						
Initial Calculations for individual zones												
OA rate per unit area for zone	Ra	cfm/sf					0.06	0.06	0.18	0.30	0.06	0.06
OA rate per person for zone	Rp	cfm/p					10.00	10.00	7.50	0.00	10.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds			820	1370	5400	6000	2200	500
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		418.2	505.9	3951.6	1919.7	1477.4	14.7
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		418	506	3952	1920	1477	15
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=		0.51	0.37	0.73	0.32	0.67	0.03
System Ventilation Efficiency												
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=		0.91	1.05	0.69	1.10	0.75	1.39
System Ventilation Efficiency	Ev		=	min (Evz)	=	**0.43**						

Building:						**Manassas Park Elementary School**						
System Tag/Name:						**Ventilation System**						
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				76,051						
System population (including diversity)	Ps	P				2,710						
Design primary supply fan airflow rate	Vpsd	cfm				77,970						
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf				0.13						
Average outdoor airflow rate per person for the system	Rps	cfm/p				8.5						
Inputs for Potentially Critical Zones												
Zone Name		*Zone title turns purple italic for critical zone(s)*					**Kitchenette**	**Teacher's Room**	**Teacher's Room**	**Kitchenette**	**Teacher's Room**	**Teacher's Room**
Zone Tag							**1108**	**1109**	**1207**	**1208**	**1209**	**1307**
Space type							**Office space**	**Office space**	**Office space**	**Office space**	**Office space**	**Office space**
		Select from pull-down list										
Floor Area of zone	Az	sf					49	176	173	49	176	173
Design population of zone	Pz	P (default value listed; may be overridden)					0.245	0.88	0.865	0.245	0.88	0.865
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm					80	160	500	80	160	500
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er						0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%				100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list					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
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
System Ventilation Efficiency	Ev					**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm				**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf				**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p				**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%				**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm				**32975**						
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	=	77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.42						
Initial Calculations for individual zones												
OA rate per unit area for zone	Ra	cfm/sf					0.06	0.06	0.06	0.06	0.06	0.06
OA rate per person for zone	Rp	cfm/p					5.00	5.00	5.00	5.00	5.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds			80	160	500	80	160	500
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		4.2	15.0	14.7	4.2	15.0	14.7
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		4	15	15	4	15	15
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=		0.05	0.09	0.03	0.05	0.09	0.03
System Ventilation Efficiency												
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=		1.37	1.33	1.39	1.37	1.33	1.39
System Ventilation Efficiency	Ev		=	min (Evz)	=	**0.43**						

Building:					**Manassas Park Elementary School**							
System Tag/Name:					**Ventilation System**							
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			76,051							
System population (including diversity)	Ps	P			2,710							
Design primary supply fan airflow rate	Vpsd	cfm			77,970							
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf			0.13							
Average outdoor airflow rate per person for the system	Rps	cfm/p			8.5							
Inputs for Potentially Critical Zones												
Zone Name						**Kitchenette**	**Teacher's Room**	**Office (gym)**	**Office (gym)**	**Office (band)**	***Office (band)***
					Zone title turns purple italic for critical zone(s)						
Zone Tag						**1308**	**1309**	**1411**	**1413**	**1424**	***1423***
Space type						**Office space**	**Office space**	**Office space**	**Office space**	**Office space**	**Office space**
		Select from pull-down list									
Floor Area of zone	Az	sf				49	176	345	172	231	234
Design population of zone	Pz	P	(default value listed; may be overridden)			0.245	0.88	1.725	0.86	1.155	1.17
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm				5	160	500	15	20	20
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A				None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er					0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed											
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list				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
Primary air fraction of supply air at conditioned analyzed	Ep										
Results											
System Ventilation Efficiency	Ev				**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm			**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf			**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p			**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%			**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm			**32975**						
Detailed Calculations											
Initial Calculations for the System as a whole											
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= Vpsd Ds	=	77970						
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.42						
Initial Calculations for individual zones											
OA rate per unit area for zone	Ra	cfm/sf				0.06	0.06	0.06	0.06	0.06	0.06
OA rate per person for zone	Rp	cfm/p				5.00	5.00	5.00	5.00	5.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	= Vdsd Ds			5	160	500	15	20	20
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=		4.2	15.0	29.3	14.6	19.6	19.9
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	=		4	15	29	15	20	20
Fraction of supply air to zone from sources outside the zone	Fa		= Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		= Ep	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		= Voz / Vdz	=		0.83	0.09	0.06	0.97	0.98	0.99
System Ventilation Efficiency											
Zone Ventilation Efficiency	Evz		= (Fa + FbXs - FcZ) / Fa	=		0.59	1.33	1.36	0.45	0.44	0.43
System Ventilation Efficiency	Ev		= min (Evz)	=	**0.43**						

