Grunenwald Science and Technology Building

Clarion University- Clarion, PA

Technical Report One:

ASHRAE Standard 62.1 Ventilation and Standard 90.1 Energy Design Evaluation

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Executive Summary:

In this report, the Grunenwald Science and Technology Building on Clarion University's campus was analyzed to check for compliance with ASHRAE Standard 62.1 and ASHRAE Standard 90.1. The Science and Technology Building are 98,000 square feet of new construction, along with 10,000 square feet of building renovation from the previous science building on the site. The building is comprised of university labs, classrooms, and faculty office space for science and math based areas of study.

ASHRAE Standard 62.1 was the first to be evaluated for Section 5 and 6 of the standard to check for building compliance. The analysis of Section 5 went through and checked for compliance in areas dealing with mold prevention, outdoor air intakes, humidification, particulate filtration, and drain pans employed in the building design. The analysis determined that the building did meet all minimum requirements of Section 5. Following Section 5, an analysis of Section 6 was done to determine whether the building was meeting the ventilation rate requirements set forth by ASHRAE to obtain an acceptable indoor air quality. Through calculations for each of the spaces for the particular systems, it was found through the ventilation rate procedure that all of the systems for the Science and Technology Building did meet the minimum ventilation rates.

ASHRAE Standard 90.1 was performed to see whether the building meet the minimum equipment efficiencies, and building envelope insulation values. In Section 5, the climate zone of the building was determined and used to determine the minimum U-values to be used in the building design. All construction types for walls, roof, and windows were found to comply, while the floor U-value did not comply as the air is conditioned to the same temperature below and above the slab so insulation would not be required. In Section 6, the building's HVAC system was determined to be compliant with all of the mandatory provisions, while some fans did not meet the fan power limitations set by ASHRAE. Section 7 covered the electrical water heater compliance check, in which all heaters did meet the minimum requirements. The voltage drop was then analyzed to check for compliance with Section 8. The voltage drops were designed to be less than 2% for feeders and 3% for branch circuits meeting the section guidelines. The lighting was analyzed in Section 9 using the building area method, which stipulates the Watts per square foot for a particular building type allowed. The Science and Technology Building meet the standard for Lighting Power Density (LPD).

Overall the building met nearly all of ASHRAE Standard 62.1 and 90.1 that were analyzed, with the exception of the fans in Section 6. The building design is to be energy efficient as the designers strive for a LEED Silver or Gold rating for Clarion University.

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

Section 5.1- Natural Ventilation

Natural ventilation was not considered as a ventilation strategy for the Science and Technology Building due to the complex ventilation and exhaust requirements for the research labs located in the building. The research labs and chemical storage have the need for accurate humidity control as well as containing high internal equipment loads and dangerous contaminants. All windows are inoperable for both occupant safety and security reasons for the university research taking place within the building.

Section 5.2- Ventilation Air Distribution

The building is served by three 100 % outdoor air units to meet the requirements of Section 6 for all Laboratories, and chemical storage spaces. The use of two variable air volume units, consisting of VAV reheat boxes, will continually supply the adequate ventilation required by Section 6 to the offices, and standard classrooms. The outdoor air entering the system cannot be less than that of the designed ventilation requirement, but through the use of an economizer the system can have greater CFM than the required outdoor air for the (2) VAV systems. A full analysis of Section 6 is provided in the next section of this report.

Section 5.3- Exhaust Duct Location

The exhaust that contains potentially dangerous contaminants is negatively pressurized relative to all the spaces the exhaust duct does pass through, so no contaminants from the storage or research labs will enter the building through leakage through the duct. The negative pressure is produced by the 3 primary and 1 secondary exhaust fans located on the roof of the Science and Technology Building. The exhaust goes through a smoke stack to make sure that is does not enter back into the building or into neighboring buildings or homes.

Section 5.4- Ventilation System Controls

The ventilation control works with occupancy sensors in each of the spaces in the Science and Technology Building, and is controlled by four different modes of operation which are; unoccupied heating or cooling, and occupied heating or cooling. The modes of operation will allow the system to have a setback when it is not occupied, but will still meet the minimum required ventilation air for the VAV systems. The VAV systems in the building do have an economizer to control the outdoor air damper to allow for more than the required outdoor air from Section 6 based on the outdoor air temperature. The building automation system used for the building is a BACNet communication protocol linked between the workstations and the servers on the network.

Section 5.5- Airstream Surfaces

All airstream surfaces for rectangular ducts and equipment are made of sheet metal and use metal fasteners to resist mold growth and erosion. The flexible ducts specified in the specifications are to be in accordance with the UL-181 test method.

Section 5.6- Outdoor Air Intakes

All the outdoor air intakes are at least the required minimum distance specified in Table 5-1 of ASHRAE 62.1-2007, even though the equipment is located on the roof. The exhaust air exits the building through stacks with a velocity of 7186 fpm with an effective stack height of 69 feet corresponding to a wind speed of 15 mph, meeting the minimum distance requirements for intake locations on the roof. The exhaust stacks do extend 26 feet above the roof, which would also meet the requirements as the intake is not located near the stacks on the roof plan.

The use of rain hoods and bird screens are used on every outdoor air intake for the building air handling units. The material for both is aluminum and the surface of the bird screen is vertical to prevent nesting and ½" by ½" mesh to prevent intrusion.

Table 1- Minimum Distances between Outdoor Air Intake and Exhaust Air

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.

Section 5.7- Local Capture of Contaminants

Fume hoods and self-supporting snorkels are used in the laboratory and chemical storage spaces in order to directly exhaust the contaminated air using ducts with exhaust fans located on the roof of the building.

Section 5.8- Combustion Air

The Science and Technology Building uses the campus generated steam to generate the hot water through a plate and frame heat exchanger making there no need to have a boiler. The natural gas emergency generator is located outside in a weatherproof enclosure. With no combustion equipment located within the Science and Technology Building no further analysis was needed.

Section 5.9- Particle Removal

The AHU's serving the Lab and storage spaces uses a MERV 14 for the final filter along with a MERV 7 pre-filter, and the AHU's serving the classrooms and offices uses a MERV 7. These all meet the required efficiency of at least a MERV 6, and all of the filters are located upstream of the cooling coils.

Section 5.10- Dehumidification System

The relative humidity is maintained at 50 % for summer conditions and at 35 % for winter conditions in the occupied spaces of the building, which is less than the limit of 65 % relative humidity. For the laboratory spaces, the relative humidity is maintained year round at 50 % by using both dehumidification by the cooling coil and then passing the supply air through a humidifier to get the same conditions in the lab all the time. The typical classrooms and offices are kept at a positive pressure as more air is supplied than exhausted from a space, while the labs and chemical storage rooms are kept at negative pressure to ensure no contaminates will infiltrate into adjacent rooms.

Section 5.11- Drain Pans

The use of galvanized steel drain pans with a slope of at minimum of 1/8" is used with the drain located at the lowest point of the drain pan. The galvanized steel is used to prevent corrosion of the drain pan. The location of the drain pans is under the cooling coils, beginning at the leading face and extending past to catch water droplets in the air, as through dehumidification condensation will form, and drain pans are also located under all water-producing devices located in the mechanical room. The drain pans are connected to the plumbing of the roof drains, for the HVAC modular units, and to floor drains inside the mechanical room of the building.

Section 5.12- Finned-Tube Coils and Heat Exchangers

All drain pans are compliant with Section 5.11 as described above, and are located below all condensate-producing heat exchangers. In each of the modular units, access sections are provided on both sides of the cooling and heating coils, which are greater than 18 inches in width as specified in the equipment manufacture's information.

Section 5.13- Humidifiers and Water Spray Systems

The use of a Humidifier is used to insure the designated humidity percentage is delivered to the Lab and Chemical Storage rooms. The source of the steam used to humidify is potable domestic water from the campus steam system. There are no obstructions within the absorption distance of 2.46 feet specified for each system.

Section 5.14- Access for Inspection, Cleaning, and Maintenance

Access sections are provided in the (5) modular air handling units, allowing access to all sections of the modular units including; cooling coils, heating coils, filters, humidifiers and fans. Access panels were provided in walls and inaccessible ceilings in order to access the VAV boxes, dampers, valves, and other concealed equipment.

Section 5.15- Building Envelope and Interior Surfaces

The wall and roof construction consist of a vapor barrier in order to prevent liquid penetration into the building envelope, and the foundation also has specifications for a vapor barrier placed on top of gravel rock to keep the moisture from entering through the slab on grade. The specifications also call for the proper insulation to be installed on pipes and ducts to prevent condensation from forming.

Section 5.16- Buildings with Attached Parking Garages

No parking structures are connected to the Science and Technology Building; therefore this section is not applicable.

Section 5.17- Air Classification and Recirculation

The air classification for both the lecture classrooms and offices found on Table 6-1 is an air class 1, while for University/college laboratories have an air class 2. The class 1 air can have recirculation, and in the case for this building is only used as recirculation air to the same spaces, but could go to any other air class. The class 2 air may only be recirculated within a space used for the same purpose either class 2, 3, or 4. The class 2 air is not recirculated as the University Labs require 100 % outdoor air in the Science and Technology Building.

Section 5.18- Requirements for Buildings Containing ETS Areas and Non-ETS Areas

The Grunenwald Science and Technology Center is a LEED certified building, therefore smoking is not allowed within 25 feet of the building. The contaminate from smoking would be at a distance greater than that in Section 5.6.1, since all of the outdoor air intakes are located on the roof of the three story building.

ASHRAE Standard 62.1- 2007 Section 6- Procedures:

In Section 6, the prescriptive procedure for calculating the ventilation rate required based on "the space type/application, occupancy level, and floor area." The outline for the ventilation rate procedure allows the ventilation systems to be designed for the entire building. The procedure also outlines other considerations and restrictions that must be factored in to any ventilation design.

The entire mechanical ventilation system of Grunenwald Science and Technology Building was checked for compliance with Section 6 in this study. The ventilation systems include (3) 100% outdoor air units, (2) variable air volume units, and (2) energy recovery wheels. At the site outdoor air quality has been classified as acceptable in accordance to Section 4-1 of ASHRAE Standard 62.1- 2007. Air-cleaning devices do not need to be provided for Ozone as the one-hour maximum average concentration does not exceed 0.160 ppm.

The following calculations outlined come directly from ASHRAE Standard 62.1-Section 6, and are used to calculate the compliance of building ventilation systems with Section 6.

Breathing Zone Outdoor Airflow (V_{bz})

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

where,
A_z= zone floor area: net occupiable floor area of the zone m^2 (ft^2)
P_z= zone population: the largest number of people expected to occupy the zone during typical usage.
R_p= outdoor air flow rate required per person as determined by Table 6-1 of ASHRAE Standard 62.1
R_a= outdoor air flow rate required per unit area as determined by Table 6-1 of ASHRAE Standard 62.1

Zone Air Distribution Effectiveness

The Zone Air Distribution Effectiveness (E_z) was determined by using Table 6-2, and the E_z was found to be 1.0 for the building. (E_z=1.0)

Zone Outdoor Air Flow

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

100 % Outdoor Air Systems

$V_{ot}=\Sigma_{all\ zone} V_{oz}$ (Equation 6-4)

Primary Outdoor Air Fraction

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

where,
V_{pz}= zone primary air flow, including outdoor air and recirculated air

Uncorrected Outdoor Air Intake

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

Occupant Diversity

$D=P_s/(\Sigma_{all\ zones} P_z)$ (Equation 6-7)

where, P_s= total population in the area served by the system

Standard 62.1 Compliance Check

All (5) systems were analyzed with the results for each of the systems contained within Appendix A and Appendix B. The calculations were completed using the ASHRAE Standard 62.1 User Manual, which includes a Microsoft Excel based spreadsheet. The spreadsheet has inputs such as; type of space, assumed population, and square footage of the room. For the purpose of this study all spaces were analyzed for the (3) 100 % outdoor air units. The ventilation rate was found to always meet the minimum requirement of outdoor air provided to each space except for two spaces which are labeled as the critical spaces for the analysis of AHU-1, 2, 5. The two spaces that do not comply with Section 6 are a Clean Room and Cold Room as they do not receive the minimum ventilation rate.

The VAV systems were analyzed using the same process as the 100 % outdoor air units, and all spaces in the VAV system comply with the minimum ventilation rates stated in Section 6 of ASHRAE Standard 62.1- 2007. The ventilation system efficiency (E_v) can be found on in the spreadsheet highlighted in blue for the VAV system. The VAV systems as designed is greater than the CFM required of outdoor air when the calculation requires 11,500 CFM, therefore it complies with Section 6.

ASHRAE Standard 62.1- 2007 Conclusion:

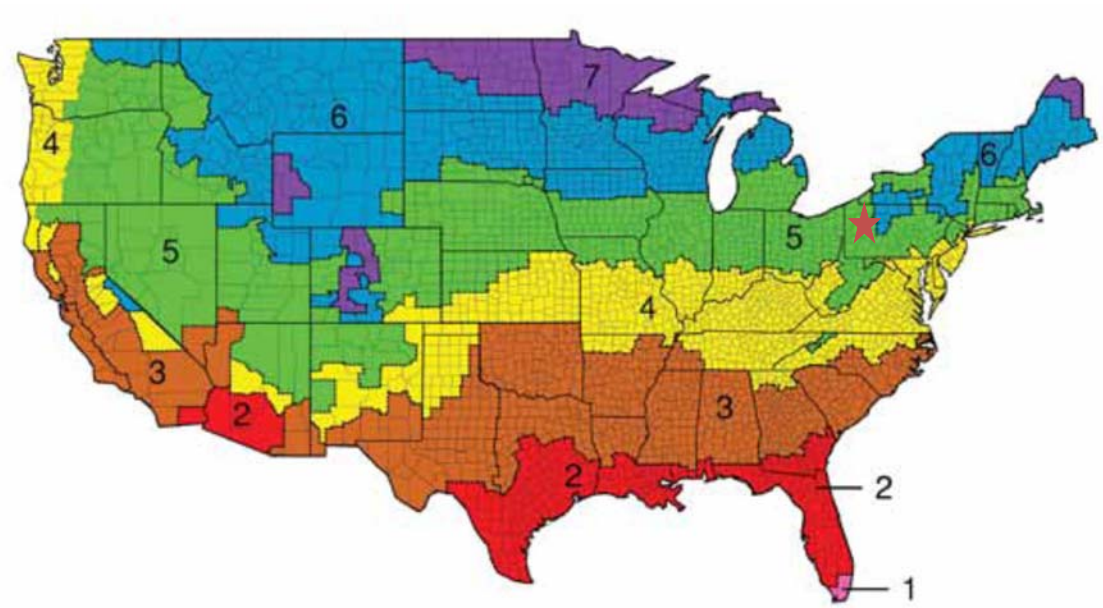
The Science and Technology Building is nearly 100 % compliant with both Sections 5 and 6 of ASHRAE Standard 62.1-2007. The building meets all requirements set forth by Section 5, but has two small rooms that do not meet the required ventilation rate for the space. Each of these spaces requires 60 CFM of outdoor air, while only receiving 50 CFM outdoor air. This may be the case do to the interior loads of those spaces controlling the needed CFM and the difference between 60 and 50 not being to great would not be noticed within those spaces as they are not occupied continuously throughout the day. The building does supply a greater percentage of outdoor air than is required through the ventilation rate procedure. By complying with ASHRAE Standard 62.1, the designers have supplied the students and faculty with an acceptable indoor air quality that provides a healthy learning and research environment in the Science and Technology Building.

ASHRAE Standard 90.1- 2007 Section 5- Building Envelope:

Section 5.1.4- Climate

The Science and Technology Building in Clarion, PA is located within Climate Zone 5A according to the following figure obtained from Appendix B of the ASHRAE Standards. The exact location of Clarion, PA is represented by the red star on Figure 1.

Figure 1- Minimum R Value Map United States Climate Zones



Section 5.4- Mandatory Compliance

All fenestrations and door frames are sealed, calked, or gasketed to prevent infiltration of outdoor air into the conditioned spaces. The utility openings through the exterior walls and the roof are also sealed in accordance with ASHRAE 90.1. The vestibules used in the Science and Technology Building are a depth of 12'-3" in compliance with the minimum requirement of a depth of 7 feet, this is so that the opening of the interior and exterior doors at the same time is not required to enter/exit the building.

<u>Section 5.5</u>- Prescriptive Building Envelope Method

This method requires that the vertical fenestration is not to exceed 40 % of the gross wall area, and for the Science and Technology Building the window to gross wall area is 34 % complying with ASHRAE Standard 90.1. The Science and Technology Building does not contain any skylight fenestrations, therefore it is in accordance with ASHRAE Standard 90.1 that states the skylight fenestrations must be less than 5 % of the the gross roof area. The compliance check for the building envelope is contained in Table 3. The ASHRAE requirements for the U values are from Table 5.5-5 from ASHRAE Standard 90.1-2007.