Building:						**Manassas Park Elementary School**						
System Tag/Name:						**Ventilation System**						
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				76,051						
System population (including diversity)	Ps	P				2,710						
Design primary supply fan airflow rate	Vpsd	cfm				77,970						
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf				0.13						
Average outdoor airflow rate per person for the system	Rps	cfm/p				8.5						
Inputs for Potentially Critical Zones												
Zone Name							**Engineer's Office**	**Support Staff**	**Mechanical**	**Custodial**	**Storage (band)**	**Storage (gym)**
						Zone title turns purple italic for critical zone(s)						
Zone Tag							**1442**	**1441**	**1M01**	**1440**	**1420**	**1412**
Space type							**Office space**	**Office space**	**Storage rooms**	**Storage rooms**	**Storage rooms**	**Storage rooms**
						Select from pull-down list						
Floor Area of zone	Az	sf					153	177	1,212	288	334	555
Design population of zone	Pz	P	(default value listed; may be overridden)				0.765	0.885	0	0	0	0
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm					500	20	150	35	840	70
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er						0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%				100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list					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
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
System Ventilation Efficiency	Ev					**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm				**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf				**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p				**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%				**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm				**32975**						
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	=	77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.42						
Initial Calculations for individual zones												
OA rate per unit area for zone	Ra	cfm/sf					0.06	0.06	0.12	0.12	0.12	0.12
OA rate per person for zone	Rp	cfm/p					5.00	5.00	0.00	0.00	0.00	0.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds			500	20	150	35	840	70
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		13.0	15.0	145.4	34.6	40.1	66.6
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		13	15	145	35	40	67
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=		0.03	0.75	0.97	0.99	0.05	0.95
System Ventilation Efficiency												
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=		1.40	0.67	0.45	0.44	1.38	0.47
System Ventilation Efficiency	Ev		=	min (Evz)	=	**0.43**						

Building:					**Manassas Park Elementary School**							
System Tag/Name:					**Ventilation System**							
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			76,051							
System population (including diversity)	Ps	P			2,710							
Design primary supply fan airflow rate	Vpsd	cfm			77,970							
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf			0.13							
Average outdoor airflow rate per person for the system	Rps	cfm/p			8.5							
Inputs for Potentially Critical Zones												
Zone Name					*Zone title turns purple italic for critical zone(s)*		**Receiving**	**Kitchen & Adjacents**	**Classroom**	**Classroom**	**Classroom**	**Resource Room**
Zone Tag							**1434**	**1432**	**2101**	**2102**	**2103**	**2104**
Space type					Select from pull-down list		**Storage rooms**	**Cafeteria/fast food dining**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**
Floor Area of zone	Az	sf					345	2,967	783	788	786	405
Design population of zone	Pz	P	(default value listed; may be overridden)				0	296.7	27.405	27.58	27.51	14.175
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm					45	7400	840	840	840	500
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er						0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%		100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list					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
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
System Ventilation Efficiency	Ev				**0.43**							
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm			**76969**							
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf			**1.01**							
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p			**28.4**							
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%			**99%**							
Uncorrected outdoor air intake airflow rate	Vou	cfm			**32975**							
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	=	77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.42						
Initial Calculations for individual zones												
OA rate per unit area for zone	Ra	cfm/sf					0.12	0.18	0.12	0.12	0.12	0.12
OA rate per person for zone	Rp	cfm/p					0.00	7.50	10.00	10.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds			45	7400	840	840	840	500
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		41.4	2759.3	368.0	370.4	369.4	190.4
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		41	2759	368	370	369	190
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=		0.92	0.37	0.44	0.44	0.44	0.38
System Ventilation Efficiency												
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=		0.50	1.05	0.98	0.98	0.98	1.04
System Ventilation Efficiency	Ev		=	min (Evz)	=	**0.43**						

Building:						**Manassas Park Elementary School**						
System Tag/Name:						**Ventilation System**						
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				76,051						
System population (including diversity)	Ps	P				2,710						
Design primary supply fan airflow rate	Vpsd	cfm				77,970						
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf				0.13						
Average outdoor airflow rate per person for the system	Rps	cfm/p				8.5						
Inputs for Potentially Critical Zones												
Zone Name							Classroom	Classroom	Classroom	Classroom	Classroom	Resource Room
		Zone title turns purple italic for critical zone(s)										
Zone Tag							2105	2106	2201	2202	2203	2204
Space type							Classrooms (age 9 plus)	Classrooms (age 9 plus)	Classrooms (age 9 plus)	Classrooms (age 9 plus)	Classrooms (age 9 plus)	Classrooms (age 9 plus)
		Select from pull-down list										
Floor Area of zone	Az	sf					788	783	783	788	786	405
Design population of zone	Pz	P (default value listed; may be overridden)					27.58	27.405	27.405	27.58	27.51	14.175
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm					700	700	840	840	840	500
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er						0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%				100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list					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
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
System Ventilation Efficiency	Ev					**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm				**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf				**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p				**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%				**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm				**32975**						
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	=	77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.42						
Initial Calculations for individual zones												
OA rate per unit area for zone	Ra	cfm/sf					0.12	0.12	0.12	0.12	0.12	0.12
OA rate per person for zone	Rp	cfm/p					10.00	10.00	10.00	10.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds			700	700	840	840	840	500
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		370.4	368.0	368.0	370.4	369.4	190.4
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		370	368	368	370	369	190
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=		0.53	0.53	0.44	0.44	0.44	0.38
System Ventilation Efficiency												
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=		0.89	0.90	0.98	0.98	0.98	1.04
System Ventilation Efficiency	Ev		=	min (Evz)	=	**0.43**						

Building:					**Manassas Park Elementary School**							
System Tag/Name:					**Ventilation System**							
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			76,051							
System population (including diversity)	Ps	P			2,710							
Design primary supply fan airflow rate	Vpsd	cfm			77,970							
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf			0.13							
Average outdoor airflow rate per person for the system	Rps	cfm/p			8.5							
Inputs for Potentially Critical Zones						**Potentially Critical Zones**						
Zone Name						**Classroom**	**Classroom**	**Classroom**	**Classroom**	**Classroom**	**Resource Room**
					Zone title turns purple italic for critical zone(s)						
Zone Tag						**2205**	**2206**	**2301**	**2302**	**2303**	**2304**
Space type						**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**
					Select from pull-down list						
Floor Area of zone	Az	sf				788	783	783	788	786	405
Design population of zone	Pz	P			(default value listed; may be overridden)	27.58	27.405	27.405	27.58	27.51	14.175
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm				700	700	840	840	840	500
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A				None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er					0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed											
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list				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
Primary air fraction of supply air at conditioned analyzed	Ep										
Results											
System Ventilation Efficiency	Ev				**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm			**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf			**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p			**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%			**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm			**32975**						
Detailed Calculations											
Initial Calculations for the System as a whole											
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	= 77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	= 32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	= 0.42						
Initial Calculations for individual zones											
OA rate per unit area for zone	Ra	cfm/sf				0.12	0.12	0.12	0.12	0.12	0.12
OA rate per person for zone	Rp	cfm/p				10.00	10.00	10.00	10.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds		700	700	840	840	840	500
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=	370.4	368.0	368.0	370.4	369.4	190.4
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=	370	368	368	370	369	190
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=	1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=	0.53	0.53	0.44	0.44	0.44	0.38
System Ventilation Efficiency											
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=	0.89	0.90	0.98	0.98	0.98	1.04
System Ventilation Efficiency	Ev		=	min (Evz)	= **0.43**						

Building:						**Manassas Park Elementary School**						
System Tag/Name:						**Ventilation System**						
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				76,051						
System population (including diversity)	Ps	P				2,710						
Design primary supply fan airflow rate	Vpsd	cfm				77,970						
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf				0.13						
Average outdoor airflow rate per person for the system	Rps	cfm/p				8.5						
Inputs for Potentially Critical Zones												
Zone Name							**Classroom**	**Classroom**	**Choral**	**Art**	**Health Classroom**	**Media Center**
		Zone title turns purple italic for critical zone(s)										
Zone Tag							**2305**	**2306**	**2408**	**2404**	**2403**	**2410**
Space type							**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Media center**
		Select from pull-down list										
Floor Area of zone	Az	sf					788	783	898	972	972	2,651
Design population of zone	Pz	P (default value listed; may be overridden)					27.58	27.405	31.43	34.02	34.02	66.275
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm					700	700	1220	1370	1030	2400
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er						0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%				100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list					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
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
System Ventilation Efficiency	Ev					**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm				**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf				**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p				**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%				**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm				**32975**						
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	=	77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.42						
Initial Calculations for individual zones												
OA rate per unit area for zone	Ra	cfm/sf					0.12	0.12	0.12	0.12	0.12	0.12
OA rate per person for zone	Rp	cfm/p					10.00	10.00	10.00	10.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds			700	700	1220	1370	1030	2400
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		370.4	368.0	422.1	456.8	456.8	980.9
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		370	368	422	457	457	981
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=		0.53	0.53	0.35	0.33	0.44	0.41
System Ventilation Efficiency												
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=		0.89	0.90	1.08	1.09	0.98	1.01
System Ventilation Efficiency	Ev		=	min (Evz)	=	**0.43**						

Building:					**Manassas Park Elementary School**							
System Tag/Name:					**Ventilation System**							
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			76,051							
System population (including diversity)	Ps	P			2,710							
Design primary supply fan airflow rate	Vpsd	cfm			77,970							
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf			0.13							
Average outdoor airflow rate per person for the system	Rps	cfm/p			8.5							
Inputs for Potentially Critical Zones												
Zone Name						**Reading Office**	**Conference Room**	**Reading Office**	**Conference Room**	**Reading Office**	**Conference Room**
		Zone title turns purple italic for critical zone(s)									
Zone Tag						**2107**	**2108**	**2207**	**2208**	**2307**	**2308**
Space type						**Office space**	**Office space**	**Office space**	**Office space**	**Office space**	**Office space**
		Select from pull-down list									
Floor Area of zone	Az	sf				156	191	156	191	156	191
Design population of zone	Pz	P	(default value listed; may be overridden)			0.78	0.955	0.78	0.955	0.78	0.955
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm				500	20	500	20	500	20
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A				None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er					0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed											
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list				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
Primary air fraction of supply air at conditioned analyzed	Ep										
Results											
System Ventilation Efficiency	Ev				**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm			**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf			**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p			**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%			**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm			**32975**						
Detailed Calculations											
Initial Calculations for the System as a whole											
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= Vpsd Ds	=	77970						
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.42						
Initial Calculations for individual zones											
OA rate per unit area for zone	Ra	cfm/sf				0.06	0.06	0.06	0.06	0.06	0.06
OA rate per person for zone	Rp	cfm/p				5.00	5.00	5.00	5.00	5.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	= Vdsd Ds			500	20	500	20	500	20
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=		13.3	16.2	13.3	16.2	13.3	16.2
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	=		13	16	13	16	13	16
Fraction of supply air to zone from sources outside the zone	Fa		= Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		= Ep	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		= Voz / Vdz	=		0.03	0.81	0.03	0.81	0.03	0.81
System Ventilation Efficiency											
Zone Ventilation Efficiency	Evz		= (Fa + FbXs - FcZ) / Fa	=		1.40	0.61	1.40	0.61	1.40	0.61
System Ventilation Efficiency	Ev		= min (Evz)	=	**0.43**						