Table 2- Building Envelope Compliance Check

Elements	ASHRAE Assembly Max U-value	Designed Assembly Max U-value	Compliance
Roofs	0.048	0.044	Achieved
Walls	0.104	0.056	Achieved
Floors/Slabs			
Unheated Slab on grade	No Insulation Required	Not Required	Achieved
Elevated Slabs	0.087	0.76	Not Achieved
Windows			
Curtain Wall Metal Framing	0.50	0.40	Achieved
Metal Framing (All Othet)	0.55	0.40	Achieved

The Science and Technology Building complies with nearly all of Section 5 in ASHRAE Standard 90.1. The building envelope check showed that the elevated slabs to do not meet the required U-value for the assembly. The elevated slabs do not comply because the spaces above and below the floor slabs is to be conditioned to similar design conditions. The floors used between levels are 4" thick concrete slabs. The wall construction used to obtain a design U-value was 4" face brick, 1" air space, and 2" rigid insulation, while the roof construction is a roof membrane, ½" sheathing, and 4" rigid insulation. The SHGC for the curtain wall and metal framed windows analyzed above was found to be compliant as both had SHGC values less than 0.40.

ASHRAE Standard 90.1- 2007 Sect. 6-Heating, Ventilating, & Air Conditioning:

Section 6.3- Simplified Approach Option for HVAC Systems

The simplified approach cannot be used for the Science and Technology Building has a square footage of 108,000 which exceeds 25,000 square feet maximum. The building has three floors exceeding the limit of 2 stories or fewer for this approach to be used.

Section 6.4- Mandatory Provisions

All the equipment that is used must meet the minimum standards and efficiencies at operating conditions. This equipment must also be labeled by the manufacturer that it does meet Standard 90.1. The Science and Technology Building uses automatic setback controls through the building automation system to automatically adjust the set point when the building is in unoccupied mode. This occurs in this building during the overnight hours and none of the zones are scheduled to be occupied for 24 hours. All AHU's use optimized start up controls to bring the temperature to the set point prior to the scheduled occupancy in the particular zones.

Section 6.5- Prescriptive Path

The use of an air economizer in the Science and Technology Building is done for the (2) VAV AHU's as required for Climate Zone 5A for cooling loads greater than 135,000 BTU/h. The economizer makes use of dampers that control the exhaust air from these spaces and the outdoor air required to meet the cooling load CFM. The economizer operates with a high limit shut off dependent on fixed outdoor air temperature, which is in compliance for climate zone 5A according to Table 6.5.1.1.3B.

The requirements for fan power limitations of HVAC equipment with horsepower greater than 5 have to comply with those outlined in Table 6.5.3.1.1A. The fans were compared to the ASHRAE Standards of Section 6 in Table 3 to see if compliance was achieved. The exhaust fans EF-1 to EF-4 are exempt from this requirement as they are the exhaust from fume hoods, which is can explain the non-compliance with fan power limitation. There were three other fans that did not comply with Table 6.5.3.1.1A, and they were the supply fans for the AHU-1, AHU-2, and

AHU-5. These are the 100 % outdoor air units which do contain VFD motors to control the supply fans. All other fans have been calculated to satisfy Standard 90.1 Section 6.5.3.

Table 3- Fan Power Limitation Compliance Check

Fan Tag	Flow Rate (CFM)	ASHRAE Hp	Actual Hp	Compliance
EF-1	38000	57	60	Not Achieved
EF-2	38000	57	60	Not Achieved
EF-3	38000	57	60	Not Achieved
EF-4	38000	57	60	Not Achieved
RAF-3	22000	33	25	Achieved
RAF-4	19400	29.1	25	Achieved
EF-5	4500	6.75	3	Achieved
EF-6	2895	4.3	3/4	Achieved
EF-7	1750	2.6	1/6	Achieved
EF-8	1000	1.5	1/8	Achieved
EF-9	1000	1.5	1/8	Achieved
EF-10	2100	3.2	2	Achieved
EF-11	750	1.13	1/4	Achieved
AHU-1	40890	61.3	75	Not Achieved
AHU-2	41735	62.6	75	Not Achieved
AHU-3	27500	41.25	25	Achieved
AHU-4	24000	36	25	Achieved
AHU-5	22450	33.7	40	Not Achieved
ERU-1 Supply	13000	19.5	10	Achieved
ERU-1 Exhaust	14050	21.1	15	Achieved
ERU-2 Supply	4553	6.8	3	Achieved
ERU-2 Exhaust	4891	7.3	5	Achieved

The service water heaters do not need to use a heat recovery method as the building is not scheduled to be in operation for 24 hours. The Science and Technology building does contain a fume hood system that exhausts more than 15,000 CFM. To comply with ASHRAE Standard 90.1, the exhaust from the fume hoods is used in a heat recovery system to precondition the outdoor air for the 100 % outdoor air systems. The energy recovery for buildings requiring 5,000 CFM and at least 70 % outdoor air, is also fulfilled by the use of the exhaust air being used for heat recovery.

Section 6.8- Minimum Equipment Efficiency Tables

In this section, the compliance of the centrifugal chillers and cooling towers was analyzed for compliance with Standard 90.1. Both of the centrifugal chillers used in the Science and Technology Building meet the minimum equipment efficiency in ASHRAE Standard 90.1 Section 6.8. The cooling towers used in the Science and Technology Building uses two axial fan cooling towers, which comply with the ASHRAE Table 6.8.1G.

Table 4- Centrifugal Chiller Compliance Check

Label	Capacity (Tons)	Condensor Flow Rate	Temp Leaving Chilled Water	Temp Ent. Cond	ASHRAE COP	Chiller COP	Compliance
CH-1	250	3 gpm/ton	48	85	5.89	6.1	Achieved
CH-2	250	3 gpm/ton	44	85	5.55	6.1	Achieved

Table 5- Cooling Tower Compliance Check

Label	Capacity	EWT (F)	ASHRAE gpm/hp	Equipment gpm/hp	Compliance
CT-1A and CT-1B	2.4 gpm/ton, 15 hp	95	38.2	50	Achieved

ASHRAE Standard 90.1- 2007 Section 7- Service Water Heating:

Domestic hot water is supplied in the Science and Technology Building through a variety of electrical water heaters. The types of water heaters include electric vertical storage heaters and electric instant heaters. The following Table 6 lists the various types of water heaters, and was used in the analysis of each heater to compliance with Section 7. The ASHRAE requirements were obtained from equations found for electric water heaters based on volume ratings found on Table 7.8 of ASHRAE Standard 90.1.

Table 6- Electric Water Heater Compliance Check

Symbol	Fuel	Input (kW)	Storage Capacity	ASHRAE Requirement.	Compliance
EWH-1	Electric	90	250	573.4	Achieved
EWH-2	Electric	4.5	30	.89	Achieved
EWH-3	Electric	4.5	30	.89	Achieved
EWH-4	Electric	24	0	20	Achieved
EWH-5	Electric	126	0	20	Achieved

All of the electric water heaters were designed to meet the ASHRAE requirements as follows; EWH-1, EWH-4 and EWH-5 will according to the specifications need to be selected based on whether the equipment can achieve compliance with Standard 90.1 and both EWH-1 and EWH-2 are to be greater than 92 % efficient as stated in the plumbing specifications. Therefore, the water heaters selected for the Grunenwald Science and Technology Building will be compliant with Standard 90.1

ASHRAE Standard 90.1- 2007 Section 8- Power:

The requirements of Section 8 that must be followed to achieve compliance are maximum voltage drops for the feeders and branch circuits. For the feeders the maximum allowed is a 2% voltage drop and for branch circuits the maximum voltage drop is 3%. Stated in the specifications, the maximum design voltage drops have to comply with ASHRAE Standard 90.1, which implies that the building will comply with Section 8.

ASHRAE Standard 90.1- 2007 Section 9- Lighting:

Section 9.4- Mandatory Provisions

The use of automatic shut offs for the lighting systems is used in all labs, classrooms, and offices. The lighting is controlled by motion sensors which shut off the lights in the particular space when no motion has been detected within 10 minutes, which is less than the maximum time for shut off to occur of 30 minutes. The interior lighting is controlled by photoelectric sensors, which will automatically dim the lights in that space based on the natural daylight to a space. The exterior lights are controlled by a time-of-day operated control to turn the lights on or off at programmed times. The exit signs within the building are LEDs specified to use less than the maximum required value per face of 5 watts.

Section 9.5- Building Area Compliance Path

The method takes the building type and sets a requirement of watts per square footage that must be achieved for compliance with Standard 90.1. Table 7 outlines the calculated value versus the ASHRAE requirement to show whether the building complies with Section 9.

Table 7- Lighting Density Compliance Check

Building	Type	ASHRAE Required	As Designed	Compliance
Science and Technology Building	School/University	1.2 W/sf	0.87 W/sf	Achieved

ASHRAE Standard 90.1- 2007- Conclusion:

The prescriptive performance evaluation method was used to determine whether the Science and Technology Building complied with Standard 90.1. In the areas that were evaluated, the building was found to comply with nearly all of the requirements set forth. When the requirement was reached, the design of the building lead to higher efficiencies than required being meet, as the Science and Technology Building has been designed to achieve a LEED Silver rating. The areas that did not meet ASHRAE Standard 90.1 where found to be in the two following system types, the 100 % outdoor air AHU's and the pumps used in the HVAC equipment. The reason that these may not have met the Standard is the use of variable frequency drives on the supply fans and the pump motors to have a better efficiency at part load. Other than these two specific components the Science and Technology Building was found to meet the minimum requirements of ASHRAE Standard 90.1.

References:

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

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

BCJ Architects. Architectural Construction Documents. BCJ Architects, Pittsburgh, PA

Brinjac Engineering, Inc. MEP Construction Documents & Specifications. Brinjac Engineering, Inc., Harrisburg, PA

Appendix A- ASHRAE Standard 62.1 Section 6 Calculations- 100 % Outdoor Air AHU's 1, 2,

Building:	Grunenwald Science and Technology Building									
System Tag/Name:	AHU-1,2,5- Levels 1 and 2									
Operating Condition Description:	Occupied Operation Conditons									
Units (select from pull-down list)	IP									
Inputs for System	**Name**	**Units**		**System**						
Floor area served by system	As	sf		39411						
Population of area served by system (including diversity)	Ps	P	100% diversity	936						
Design primary supply fan airflow rate	Vpsd	cfm		62,640						
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.15						
OA req'd per person for system area (Weighted average)	Rps	cfm/p		8.6						
Inputs for Potentially Critical zones										
Zone Name			*Zone title turns purple italic for critical zone(s)*		Corridor	Corridor	Mudroom	Biology Storage	Soils	Rock Prep
Zone Tag					100C	100F	101A	101	103	105
Space type		Select from pull-down list			Corridors	Corridors	Corridors	Storage rooms	Health club/weight rooms	Science laboratories
Floor Area of zone	Az	sf			380	900	100	150	220	290
Design population of zone	Pz	P	(default value listed; may be overridden)		0	0	0	0	1	1
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			250	2050	75	300	350	425
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A								
Local recirc. air % representative of ave system return air	Er									
Inputs for Operating Condition Analyzed										
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	100%	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										
Ventilation System Efficiency	Ev			**0.23**						
Outdoor air intake required for system	Vot	cfm		**61536**						
Outdoor air per unit floor area	Vot/As	cfm/sf		**1.56**						
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		**65.7**						
Outdoor air as a % of design primary supply air	Ypd	cfm		**98%**						
Detailed Calculations										
Initial Calculations for the System as a whole										
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	62640						
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	13960						
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.22						
Initial Calculations for individual zones										
OA rate per unit area for zone	Raz	cfm/sf			0.06	0.06	0.06	0.12	0.06	0.18
OA rate per person	Rpz	cfm/p			0.00	0.00	0.00	0.00	20.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			250	2050	75	300	350	425
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		22.8	54.0	6.0	18.0	33.2	62.2
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		23	54	6	18	33	62
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er =		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep =		1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =		1.00	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.09	0.03	0.08	0.06	0.09	0.15
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.09	0.03	0.08	0.06	0.09	0.15
System Ventilation Efficiency										
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		1.13	1.20	1.14	1.16	1.13	1.08
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.23**						
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	n/a						
Minimum outdoor air intake airflow										
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**61536**						
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.98**						
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev =	n/a						
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps =	n/a						
OA Temp at which Min OA provides all cooling										
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTrl =	55						

Building:	Grunenwald Science and Technology Building
System Tag/Name:	AHU-1,2,5- Levels 1 and 2
Operating Condition Description:	Occupied Operation Conditons
Units (select from pull-down list)	IP

Item	Name	Units	Formula / Note		System	Chem/Bio Storage	Physics Machine	Experimental Physics	Animal Facility	Holding Aquarium
Inputs for System	**Name**	**Units**			**System**					
Floor area served by system	As	sf			39411					
Population of area served by system (including diversity)	Ps	P	100% diversity		936					
Design primary supply fan airflow rate	Vpsd	cfm			62,640					
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf			0.15					
OA req'd per person for system area (Weighted average)	Rps	cfm/p			8.6					
Inputs for Potentially Critical zones										
Zone Name			*Zone title turns purple italic for critical zone(s)*			Chem/Bio Storage	Physics Machine	Experimental Physics	Animal Facility	Holding Aquarium
Zone Tag						114A	113	115	116	116A
Space type			Select from pull-down list			Storage rooms	University/college laboratories	University/college laboratories	University/college laboratories	University/college laboratories
Floor Area of zone	Az	sf				128	200	648	730	220
Design population of zone	Pz	P	(default value listed; may be overridden)			0	6	16	0	0
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm				200	325	850	1825	550
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A							
Local recirc. air % representative of ave system return air	Er									
Inputs for Operating Condition Analyzed										
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed			Select from pull-down list			CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez					1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep									
Results										
Ventilation System Efficiency	Ev				**0.23**					
Outdoor air intake required for system	Vot	cfm			**61536**					
Outdoor air per unit floor area	Vot/As	cfm/sf			**1.56**					
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p			**65.7**					
Outdoor air as a % of design primary supply air	Ypd	cfm			**98%**					
Detailed Calculations										
Initial Calculations for the System as a whole										
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	62640					
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	13960					
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.22					
Initial Calculations for individual zones										
OA rate per unit area for zone	Raz	cfm/sf				0.12	0.18	0.18	0.18	0.18
OA rate per person	Rpz	cfm/p				0.00	10.00	10.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm				200	325	850	1825	550
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=		15.4	96.0	276.6	131.4	39.6
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	=		15	96	277	131	40
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	=		1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	=		0.08	0.30	0.33	0.07	0.07
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	=		0.08	0.30	0.33	0.07	0.07
System Ventilation Efficiency										
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	=		1.15	0.93	0.90	1.15	1.15
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=	**0.23**					
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	=	n/a					
Minimum outdoor air intake airflow										
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	=	**61536**					
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	**0.98**					
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	=	n/a					
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	=	n/a					
OA Temp at which Min OA provides all cooling										
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTri	=	55					

Building:	Grunenwald Science and Technology Building									
System Tag/Name:	AHU-1,2,5- Levels 1 and 2									
Operating Condition Description:	Occupied Operation Conditons									
Units (select from pull-down list)	IP									
Inputs for System	**Name**	**Units**		**System**						
Floor area served by system	As	sf		39411						
Population of area served by system (including diversity)	Ps	P	100% diversity	936						
Design primary supply fan airflow rate	Vpsd	cfm		62,640						
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.15						
OA req'd per person for system area (Weighted average)	Rps	cfm/p		8.6						
Inputs for Potentially Critical zones										
Zone Name			*Zone title turns purple italic for critical zone(s)*		Vestibule	Plasma Research	Nanotech Research	ADV-Comp Physics	Biology Facility	Jar
Zone Tag					New zone ID	New zone ID	New zone ID	New zone ID	New zone ID	Ne
Space type			Select from pull-down list		University/college laboratories	University/college laboratories	University/college laboratories	University/college laboratories	University/college laboratories	Uni lal
Floor Area of zone	Az	sf			225	540	1080	110	570	
Design population of zone	Pz	P	(default value listed; may be overridden)		4	16	32	3	17	
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			400	850	925	175	900	
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A							
Local recirc. air % representative of ave system return air	Er									
Inputs for Operating Condition Analyzed										
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	100%	100%	
Air distribution type at conditioned analyzed			Select from pull-down list		CS	CS	CS	CS	CS	
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00	
Primary air fraction of supply air at conditioned analyzed	Ep									
Results										
Ventilation System Efficiency	Ev			**0.23**						
Outdoor air intake required for system	Vot	cfm		**61536**						
Outdoor air per unit floor area	Vot/As	cfm/sf		**1.56**						
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		**65.7**						
Outdoor air as a % of design primary supply air	Ypd	cfm		**98%**						
Detailed Calculations										
Initial Calculations for the System as a whole										
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	62640						
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	13960						
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.22						
Initial Calculations for individual zones										
OA rate per unit area for zone	Raz	cfm/sf			0.18	0.18	0.18	0.18	0.18	
OA rate per person	Rpz	cfm/p			10.00	10.00	10.00	10.00	10.00	
Total supply air to zone (at condition being analyzed)	Vdz	cfm			400	850	925	175	900	
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		80.5	257.2	514.4	49.8	272.6	
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		81	257	514	50	273	
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er =		1.00	1.00	1.00	1.00	1.00	
Fraction of zone supply from fully mixed primary air	Fb		= Ep =		1.00	1.00	1.00	1.00	1.00	
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =		1.00	1.00	1.00	1.00	1.00	
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.20	0.30	0.56	0.28	0.30	
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.20	0.30	0.56	0.28	0.30	
System Ventilation Efficiency										
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		1.02	0.92	0.67	0.94	0.92	
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.23**						
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	n/a						
Minimum outdoor air intake airflow										
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**61536**						
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.98**						
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev =	n/a						
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps =	n/a						
OA Temp at which Min OA provides all cooling										
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTri =	55						