Building:						**Manassas Park Elementary School**						
System Tag/Name:						**Ventilation System**						
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				76,051						
System population (including diversity)	Ps	P				2,710						
Design primary supply fan airflow rate	Vpsd	cfm				77,970						
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf				0.13						
Average outdoor airflow rate per person for the system	Rps	cfm/p				8.5						
Inputs for Potentially Critical Zones												
Zone Name							Administration Suite (all spaces)	Office (media center)	Office (art)	Office (choral)	Workroom	Mechanical
						Zone title turns purple italic for critical zone(s)						
Zone Tag							2510	2411	2407	2406	2400	2M01
Space type							Office space	Office space	Office space	Office space	Office space	Storage rooms
		Select from pull-down list										
Floor Area of zone	Az	sf					4,580	147	196	196	360	194
Design population of zone	Pz	P	(default value listed; may be overridden)				22.9	0.735	0.98	0.98	1.8	0
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm					500	15	20	20	500	25
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er						0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%				100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list					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
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
System Ventilation Efficiency	Ev					**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm				**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf				**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p				**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%				**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm				**32975**						
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	=	77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.42						
Initial Calculations for individual zones												
OA rate per unit area for zone	Ra	cfm/sf					0.06	0.06	0.06	0.06	0.06	0.12
OA rate per person for zone	Rp	cfm/p					5.00	5.00	5.00	5.00	5.00	0.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds			500	15	20	20	500	25
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		389.3	12.5	16.7	16.7	30.6	23.3
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		389	12	17	17	31	23
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=		0.78	0.83	0.83	0.83	0.06	0.93
System Ventilation Efficiency												
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=		0.64	0.59	0.59	0.59	1.36	0.49
System Ventilation Efficiency	Ev		=	min (Evz)	=	**0.43**						

Building:					**Manassas Park Elementary School**							
System Tag/Name:					**Ventilation System**							
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			76,051							
System population (including diversity)	Ps	P			2,710							
Design primary supply fan airflow rate	Vpsd	cfm			77,970							
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf			0.13							
Average outdoor airflow rate per person for the system	Rps	cfm/p			8.5							
Inputs for Potentially Critical Zones												
Zone Name		*Zone title turns purple italic for critical zone(s)*				**Storage (media center)**	**Storage (media center)**	**Storage (media center)**	**Storage (media center)**	**Storage (art)**	**Classroom**
Zone Tag						**2412**	**2413**	**2414**	**2415**	**2405**	**3101**
Space type		Select from pull-down list				**Storage rooms**	**Storage rooms**	**Storage rooms**	**Storage rooms**	**Storage rooms**	**Classrooms (age 9 plus)**
Floor Area of zone	Az	sf				163	186	63	123	218	783
Design population of zone	Pz	P (default value listed; may be overridden)				0	0	0	0	0	27.405
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm				20	25	10	15	30	840
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A				None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er					0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed											
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list				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
Primary air fraction of supply air at conditioned analyzed	Ep										
Results											
System Ventilation Efficiency	Ev				**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm			**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf			**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p			**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%			**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm			**32975**						
Detailed Calculations											
Initial Calculations for the System as a whole											
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	= 77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	= 32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	= 0.42						
Initial Calculations for individual zones											
OA rate per unit area for zone	Ra	cfm/sf				0.12	0.12	0.12	0.12	0.12	0.12
OA rate per person for zone	Rp	cfm/p				0.00	0.00	0.00	0.00	0.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds		20	25	10	15	30	840
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=	19.6	22.3	7.6	14.8	26.2	368.0
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=	20	22	8	15	26	368
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=	1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=	0.98	0.89	0.76	0.98	0.87	0.44
System Ventilation Efficiency											
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=	0.44	0.53	0.67	0.44	0.55	0.98
System Ventilation Efficiency	Ev		=	min (Evz)	= **0.43**						

Building:						**Manassas Park Elementary School**						
System Tag/Name:						**Ventilation System**						
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				76,051						
System population (including diversity)	Ps	P				2,710						
Design primary supply fan airflow rate	Vpsd	cfm				77,970						
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf				0.13						
Average outdoor airflow rate per person for the system	Rps	cfm/p				8.5						
Inputs for Potentially Critical Zones												
Zone Name							**Classroom**	**Classroom**	**Resource Room**	**Classroom**	**Classroom**	**Classroom**
		Zone title turns purple italic for critical zone(s)										
Zone Tag							**3102**	**3103**	**3104**	**3105**	**3106**	**3201**
Space type							**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**
		Select from pull-down list										
Floor Area of zone	Az	sf					788	786	405	788	783	783
Design population of zone	Pz	P (default value listed; may be overridden)					27.58	27.51	14.175	27.58	27.405	27.405
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm					840	840	500	700	700	840
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er						0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%				100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list					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
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
System Ventilation Efficiency	Ev					**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm				**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf				**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p				**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%				**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm				**32975**						
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	=	77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.42						
Initial Calculations for individual zones												
OA rate per unit area for zone	Ra	cfm/sf					0.12	0.12	0.12	0.12	0.12	0.12
OA rate per person for zone	Rp	cfm/p					10.00	10.00	10.00	10.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds			840	840	500	700	700	840
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		370.4	369.4	190.4	370.4	368.0	368.0
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		370	369	190	370	368	368
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=		0.44	0.44	0.38	0.53	0.53	0.44
System Ventilation Efficiency												
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=		0.98	0.98	1.04	0.89	0.90	0.98
System Ventilation Efficiency	Ev		=	min (Evz)	=	**0.43**						