Building:	Grunenwald Science and Technology Building
System Tag/Name:	AHU-1,2,5- Levels 1 and 2
Operating Condition Description:	Occupied Operation Conditons
Units (select from pull-down list)	IP

Item	Name	Units	Formula / Notes	System	Lounge	Corridor	Biology Research	Faculty Musuem	Ecology	Pr
Inputs for System	**Name**	**Units**		**System**						
Floor area served by system	As	sf		39411						
Population of area served by system (including diversity)	Ps	P	100% diversity	936						
Design primary supply fan airflow rate	Vpsd	cfm		62,640						
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.15						
OA req'd per person for system area (Weighted average)	Rps	cfm/p		8.6						
Inputs for Potentially Critical zones										
Zone Name			*Zone title turns purple italic for critical zone(s)*		Lounge	Corridor	Biology Research	Faculty Musuem	Ecology	Pr
Zone Tag					200A	200C	201	202	203	
Space type			Select from pull-down list		Corridors	Corridors	University/college laboratories	Museums/galleries	University/college laboratories	
Floor Area of zone	Az	sf			885	1500	640	555	920	
Design population of zone	Pz	P	(default value listed; may be overridden)		0	0	19	17	28	
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			1450	1225	900	800	1500	
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A							
Local recirc. air % representative of ave system return air	Er									
Inputs for Operating Condition Analyzed										
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	100%	100%	
Air distribution type at conditioned analyzed			Select from pull-down list		CS	CS	CS	CS	CS	
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00	
Primary air fraction of supply air at conditioned analyzed	Ep									
Results										
Ventilation System Efficiency	Ev			**0.23**						
Outdoor air intake required for system	Vot	cfm		**61536**						
Outdoor air per unit floor area	Vot/As	cfm/sf		**1.56**						
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		**65.7**						
Outdoor air as a % of design primary supply air	Ypd	cfm		**98%**						
Detailed Calculations										
Initial Calculations for the System as a whole										
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	62640						
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	13960						
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.22						
Initial Calculations for individual zones										
OA rate per unit area for zone	Raz	cfm/sf			0.06	0.06	0.18	0.06	0.18	
OA rate per person	Rpz	cfm/p			0.00	0.00	10.00	7.50	10.00	
Total supply air to zone (at condition being analyzed)	Vdz	cfm			1450	1225	900	800	1500	
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		53.1	90.0	305.2	160.8	445.6	
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		53	90	305	161	446	
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er =		1.00	1.00	1.00	1.00	1.00	
Fraction of zone supply from fully mixed primary air	Fb		= Ep =		1.00	1.00	1.00	1.00	1.00	
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =		1.00	1.00	1.00	1.00	1.00	
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.04	0.07	0.34	0.20	0.30	
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.04	0.07	0.34	0.20	0.30	
System Ventilation Efficiency										
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		1.19	1.15	0.88	1.02	0.93	
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.23**						
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	n/a						
Minimum outdoor air intake airflow										
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**61536**						
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.98**						
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev =	n/a						
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps =	n/a						
OA Temp at which Min OA provides all cooling										
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTrf =	55						

	Name	Units		System						
Building:	Grunenwald Science and Technology Building									
System Tag/Name:	AHU-1,2,5- Levels 1 and 2									
Operating Condition Description:	Occupied Operation Conditons									
Units (select from pull-down list)	IP									
Inputs for System	**Name**	**Units**		**System**						
Floor area served by system	As	sf		39411						
Population of area served by system (including diversity)	Ps	P	100% diversity	936						
Design primary supply fan airflow rate	Vpsd	cfm		62,640						
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.15						
OA req'd per person for system area (Weighted average)	Rps	cfm/p		8.6						
Inputs for Potentially Critical zones										
Zone Name			*Zone title turns purple italic for critical zone(s)*		Bio Prep/Storage	Chem. Principle	Chem. Instruction	Freshman Majors	General Chem	Pr
Zone Tag					205A	206	206A	207	208	
Space type		Select from pull-down list			Storage rooms	University/college laboratories	University/college laboratories	Lecture classroom	University/college laboratories	
Floor Area of zone	Az	sf			490	890	1150	890	1190	
Design population of zone	Pz	P	(default value listed; may be overridden)		15	27	35	27	36	
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			950	1490	1750	1450	1525	
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A								
Local recirc. air % representative of ave system return air	Er									
Inputs for Operating Condition Analyzed										
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	100%	100%	
Air distribution type at conditioned analyzed		Select from pull-down list			CS	CS	CS	CS	CS	
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00	
Primary air fraction of supply air at conditioned analyzed	Ep									
Results										
Ventilation System Efficiency	Ev			**0.23**						
Outdoor air intake required for system	Vot	cfm		**61536**						
Outdoor air per unit floor area	Vot/As	cfm/sf		**1.56**						
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		**65.7**						
Outdoor air as a % of design primary supply air	Ypd	cfm		**98%**						
Detailed Calculations										
Initial Calculations for the System as a whole										
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	62640						
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	13960						
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.22						
Initial Calculations for individual zones										
OA rate per unit area for zone	Raz	cfm/sf			0.12	0.18	0.18	0.06	0.18	
OA rate per person	Rpz	cfm/p			0.00	10.00	10.00	7.50	10.00	
Total supply air to zone (at condition being analyzed)	Vdz	cfm			950	1490	1750	1450	1525	
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		58.8	430.2	557.0	255.9	574.2	
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		59	430	557	256	574	
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er =		1.00	1.00	1.00	1.00	1.00	
Fraction of zone supply from fully mixed primary air	Fb		= Ep =		1.00	1.00	1.00	1.00	1.00	
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =		1.00	1.00	1.00	1.00	1.00	
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.06	0.29	0.32	0.18	0.38	
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.06	0.29	0.32	0.18	0.38	
System Ventilation Efficiency										
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		1.16	0.93	0.90	1.05	0.85	
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.23**						
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	n/a						
Minimum outdoor air intake airflow										
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**61536**						
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.98**						
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev =	n/a						
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps =	n/a						
OA Temp at which Min OA provides all cooling										
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTri =	55						

Building:	Grunenwald Science and Technology Building
System Tag/Name:	AHU-1,2,5- Levels 1 and 2
Operating Condition Description:	Occupied Operation Conditons
Units (select from pull-down list)	IP

Inputs for System	Name	Units		System
Floor area served by system	As	sf		39411
Population of area served by system (including diversity)	Ps	P	100% diversity	936
Design primary supply fan airflow rate	Vpsd	cfm		62,640
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.15
OA req'd per person for system area (Weighted average)	Rps	cfm/p		8.6

Inputs for Potentially Critical zones	Name	Units	Notes	System	ones					
Zone Name			*Zone title turns purple italic for critical zone(s)*		Bio Prep/Storage	Physics	Physics Prep/Storage	Genetics	Bio Storage	Ph
Zone Tag					209A	210	210A	211	211A	
Space type			Select from pull-down list		Storage rooms	University/college laboratories	Storage rooms	University/college laboratories	Storage rooms	Uni… lal…
Floor Area of zone	Az	sf			250	1190	750	890	100	
Design population of zone	Pz	P	(default value listed; may be overridden)		8	36	23	27	3	
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			300	1800	1050	1400	200	
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A							
Local recirc. air % representative of ave system return air	Er									
Inputs for Operating Condition Analyzed										
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	100%	100%	
Air distribution type at conditioned analyzed			Select from pull-down list		CS	CS	CS	CS	CS	
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00	
Primary air fraction of supply air at conditioned analyzed	Ep									

Results	Name	Units	Value
Ventilation System Efficiency	Ev		**0.23**
Outdoor air intake required for system	Vot	cfm	**61536**
Outdoor air per unit floor area	Vot/As	cfm/sf	**1.56**
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	**65.7**
Outdoor air as a % of design primary supply air	Ypd	cfm	**98%**

Detailed Calculations	Name	Units	Formula	System	209A	210	210A	211	211A
Initial Calculations for the System as a whole									
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	62640					
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	13960					
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.22					
Initial Calculations for individual zones									
OA rate per unit area for zone	Raz	cfm/sf			0.12	0.18	0.12	0.18	0.12
OA rate per person	Rpz	cfm/p			0.00	10.00	0.00	10.00	0.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			300	1800	1050	1400	200
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		30.0	574.2	90.0	430.2	12.0
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		30	574	90	430	12
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er =		1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep =		1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =		1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.10	0.32	0.09	0.31	0.06
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.10	0.32	0.09	0.31	0.06
System Ventilation Efficiency									
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		1.12	0.90	1.14	0.92	1.16
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.23**					
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	n/a					
Minimum outdoor air intake airflow									
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**61536**					
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.98**					
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev =	n/a					
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps =	n/a					
OA Temp at which Min OA provides all cooling									
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTri =	55					

Building:	Grunenwald Science and Technology Building
System Tag/Name:	AHU-1,2,5- Levels 1 and 2
Operating Condition Description:	Occupied Operation Conditons
Units (select from pull-down list)	IP

	Name	Units			System						
Inputs for System											
Floor area served by system	As	sf			39411						
Population of area served by system (including diversity)	Ps	P	100% diversity		936						
Design primary supply fan airflow rate	Vpsd	cfm			62,640						
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf			0.15						
OA req'd per person for system area (Weighted average)	Rps	cfm/p			8.6						
Inputs for Potentially Critical zones											
Zone Name			*Zone title turns purple italic for critical zone(s)*			Corridors	Clean Cellular	*Clean Room*	Systematic Lab	Cell Tissue Culture Room	C
Zone Tag						300A	301	301A	302	303	
Space type			Select from pull-down list			Corridors	University/college laboratories	University/college laboratories	University/college laboratories	University/college laboratories	Uni la
Floor Area of zone	Az	sf				1500	900	110	580	350	
Design population of zone	Pz	P	(default value listed; may be overridden)			0	27	3	17	11	
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm				2950	1300	50	875	475	
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A								
Local recirc. air % representative of ave system return air	Er										
Inputs for Operating Condition Analyzed											
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100%	100%	100%	
Air distribution type at conditioned analyzed			Select from pull-down list			CS	CS	CS	CS	CS	
Zone air distribution effectiveness at conditioned analyzed	Ez					1.00	1.00	1.00	1.00	1.00	
Primary air fraction of supply air at conditioned analyzed	Ep										
Results											
Ventilation System Efficiency	Ev				**0.23**						
Outdoor air intake required for system	Vot	cfm			**61536**						
Outdoor air per unit floor area	Vot/As	cfm/sf			**1.56**						
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p			**65.7**						
Outdoor air as a % of design primary supply air	Ypd	cfm			**98%**						
Detailed Calculations											
Initial Calculations for the System as a whole											
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	62640						
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	13960						
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.22						
Initial Calculations for individual zones											
OA rate per unit area for zone	Raz	cfm/sf				0.06	0.18	0.18	0.18	0.18	
OA rate per person	Rpz	cfm/p				0.00	10.00	10.00	10.00	10.00	
Total supply air to zone (at condition being analyzed)	Vdz	cfm				2950	1300	50	875	475	
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=		90.0	432.0	49.8	274.4	173.0	
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	=		90	432	50	274	173	
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	
Fraction of zone supply from fully mixed primary air	Fb		= Ep	=		1.00	1.00	1.00	1.00	1.00	
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	=		0.03	0.33	1.00	0.31	0.36	
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	=		0.03	0.33	1.00	0.31	0.36	
System Ventilation Efficiency											
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	=		1.19	0.89	0.23	0.91	0.86	
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=	**0.23**						
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	=	n/a						
Minimum outdoor air intake airflow											
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	=	**61536**						
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	**0.98**						
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	=	n/a						
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	=	n/a						
OA Temp at which Min OA provides all cooling											
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTri	=	55						

Building:	Grunenwald Science and Technology Building
System Tag/Name:	AHU-1,2,5- Levels 1 and 2
Operating Condition Description:	Occupied Operation Conditons
Units (select from pull-down list)	IP

Inputs for System

	Name	Units		System
Floor area served by system	As	sf		39411
Population of area served by system (including diversity)	Ps	P	100% diversity	936
Design primary supply fan airflow rate	Vpsd	cfm		62,640
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.15
OA req'd per person for system area (Weighted average)	Rps	cfm/p		8.6

Inputs for Potentially Critical zones

Zone title turns purple italic for critical zone(s)

	Name	Units						
Zone Name				Culture Room	Lounge	Bio Research	Dark Room	Chem Storage
Zone Tag				303C	304	305	305A	307
Space type			Select from pull-down list	University/college laboratories	Corridors	University/college laboratories	Office space	Storage rooms
Floor Area of zone	Az	sf		135	445	920	245	250
Design population of zone	Pz	P	(default value listed; may be overridden)	4	0	28	7	8
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm		450	1200	1300	625	625
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A					
Local recirc. air % representative of ave system return air	Er							

Inputs for Operating Condition Analyzed

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

Results

	Name	Units	
Ventilation System Efficiency	Ev		**0.23**
Outdoor air intake required for system	Vot	cfm	**61536**
Outdoor air per unit floor area	Vot/As	cfm/sf	**1.56**
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	**65.7**
Outdoor air as a % of design primary supply air	Ypd	cfm	**98%**

Detailed Calculations

Initial Calculations for the System as a whole

	Name	Units	Formula	=	System
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	62640
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	13960
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.22

Initial Calculations for individual zones

	Name	Units	Formula	=	303C	304	305	305A	307
OA rate per unit area for zone	Raz	cfm/sf			0.18	0.06	0.18	0.06	0.12
OA rate per person	Rpz	cfm/p			10.00	0.00	10.00	5.00	0.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			450	1200	1300	625	625
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=	64.3	26.7	445.6	49.7	30.0
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	=	64	27	446	50	30
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	=	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	=	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	=	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	=	0.14	0.02	0.34	0.08	0.05
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	=	0.14	0.02	0.34	0.08	0.05

System Ventilation Efficiency

	Name	Units	Formula	=	System	303C	304	305	305A	307
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	=		1.08	1.20	0.88	1.14	1.17
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=	**0.23**					
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	=	n/a					

Minimum outdoor air intake airflow

	Name	Units	Formula	=	System
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	=	**61536**
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	**0.98**
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	=	n/a
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	=	n/a

OA Temp at which Min OA provides all cooling

OAT below which OA Intake flow is @ minimum	Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTr1	=	55

Building:	Grunenwald Science and Technology Building								
System Tag/Name:	AHU-1,2,5- Levels 1 and 2								
Operating Condition Description:	Occupied Operation Conditons								
Units (select from pull-down list)	IP								
Inputs for System	**Name**	**Units**		**System**					
Floor area served by system	As	sf		39411					
Population of area served by system (including diversity)	Ps	P	100% diversity	936					
Design primary supply fan airflow rate	Vpsd	cfm		62,640					
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.15					
OA req'd per person for system area (Weighted average)	Rps	cfm/p		8.6					
Inputs for Potentially Critical zones									
Zone Name			*Zone title turns purple italic for critical zone(s)*		Chemistry	Chem Prep	Microbiology Lab	Bio Prep/Storage	Bio Chemistry
Zone Tag					310	310A	311	311A	312
Space type			Select from pull-down list		University/college laboratories	Storage rooms	University/college laboratories	Storage rooms	University/college laboratories
Floor Area of zone	Az	sf			900	250	920	250	900
Design population of zone	Pz	P	(default value listed; may be overridden)		27	8	28	8	27
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			1400	350	1300	400	1250
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A						
Local recirc. air % representative of ave system return air	Er								
Inputs for Operating Condition Analyzed									
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed			Select from pull-down list		CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep								
Results									
Ventilation System Efficiency	Ev			**0.23**					
Outdoor air intake required for system	Vot	cfm		**61536**					
Outdoor air per unit floor area	Vot/As	cfm/sf		**1.56**					
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		**65.7**					
Outdoor air as a % of design primary supply air	Ypd	cfm		**98%**					
Detailed Calculations									
Initial Calculations for the System as a whole									
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	62640					
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	13960					
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.22					
Initial Calculations for individual zones									
OA rate per unit area for zone	Raz	cfm/sf			0.18	0.12	0.18	0.12	0.18
OA rate per person	Rpz	cfm/p			10.00	0.00	10.00	0.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			1400	350	1300	400	1250
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		432.0	30.0	445.6	30.0	432.0
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		432	30	446	30	432
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er =		1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep =		1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =		1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.31	0.09	0.34	0.08	0.35
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.31	0.09	0.34	0.08	0.35
System Ventilation Efficiency									
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		0.91	1.14	0.88	1.15	0.88
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.23**					
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	n/a					
Minimum outdoor air intake airflow									
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**61536**					
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.98**					
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev =	n/a					
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps =	n/a					
OA Temp at which Min OA provides all cooling									
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTrt =	55					