Building:						**Manassas Park Elementary School**						
System Tag/Name:						**Ventilation System**						
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				76,051						
System population (including diversity)	Ps	P				2,710						
Design primary supply fan airflow rate	Vpsd	cfm				77,970						
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf				0.13						
Average outdoor airflow rate per person for the system	Rps	cfm/p				8.5						
Inputs for Potentially Critical Zones												
Zone Name							**Classroom**	**Classroom**	**Resource Room**	**Classroom**	**Classroom**	**Classroom**
		Zone title turns purple italic for critical zone(s)										
Zone Tag							**3202**	**3203**	**3204**	**3205**	**3206**	**3301**
Space type							**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**	**Classrooms (age 9 plus)**
		Select from pull-down list										
Floor Area of zone	Az	sf					788	786	405	788	783	783
Design population of zone	Pz	P (default value listed; may be overridden)					27.58	27.51	14.175	27.58	27.405	27.405
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm					840	840	500	700	700	840
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er						0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%				100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list					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
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
System Ventilation Efficiency	Ev					**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm				**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf				**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p				**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%				**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm				**32975**						
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	=	77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.42						
Initial Calculations for individual zones												
OA rate per unit area for zone	Ra	cfm/sf					0.12	0.12	0.12	0.12	0.12	0.12
OA rate per person for zone	Rp	cfm/p					10.00	10.00	10.00	10.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds			840	840	500	700	700	840
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		370.4	369.4	190.4	370.4	368.0	368.0
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		370	369	190	370	368	368
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=		0.44	0.44	0.38	0.53	0.53	0.44
System Ventilation Efficiency												
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=		0.98	0.98	1.04	0.89	0.90	0.98
System Ventilation Efficiency	Ev		=	min (Evz)	=	**0.43**						

Building:					**Manassas Park Elementary School**							
System Tag/Name:					**Ventilation System**							
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			76,051							
System population (including diversity)	Ps	P			2,710							
Design primary supply fan airflow rate	Vpsd	cfm			77,970							
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf			0.13							
Average outdoor airflow rate per person for the system	Rps	cfm/p			8.5							
Inputs for Potentially Critical Zones												
Zone Name						Classroom	Classroom	Resource Room	Classroom	Classroom	Teacher's Room	
		Zone title turns purple italic for critical zone(s)										
Zone Tag						3302	3303	3304	3305	3306	3107	
Space type						Classrooms (age 9 plus)	Classrooms (age 9 plus)	Classrooms (age 9 plus)	Classrooms (age 9 plus)	Classrooms (age 9 plus)	Office space	
		Select from pull-down list										
Floor Area of zone	Az	sf				788	786	405	788	783	147	
Design population of zone	Pz	P	(default value listed; may be overridden)			27.58	27.51	14.175	27.58	27.405	0.735	
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm				840	840	500	700	700	160	
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A				None	None	None	None	None	None	
Local recirc.air fraction representative of ave system return air	Er					0.80	0.80	0.80	0.80	0.80	0.80	
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100%	100%	100%	100%	
Air distribution type at conditioned analyzed		Select from pull-down list				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	
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
System Ventilation Efficiency	Ev				**0.43**							
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm			**76969**							
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf			**1.01**							
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p			**28.4**							
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%			**99%**							
Uncorrected outdoor air intake airflow rate	Vou	cfm			**32975**							
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	= 77970							
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	= 32975							
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	= 0.42							
Initial Calculations for individual zones												
OA rate per unit area for zone	Ra	cfm/sf				0.12	0.12	0.12	0.12	0.12	0.06	
OA rate per person for zone	Rp	cfm/p				10.00	10.00	10.00	10.00	10.00	5.00	
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds		840	840	500	700	700	160	
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=	370.4	369.4	190.4	370.4	368.0	12.5	
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=	370	369	190	370	368	12	
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=	1.00	1.00	1.00	1.00	1.00	1.00	
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=	1.00	1.00	1.00	1.00	1.00	1.00	
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=	1.00	1.00	1.00	1.00	1.00	1.00	
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=	0.44	0.44	0.38	0.53	0.53	0.08	
System Ventilation Efficiency												
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=	0.98	0.98	1.04	0.89	0.90	1.34	
System Ventilation Efficiency	Ev		=	min (Evz)	= **0.43**							

Building:					**Manassas Park Elementary School**							
System Tag/Name:					**Ventilation System**							
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			76,051							
System population (including diversity)	Ps	P			2,710							
Design primary supply fan airflow rate	Vpsd	cfm			77,970							
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf			0.13							
Average outdoor airflow rate per person for the system	Rps	cfm/p			8.5							
Inputs for Potentially Critical Zones												
Zone Name					*Zone title turns purple italic for critical zone(s)*	**Kitchenette**	**Teacher's Room**	**Teacher's Room**	**Kitchenette**	**Teacher's Room**	**Teacher's Room**
Zone Tag						**3108**	**3109**	**3207**	**3208**	**3209**	**3307**
Space type						**Office space**	**Office space**	**Office space**	**Office space**	**Office space**	**Office space**
		Select from pull-down list									
Floor Area of zone	Az	sf				49	151	147	49	151	147
Design population of zone	Pz	P (default value listed; may be overridden)				0.245	0.755	0.735	0.245	0.755	0.735
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm				80	160	500	80	160	500
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A				None	None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er					0.80	0.80	0.80	0.80	0.80	0.80
Inputs for Operating Condition Analyzed											
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list				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
Primary air fraction of supply air at conditioned analyzed	Ep										
Results											
System Ventilation Efficiency	Ev				**0.43**						
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm			**76969**						
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf			**1.01**						
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p			**28.4**						
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%			**99%**						
Uncorrected outdoor air intake airflow rate	Vou	cfm			**32975**						
Detailed Calculations											
Initial Calculations for the System as a whole											
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	= 77970						
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	= 32975						
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	= 0.42						
Initial Calculations for individual zones											
OA rate per unit area for zone	Ra	cfm/sf				0.06	0.06	0.06	0.06	0.06	0.06
OA rate per person for zone	Rp	cfm/p				5.00	5.00	5.00	5.00	5.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds		80	160	500	80	160	500
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=	4.2	12.8	12.5	4.2	12.8	12.5
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=	4	13	12	4	13	12
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=	1.00	1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=	0.05	0.08	0.02	0.05	0.08	0.02
System Ventilation Efficiency											
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=	1.37	1.34	1.40	1.37	1.34	1.40
System Ventilation Efficiency	Ev		=	min (Evz)	= **0.43**						