Building:	Grunenwald Science and Technology Building
System Tag/Name:	AHU-1,2,5- Levels 1 and 2
Operating Condition Description:	Occupied Operation Conditons
Units (select from pull-down list)	IP

Inputs for System	Name	Units		System
Floor area served by system	As	sf		39411
Population of area served by system (including diversity)	Ps	P	100% diversity	936
Design primary supply fan airflow rate	Vpsd	cfm		62,640
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.15
OA req'd per person for system area (Weighted average)	Rps	cfm/p		8.6

Inputs for Potentially Critical zones	Name	Units	Note	System	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Zone Name			*Zone title turns purple italic for critical zone(s)*		Bio Prep/Storage	Organic Chemistry	Prep	NMR	Instructor Room
Zone Tag					New zone ID	New zone ID	New zone ID	New zone ID	New zone ID
Space type			Select from pull-down list		Storage rooms	University/college laboratories	Storage rooms	University/college laboratories	Office space
Floor Area of zone	Az	sf			95	2130	250	360	145
Design population of zone	Pz	P	(default value listed; may be overridden)		3	64	8	11	4
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			200	5400	400	600	225
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A						
Local recirc. air % representative of ave system return air	Er								
Inputs for Operating Condition Analyzed									
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed			Select from pull-down list		CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep								

Results	Name	Units	Value
Ventilation System Efficiency	Ev		**0.23**
Outdoor air intake required for system	Vot	cfm	**61536**
Outdoor air per unit floor area	Vot/As	cfm/sf	**1.56**
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	**65.7**
Outdoor air as a % of design primary supply air	Ypd	cfm	**98%**

Detailed Calculations	Name	Units	Formula	System	Bio Prep/Storage	Organic Chemistry	Prep	NMR	Instructor Room
Initial Calculations for the System as a whole									
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	62640					
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	13960					
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.22					
Initial Calculations for individual zones									
OA rate per unit area for zone	Raz	cfm/sf			0.12	0.18	0.12	0.18	0.06
OA rate per person	Rpz	cfm/p			0.00	10.00	0.00	10.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			200	5400	400	600	225
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		11.4	1023.4	30.0	174.8	28.7
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		11	1023	30	175	29
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er =		1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep =		1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =		1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.06	0.19	0.08	0.29	0.13
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.06	0.19	0.08	0.29	0.13
System Ventilation Efficiency									
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		1.17	1.03	1.15	0.93	1.10
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.23**					
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	n/a					
Minimum outdoor air intake airflow									
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**61536**					
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.98**					
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev =	n/a					
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps =	n/a					
OA Temp at which Min OA provides all cooling									
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTr =	55					

Appendix B- ASHRAE Standard 62.1 Section 6 Calculations- VAV AHU's 3 & 4

Building:	Grunenwald Science and Technology Building	
System Tag/Name:	AHU-3, 4	
Operating Condition Description:	Occupied Operation Conditons	
Units (select from pull-down list)	IP	

	Name	Units		System	Offices 3rd Floor	Office	DC Office	Office	DC Office	Ages/Che[…] Dept.
Inputs for System										
Floor area served by system	As	sf		46169						
Population of area served by system (including diversity)	Ps	P	100% diversity	851						
Design primary supply fan airflow rate	Vpsd	cfm		72,805						
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.06						
OA req'd per person for system area (Weighted average)	Rps	cfm/p		7.1						
Inputs for Potentially Critical zones										
Zone Name			*Zone title turns purple italic for critical zone(s)*		Offices 3rd Floor	Office	DC Office	Office	DC Office	Ages/Che[…] Dept.
Zone Tag					357	353	355	351	387	389
Space type			Select from pull-down list		Office space	Office space	Office space	Office space	Office space	Storage rooms
Floor Area of zone	Az	sf			1,950	130	182	130	290	5[…]
Design population of zone	Pz	P	(default value listed; may be overridden)		15	1	1	1	1	
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			3,150	550	550	820	520	13[…]
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A							
Local recirc. air % representative of ave system return air	Er									
Inputs for Operating Condition Analyzed										
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	100%	100%	10[…]
Air distribution type at conditioned analyzed			Select from pull-down list		CS	CS	CS	CS	CS	
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00	1[…]
Primary air fraction of supply air at conditioned analyzed	Ep									
Results										
Ventilation System Efficiency	Ev			**0.78**						
Outdoor air intake required for system	Vot	cfm		**11530**						
Outdoor air per unit floor area	Vot/As	cfm/sf		**0.25**						
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		**13.5**						
Outdoor air as a % of design primary supply air	Ypd	cfm		**16%**						
Detailed Calculations										
Initial Calculations for the System as a whole										
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	72805						
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	8979						
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.12						
Initial Calculations for individual zones										
OA rate per unit area for zone	Raz	cfm/sf			0.06	0.06	0.06	0.06	0.06	0[…]
OA rate per person	Rpz	cfm/p			5.00	5.00	5.00	5.00	5.00	0[…]
Total supply air to zone (at condition being analyzed)	Vdz	cfm			3150	550	550	820	520	13[…]
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		192.0	12.8	15.9	12.8	22.4	6[…]
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		192	13	16	13	22	
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er =		1.00	1.00	1.00	1.00	1.00	1[…]
Fraction of zone supply from fully mixed primary air	Fb		= Ep =		1.00	1.00	1.00	1.00	1.00	1[…]
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =		1.00	1.00	1.00	1.00	1.00	1[…]
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.06	0.02	0.03	0.02	0.04	0[…]
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.06	0.02	0.03	0.02	0.04	0[…]
System Ventilation Efficiency										
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		1.06	1.10	1.09	1.11	1.08	1[…]
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.78**						
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	0.81						
Minimum outdoor air intake airflow										
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**11530**						
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.16**						
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev =	11148	**381.75**					
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps =	0.15	**0.03**					
OA Temp at which Min OA provides all cooling										
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTrl =	-35						

Building:	Grunenwald Science and Technology Building									
System Tag/Name:	AHU-3, 4									
Operating Condition Description:	Occupied Operation Conditons									
Units (select from pull-down list)	IP									
Inputs for System	**Name**	**Units**		**System**						
Floor area served by system	As	sf		46169						
Population of area served by system (including diversity)	Ps	P	100% diversity	851						
Design primary supply fan airflow rate	Vpsd	cfm		72,805						
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.06						
OA req'd per person for system area (Weighted average)	Rps	cfm/p		7.1						
Inputs for Potentially Critical zones										
Zone Name	*Zone title turns purple italic for critical zone(s)*				Corridor	Corridor	Corridor	Seminar	Ages GIS Lab	Server Pl
Zone Tag					300B	300C	300D	319	334	336
Space type		Select from pull-down list			Corridors	Corridors	Corridors	Lecture classroom	Lecture classroom	Storage rooms
Floor Area of zone	Az	sf			2850	1040	1040	705	1025	1
Design population of zone	Pz	P	(default value listed; may be overridden)		0	0	0	15	31	
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			2900	1040	1040	1530	1450	7
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A								
Local recirc. air % representative of ave system return air	Er									
Inputs for Operating Condition Analyzed										
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	100%	100%	10
Air distribution type at conditioned analyzed		Select from pull-down list			CS	CS	CS	CS	CS	
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00	1
Primary air fraction of supply air at conditioned analyzed	Ep									
Results										
Ventilation System Efficiency	Ev			**0.78**						
Outdoor air intake required for system	Vot	cfm		**11530**						
Outdoor air per unit floor area	Vot/As	cfm/sf		**0.25**						
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		**13.5**						
Outdoor air as a % of design primary supply air	Ypd	cfm		**16%**						
Detailed Calculations										
Initial Calculations for the System as a whole										
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	72805						
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	8979						
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.12						
Initial Calculations for individual zones										
OA rate per unit area for zone	Raz	cfm/sf			0.06	0.06	0.06	0.06	0.06	0
OA rate per person	Rpz	cfm/p			0.00	0.00	0.00	7.50	7.50	0
Total supply air to zone (at condition being analyzed)	Vdz	cfm			2900	1040	1040	1530	1450	7
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		171.0	62.4	62.4	154.8	294.0	2
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		171	62	62	155	294	
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er =		1.00	1.00	1.00	1.00	1.00	1
Fraction of zone supply from fully mixed primary air	Fb		= Ep =		1.00	1.00	1.00	1.00	1.00	1
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =		1.00	1.00	1.00	1.00	1.00	1
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.06	0.06	0.06	0.10	0.20	0
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.06	0.06	0.06	0.10	0.20	0
System Ventilation Efficiency										
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		1.06	1.06	1.06	1.02	0.92	1
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.78**						
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	0.81						
Minimum outdoor air intake airflow										
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**11530**						
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.16**						
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev =	11148						
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps =	0.15						
OA Temp at which Min OA provides all cooling										
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTr) =	-35						

Building:	Grunenwald Science and Technology Building
System Tag/Name:	AHU-3, 4
Operating Condition Description:	Occupied Operation Conditons
Units (select from pull-down list)	IP

	Name	Units			System						
Inputs for System	**Name**	**Units**			**System**						
Floor area served by system	As	sf			46169						
Population of area served by system (including diversity)	Ps	P	100% diversity		851						
Design primary supply fan airflow rate	Vpsd	cfm			72,805						
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf			0.06						
OA req'd per person for system area (Weighted average)	Rps	cfm/p			7.1						
Inputs for Potentially Critical zones						**Potentially Critical Zones**					
Zone Name			*Zone title turns purple italic for critical zone(s)*			Meteorology	*Ages Hydro*	Ages Faculty	Office	Bio/Sci Department	DC Office
Zone Tag						340	342	345	257	289	255
Space type		Select from pull-down list				Lecture classroom	Science laboratories	Lecture classroom	Office space	Office space	Office spa
Floor Area of zone	Az	sf				360	550	565	2210	575	3
Design population of zone	Pz	P	(default value listed; may be overridden)			18	28	17	17	4	
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm				600	1100	1200	4450	1275	10
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A									
Local recirc. air % representative of ave system return air	Er										
Inputs for Operating Condition Analyzed											
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100%	100%	100%	10
Air distribution type at conditioned analyzed		Select from pull-down list				CS	CS	CS	CS	CS	
Zone air distribution effectiveness at conditioned analyzed	Ez					1.00	1.00	1.00	1.00	1.00	1
Primary air fraction of supply air at conditioned analyzed	Ep										
Results											
Ventilation System Efficiency	Ev				**0.78**						
Outdoor air intake required for system	Vot	cfm			**11530**						
Outdoor air per unit floor area	Vot/As	cfm/sf			**0.25**						
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p			**13.5**						
Outdoor air as a % of design primary supply air	Ypd	cfm			**16%**						
Detailed Calculations											
Initial Calculations for the System as a whole											
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	72805						
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	8979						
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.12						
Initial Calculations for individual zones											
OA rate per unit area for zone	Raz	cfm/sf				0.06	0.18	0.06	0.06	0.06	0
OA rate per person	Rpz	cfm/p				7.50	10.00	7.50	5.00	5.00	5
Total supply air to zone (at condition being analyzed)	Vdz	cfm				600	1100	1200	4450	1275	10
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=		156.6	379.0	161.4	217.6	54.5	3
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	=		157	379	161	218	55	
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1
Fraction of zone supply from fully mixed primary air	Fb		= Ep	=		1.00	1.00	1.00	1.00	1.00	1
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	=		0.26	0.34	0.13	0.05	0.04	0
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	=		0.26	0.34	0.13	0.05	0.04	0
System Ventilation Efficiency											
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	=		0.86	0.78	0.99	1.07	1.08	1
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=	**0.78**						
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	=	0.81						
Minimum outdoor air intake airflow											
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	=	**11530**						
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	**0.16**						
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	=	11148						
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	=	0.15						
OA Temp at which Min OA provides all cooling											
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTrf	=	-35						

Building:	Grunenwald Science and Technology Building									
System Tag/Name:	AHU-3, 4									
Operating Condition Description:	Occupied Operation Conditons									
Units (select from pull-down list)	IP									
Inputs for System	**Name**	**Units**		**System**						
Floor area served by system	As	sf		46169						
Population of area served by system (including diversity)	Ps	P	100% diversity	851						
Design primary supply fan airflow rate	Vpsd	cfm		72,805						
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.06						
OA req'd per person for system area (Weighted average)	Rps	cfm/p		7.1						
Inputs for Potentially Critical zones										
Zone Name	*Zone title turns purple italic for critical zone(s)*				Geology Classrooms	Biology Resource	Rock Storage	Planeterium	Seminar	Lounge
Zone Tag					236	243	234	224	217	219
Space type		Select from pull-down list			Lecture classroom	Office space	Storage rooms	Lecture hall (fixed seats)	Lecture classroom	Corridors
Floor Area of zone	Az	sf			3070	683	285	2945	705	16
Design population of zone	Pz	P	(default value listed; may be overridden)		92	10	0	25	15	
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			6050	1010	200	2500	1520	20
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A								
Local recirc. air % representative of ave system return air	Er									
Inputs for Operating Condition Analyzed										
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	100%	100%	10
Air distribution type at conditioned analyzed		Select from pull-down list			CS	CS	CS	CS	CS	
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00	1
Primary air fraction of supply air at conditioned analyzed	Ep									
Results										
Ventilation System Efficiency	Ev			**0.78**						
Outdoor air intake required for system	Vot	cfm		**11530**						
Outdoor air per unit floor area	Vot/As	cfm/sf		**0.25**						
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		**13.5**						
Outdoor air as a % of design primary supply air	Ypd	cfm		**16%**						
Detailed Calculations										
Initial Calculations for the System as a whole										
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	72805						
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	8979						
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.12						
Initial Calculations for individual zones										
OA rate per unit area for zone	Raz	cfm/sf			0.06	0.06	0.12	0.06	0.06	0
OA rate per person	Rpz	cfm/p			7.50	5.00	0.00	7.50	7.50	0
Total supply air to zone (at condition being analyzed)	Vdz	cfm			6050	1010	200	2500	1520	20
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		874.2	91.0	34.2	364.2	154.8	9
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		874	91	34	364	155	
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er =		1.00	1.00	1.00	1.00	1.00	1
Fraction of zone supply from fully mixed primary air	Fb		= Ep =		1.00	1.00	1.00	1.00	1.00	1
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =		1.00	1.00	1.00	1.00	1.00	1
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.14	0.09	0.17	0.15	0.10	0
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.14	0.09	0.17	0.15	0.10	0
System Ventilation Efficiency										
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		0.98	1.03	0.95	0.98	1.02	1
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.78**						
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	0.81						
Minimum outdoor air intake airflow										
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**11530**						
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.16**						
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev =	11148						
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps =	0.15						
OA Temp at which Min OA provides all cooling										
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTr1 =	-35						

Building:	**Grunenwald Science and Technology Building**								
System Tag/Name:	**AHU-3, 4**								
Operating Condition Description:	**Occupied Operation Conditons**								
Units (select from pull-down list)	**IP**								
Inputs for System	**Name**	**Units**			**System**				
Floor area served by system	As	sf			46169				
Population of area served by system (including diversity)	Ps	P	100% diversity		851				
Design primary supply fan airflow rate	Vpsd	cfm			72,805				
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf			0.06				
OA req'd per person for system area (Weighted average)	Rps	cfm/p			7.1				
Inputs for Potentially Critical zones									
Zone Name	*Zone title turns purple italic for critical zone(s)*					**Math Resources**	**Classroom**	**Lobby**	**Corridors**
Zone Tag						**127**	**120**	**101**	**102**
Space type		Select from pull-down list				**Office space**	**Lecture classroom**	**Lobbies**	**Corridors**
Floor Area of zone	Az	sf				1436	7960	3260	1190
Design population of zone	Pz	P	(default value listed; may be overridden)			38	444	15	0
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm				3995	14550	850	3780
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A							
Local recirc. air % representative of ave system return air	Er								
Inputs for Operating Condition Analyzed									
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list				CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez					1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep								
Results									
Ventilation System Efficiency	Ev				**0.78**				
Outdoor air intake required for system	Vot	cfm			**11530**				
Outdoor air per unit floor area	Vot/As	cfm/sf			**0.25**				
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p			**13.5**				
Outdoor air as a % of design primary supply air	Ypd	cfm			**16%**				
Detailed Calculations									
Initial Calculations for the System as a whole									
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	72805				
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	8979				
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.12				
Initial Calculations for individual zones									
OA rate per unit area for zone	Raz	cfm/sf				0.06	0.06	0.06	0.06
OA rate per person	Rpz	cfm/p				5.00	7.50	5.00	0.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm				3995	14550	850	3780
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=		276.2	3807.6	270.6	71.4
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	=		276	3808	271	71
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	=		1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	=		0.07	0.26	0.32	0.02
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	=		0.07	0.26	0.32	0.02
System Ventilation Efficiency									
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	=		1.05	0.86	0.80	1.10
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=	**0.78**				
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	=	0.81				
Minimum outdoor air intake airflow									
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	=	**11530**				
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	**0.16**				
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	=	11148				
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	=	0.15				
OA Temp at which Min OA provides all cooling									
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTrf	=	-35				