Building:					**Manassas Park Elementary School**					
System Tag/Name:					**Ventilation System**					
Operating Condition Description:					**Occupied Operation Mode**					
Units (select from pull-down list)					**IP**					
Inputs for System	**Name**	**Units**			**System**				**Check Figures**	
Floor area served by system	As	sf			76,051					
System population (including diversity)	Ps	P			2,710				35.6	P/1000 sf
Design primary supply fan airflow rate	Vpsd	cfm			77,970				1.03	cfm/sf
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf			0.13				0.13	ave cfm/sf
Average outdoor airflow rate per person for the system	Rps	cfm/p			8.5				8.5	ave cfm/p
Inputs for Potentially Critical Zones										
Zone Name		*Zone title turns purple italic for critical zone(s)*				**Kitchenette**	**Teacher's Room**	**Totals/averages**		
Zone Tag						**3308**	**3309**			
Space type						**Office space**	**Office space**			
		Select from pull-down list								
Floor Area of zone	Az	sf				49	151	76051	total sf	
Design population of zone	Pz	P (default value listed; may be overridden)				0.245	0.755	2710	total P	
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm				80	160	77970	total cfm	
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A				None	None			
Local recirc.air fraction representative of ave system return air	Er					0.80	0.80	1.00	average	
Inputs for Operating Condition Analyzed										
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100%	average	
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	1.00	average	Primary airflow rate to zones
Primary air fraction of supply air at conditioned analyzed	Ep							1.00	average	77970 cfm
Results										100% Percent of design
System Ventilation Efficiency	Ev				**0.43**					
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm			**76969**					
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf			**1.01**					
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p			**28.4**					
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%			**99%**					
Uncorrected outdoor air intake airflow rate	Vou	cfm			**32975**					
Detailed Calculations										
Initial Calculations for the System as a whole										
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	Vpsd Ds	= 77970			2709.515	System population without diversity	
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	= 32975			1.00	System population diversity, D	
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	= 0.42					
Initial Calculations for individual zones										
OA rate per unit area for zone	Ra	cfm/sf				0.06	0.06			
OA rate per person for zone	Rp	cfm/p				5.00	5.00			
Total supply air to zone (at condition being analyzed)	Vdz	cfm	=	Vdsd Ds		80	160	77970		
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=	4.2	12.8	32975		
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=	4	13	32975		
Fraction of supply air to zone from sources outside the zone	Fa		=	Ep + (1-Ep)Er	=	1.00	1.00			
Fraction of supply air to zone from fully mixed primary air	Fb		=	Ep	=	1.00	1.00			
Fraction of outdoor air to zone from sources outside the zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=	1.00	1.00			
Outdoor air fraction required in air discharged to zone	Zd		=	Voz / Vdz	=	0.05	0.08	0.99	Maximum Zd	
System Ventilation Efficiency										
Zone Ventilation Efficiency	Evz		=	(Fa + FbXs - FcZ) / Fa	=	1.37	1.34			
System Ventilation Efficiency	Ev		=	min (Evz)	= **0.43**					

Appendix B: Building Envelope Requirements for Climate Zone 4A

TABLE 5.5-4 Building Envelope Requirements For Climate Zone 4 (A, B, C)*

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.173	R-5.0 c.i.
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above-Grade						
Mass	U-0.104	R-9.5 c.i.	U-0.090	R-11.4 c.i.	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.134	R-10.0
Steel-Framed	U-0.064	R-13.0 + R-7.5 c.i.	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
Wood-Framed and Other	U-0.089	R-13.0	U-0.064	R-13.0 + R-3.8 c.i.	U-0.089	R-13.0
Walls, Below-Grade						
Below-Grade Wall	C-1.140	NR	C-0.119	R-7.5 c.i.	C-1.140	NR
Floors						
Mass	U-0.087	R-8.3 c.i.	U-0.074	R-10.4 c.i.	U-0.137	R-4.2 c.i.
Steel-Joist	U-0.038	R-30.0	U-0.038	R-30.0	U-0.069	R-13.0
Wood-Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.540	R-10 for 24 in.	F-0.730	NR
Heated	F-0.860	R-15 for 24 in.	F-0.860	R-15 for 24in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Nonswinging	U-1.500		U-0.500		U-1.450	
Fenestration	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**
Vertical Glazing, 0%–40% of Wall						
Nonmetal framing (all)[b]	U-0.40	SHGC-0.40 all	U-0.40	SHGC-0.40 all	U-1.20	SHGC-NR all
Metal framing (curtainwall/storefront)[c]	U-0.50		U-0.50		U-1.20	
Metal framing (entrance door)[c]	U-0.85		U-0.85		U-1.20	
Metal framing (all other)[c]	U-0.55		U-0.55		U-1.20	
Skylight with Curb, Glass, % of Roof						
0%–2.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-0.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
2.1%–5.0%	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-0.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic, % of Roof						
0%–2.0%	U_{all}-1.30	$SHGC_{all}$-0.65	U_{all}-1.30	$SHGC_{all}$-0.62	U_{all}-1.90	$SHGC_{all}$-NR
2.1%–5.0%	U_{all}-1.30	$SHGC_{all}$-0.34	U_{all}-1.30	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All, % of Roof						
0%–2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.58	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-NR
2.1%–5.0%	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-0.58	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

*The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[b]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

Appendix C: Heat Pump Energy Compliance

TS:

ASHRAE/ARI/ISO 13256-1. English (IP) Units

Model	Fan Motor	Water Loop Heat Pump				Ground Water Heat Pump				Ground Loop Heat Pump			
		Cooling 86°F		Heating 68°F		Cooling 59°F		Heating 50°F		Cooling 77°F		Heating 32°F	
		Capacity Btuh	EER Btuh/W	Capacity Btuh	COP	Capacity Btuh	EER Btuh/W	Capacity Btuh	COP	Capacity Btuh	EER Btuh/W	Capacity Btuh	COP
TSH/V/D 018	PSC	17,300	16.2	21,400	5.4	20,200	26.7	17,400	4.6	18,300	19.0	13,400	3.7
	ECM	17,700	16.8	21,700	5.9	20,500	28.1	17,500	4.9	18,600	19.8	13,500	4.0
TSH/V/D 024	PSC	25,100	16.2	29,600	4.9	28,600	25.7	25,000	4.3	26,300	19.1	19,000	3.7
	ECM	25,000	17.0	30,000	5.3	28,100	27.4	25,100	4.6	26,000	20.0	19,400	3.8
TSH/V/D 030	PSC	28,200	15.3	34,900	5.0	31,700	22.9	29,400	4.4	29,400	17.6	23,600	3.8
	ECM	28,600	15.6	35,200	5.3	32,200	23.9	29,400	4.6	29,800	18.0	23,700	3.9
TSH/V/D 036	PSC	33,000	16.6	39,800	5.5	37,300	25.1	32,900	4.8	34,500	19.2	25,700	3.9
	ECM	33,100	17.6	39,500	5.8	37,300	26.5	32,900	5.1	34,600	20.2	25,800	4.2
TSH/V/D 042	PSC	37,400	16.0	49,400	5.4	42,900	24.3	40,100	4.6	39,300	19.4	31,600	3.8
	ECM	37,800	17.1	48,600	5.7	44,200	27.1	39,300	4.9	40,000	20.0	30,400	4.0
TSH/V/D 048	PSC	47,000	15.3	60,000	5.0	53,900	23.3	49,000	4.4	49,900	17.6	39,000	3.7
	ECM	47,600	15.9	59,700	5.2	54,100	24.6	48,700	4.5	50,100	18.5	38,400	3.8
TSH/V/D 060	PSC	61,000	15.9	70,400	5.0	67,000	23.2	58,700	4.5	63,300	18.2	46,500	3.7
	ECM	61,000	16.4	70,800	5.2	67,200	24.3	59,100	4.6	64,000	19.0	46,700	3.8
TSH/V/D 070	PSC	67,500	14.4	85,800	5.0	77,100	21.6	69,400	4.3	70,800	16.6	54,000	3.6
	ECM	67,000	15.2	84,900	5.0	77,000	23.5	69,000	4.4	70,000	17.8	53,900	3.6

Cooling capacities based upon 80.6°F DB, 66.2°F WB entering air temperature
Heating capacities based upon 68°F DB, 59°F WB entering air temperature
All ratings based upon operation at lower voltage of dual voltage rated models

GL:

Model	Voltage & Refrigerant	Water Loop Heat Pump				Ground Water Heat Pump				Ground Loop Heat Pump			
		Cooling 86°F [30°C]		Heating 68°F [20°C]		Cooling 59°F [15°C]		Heating 50°F [10°C]		Cooling 77°F [25°]		Heating 32°F [0°C]	
		Capacity	EER	Capacity	COP	Capacity	EER	Capacity	COP	Capacity	EER	Capacity	COP
	60Hz - R22	MBtuh [kW]	Btuh/W [W/W]	MBtuh [kW]		MBtuh [kW]	Btuh/W [W/W]	MBtuh [kW]		MBtuh [kW]	Btuh/W [W/W]	MBtuh [kW]	
	50Hz - R407c	kW	W/W	kW		kW	W/W	kW		kW	W/W	kW	
GLH072	60Hz - R22	68 [19.93]	13.2 [3.9]	86 [25.21]	4.6	76 [22.27]	18.7 [5.5]	69 [20.22]	4.1	70.5 [20.66]	14.6 [4.3]	52.5 [15.39]	3.5
	50Hz - R407c	16.50	4.0	18.78	4.6	17.40	4.5	11.75	3.7	19.00	5.8	15.26	4.2
GLH096	60Hz - R22	94.6 [27.73]	12.8 [3.8]	109 [31.86]	4.4	102 [29.87]	17.4 [5.1]	91 [26.67]	4.0	96.7 [28.34]	14.2 [4.2]	72.6 [21.28]	3.4
	50Hz - R407c	23.61	4.1	26.97	4.5	24.29	4.5	17.74	3.5	25.68	5.6	22.42	4.0
GLH120	60Hz - R22	120 [35.17]	12.7 [3.7]	138 [40.39]	4.2	128 [37.40]	17.2 [5.0]	114 [33.41]	3.9	122 [35.82]	14.1 [4.1]	90.5 [26.52]	3.2
	50Hz - R407c	29.24	3.7	24.58	4.5	29.99	4.2	21.99	3.3	21.52	5.2	27.95	3.9
GLV080	60Hz - R22	71 [20.81]	13.5 [4.0]	90 [26.38]	4.5	75.5 [22.13]	17.7 [5.2]	72 [21.10]	3.9	72 [21.16]	14.8 [4.3]	56.3 [16.50]	3.2
	50Hz - R407c	16.62	4.0	21.95	4.9	17.11	4.5	13.90	3.7	17.86	5.3	17.59	4.3
GLV100	60Hz - R22	97 [28.43]	12.5 [3.7]	111 [32.53]	4.5	108 [31.65]	17.0 [5.0]	90.7 [26.58]	4.0	103 [30.19]	14.3 [4.2]	73.3 [21.48]	3.3
	50Hz - R407c	23.14	3.8	27.85	4.6	24.03	4.3	18.26	3.4	25.51	5.1	22.84	4.0
GLV120	60Hz - R22	108 [31.65]	12.2 [3.6]	124 [36.34]	4.2	116 [34.14]	16.2 [4.7]	99.5 [29.16]	3.8	111 [32.53]	13.4 [3.9]	79 [23.15]	3.3
	50Hz - R407c	25.18	3.5	31.58	4.2	25.49	3.8	20.87	3.3	26.21	4.4	25.70	3.8
GLV160	60Hz - R22	142 [41.62]	13.5 [4.0]	180 [52.76]	4.5	151 [44.26]	17.7 [5.2]	144 [42.20]	3.9	144.4 [42.32]	14.8 [4.3]	112.6 [33.00]	3.2
	50Hz - R407c	33.23	4.0	43.91	4.9	34.22	4.5	27.79	3.7	35.71	5.3	35.19	4.3
GLV200	60Hz - R22	194 [56.86]	12.5 [3.7]	222 [65.06]	4.5	216 [63.31]	17.0 [5.0]	181.4 [53.17]	4.0	206 [60.38]	14.3 [4.2]	146.6 [42.97]	3.3
	50Hz - R407c	46.28	3.8	55.71	4.6	48.07	4.3	36.52	3.4	51.02	5.1	45.68	4.0
GLV240	60Hz - R22	216 [63.31]	12.2 [3.6]	248 [72.69]	4.2	233 [68.29]	16.2 [4.7]	199 [58.32]	3.8	222 [65.06]	13.4 [3.9]	158 [46.31]	3.3
	50Hz - R407c	50.37	3.5	63.16	4.2	50.98	3.8	41.73	3.3	52.43	4.4	51.39	3.8
GLV300	60Hz - R22	273 [80.01]	11.8 [3.5]	318 [93.20]	4.0	286 [83.82]	15.3 [4.5]	260.6 [76.38]	3.4	278.4 [81.59]	12.7 [3.7]	209.2 [61.31]	3.0
	50Hz - R407c	62.87	3.4	78.31	3.9	64.27	3.7	51.07	2.9	65.79	4.3	64.76	3.4

Cooling capacities based upon 80.6°F [27°C] DB, 66.2°F [19°C] WB entering air temperature.
Heating capacities based upon 68°F [20°C] DB, 59°F [15°C] WB entering air temperature.
All ratings based upon operation at the lower voltage of dual voltage rated models.

RE:

Model	Voltage & Refrigerant	Water Loop Heat Pump			
		Cooling 86°F [30°C]		Heating 68°F [20°C]	
		Capacity	EER	Capacity	COP
	60Hz - R22	MBtuh [kW]	Btuh/W [W/W]	MBtuh [kW]	
	50Hz - R22	kW	W/W	kW	
RE03	60Hz - R22	33.4 [9.79]	13.5 [4.0]	38.3 [11.23]	4.8
RE04	60Hz - R22	45.6 [13.37]	14.7 [4.3]	50.2 [14.71]	5.1
RE05	60Hz - R22	58.1 [17.03]	13.4 [3.9]	68 [19.93]	4.5
RE07	60Hz - R22	78.8 [23.10]	13.4 [3.9]	90.9 [26.64]	4.4
RE08	60Hz - R22	91.9 [26.93]	14.7 [4.3]	96.7 [28.34]	4.6
RE10	60Hz - R22	119.1 [34.91]	13.6 [4.0]	129.9 [38.07]	4.2
RE12	60Hz - R22	133.1 [39.01]	13.4 [3.9]	148.2 [43.44]	4.3
RE15	60Hz - R22	175.7 [51.50]	15.7 [4.6]	175.7 [51.50]	5.0
RE20	60Hz - R22	249.7 [73.18]	14.2 [4.2]	267.1 [78.28]	4.5

Cooling capacities based upon 80.6°F [27°C] DB, 66.2°F [19°C] WB entering air temperature.
Heating capacities based upon 68°F [20°C] DB, 59°F [15°C] WB entering air temperature.
All ratings based upon operation at the lower voltage of dual voltage rated models.
* ARI/ISO standard does not include rooftop WSHPs. Units are tested per ARI/ISO 13256-1, and may be applied to ground loop (geothermal) applications.