Coppin State University Physical Education Complex - Technical Report 1

ASHRAE Standard 62.1.2007 and 90.1.2007 Analysis

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Location: Baltimore, MD

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Executive Summary

This report focuses on the Coppin State University Physical Education Complex's compliance with ASHRAE Standards 62.1.2007 & 90.1.2007. The building is a LEED® Silver complex that is 246,000 square feet and houses an arena with 4,100 seats, an eight-lane NCAA regulation pool, fitness center, dance studio, auxiliary gym, racquetball courts, classrooms, maintenance and public safety as well as a future satellite central utility plant.

ASHRAE Standard 62.1 describes the qualifications and procedures for a building to achieve acceptable indoor air quality. Section 5 describes the acceptable systems and equipment needed for outdoor air intake requirements, particulate filtration and much more. The complex was determined to be compliant with all aspects of this section. The ventilation rate procedure of section 6 (found in Appendix B) illustrates that a majority of the spaces within the complex were compliant with this section's requirements. The main reason for the non-complaint units was how the occupant levels were measured. Once the actual occupancy is declared the units can be recalibrated to meet the desired values.

An analysis of ASHRAE Standard 90.1 showed that the complex is very close to being complaint with the sections evaluated. Sections that were analyzed considered the building envelope, efficiencies of the equipment installed, power distribution, lighting power densities, and more.

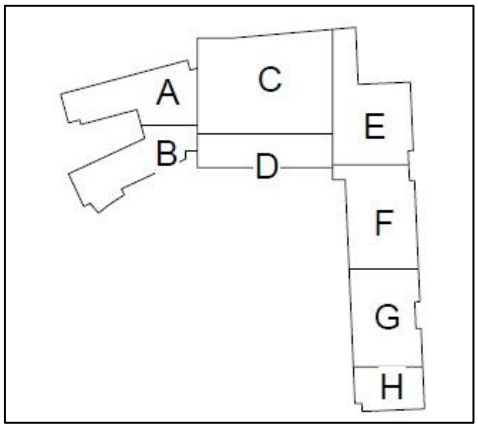
The aspects of the complex that were considered non-complaint are negligible when looking at the overall operation of the building. There is a possibility that this analysis followed a different compliance path than one used by the design engineer, and that the aspects considered non-compliant by this report are still realistically acceptable with respect to the standard.

Overall the complex is considered mostly compliant with these two ASHRAE standards and the specific sections analyzed. The building was able to gain a LEED® Silver certification. Due to these qualifications the design was performed carefully and intricately by the design engineer. Due to the complexity of the mechanical systems in the complex, a mechanical summary is included on the following pages.

Mechanical System Overview

Due to the intricacy and varying spaces in the complex it is broken up into eight zones labeled A-H as seen in Figure 1 below. The complex is served by a total of fourteen air handling units (AHUs), some interior others exterior. The future central utility plant houses two 500 ton chillers, three dual fuel 250HP boilers and space for future expansion. The cooling tower is located close to the central ytility plant, on the roof of zone A.

Figure 1 - Architectural Zoning



AHU-1 is controlled to maintain a unit discharge of 55°F, which provides sufficient cooling and dehumidification for all zones during design conditions. It serves zone A of level one which consists of shops served by constant air volume terminal units with reheat coils. Air handling units 2, 3 and 4 serve zone B on levels 1, 2 and 3, respectively; these zones are comprised of central services and facility maintenance offices. These three units utilize variable air volume (VAV) terminal units with hot water reheat coils. The arena, in zone C, is considered a single zone and is served by AHU-5 and AHU-6. Zone D includes the concourse on the second level with offices above, on the third level. This zone is served by AHU-7 on the second level and AHU-8 on the third level which both use VAV terminal units as well. The auxiliary gym is served by AHU-9 and AHU-10 in zones F and G, which also use a single zone VAV system. The classrooms and dance studio in zones G and H are served by AHU-11 with VAV air terminal units. AHU-12 and AHU-13 serve the multipurpose room and fitness area, respectively, which are also single zone VAV systems. The last unit, AHU-14, is a single zone heating only unit which serves the vehicle maintenance area in zone B. Other systems in the building include two energy recovery units which serve the locker rooms due to their high exhaust requirements and a pool dehumidification system for the indoor pool in zone E.

ASHRAE Standard 62.1.2007

Section 5 – Systems and Equipment

5.1 Natural Ventilation

The complex is designed to meet the minimum natural ventilation through engineered mechanical systems.

5.2 Ventilation Air Distribution

Most of the spaces in the complex meet ventilation requirements as later discussed in Section 6. The use of higher default occupancy values than those used by the design engineer is most likely the reason for this. All spaces in the complex will meet the minimum ventilation rates required once the system is calibrated for the actual occupancy.

5.3 Exhaust Duct Location

All exhaust ducts are negatively pressured relative to spaces through which they pass so no harmful contaminants will be exposed to those spaces.

5.4 Ventilation System Controls

Each air handling unit is energized through a DDC panel. All units are sequenced for an occupied cycle and an unoccupied cycle. During either of these cycles the minimum outdoor airflow is maintained as specified by Section 6 of Standard 62.1.2007.

5.5 Airstream Surfaces

Specification section 15810 states that all aspects of duct construction are in accordance with SMACNA Duct Construction Standards (DCS). These requirements specify an acceptable resistance to mold growth as well as resistance to erosion.

5.6 Outdoor Air Intakes

There are a total of 14 air handling units, 9 of these units are outdoor while the remaining 5 are indoor units. All units are kept separated in accordance to Table 5-1 of ASHRAE 62.1.2007 shown below as Table 1.

Table 1 - Air Intake Minimum Separation Distance

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.

All outdoor units utilize architectural louvers as intakes. Louvers are seven inch thick, storm resistant and are provided with a bird screen consisting of 16 gage aluminum wire mesh. These features allow all louvers to meet the rain and snow entrainment and intrusion requirements of section 5.6.

5.7 Local Capture of Contaminants

Exhaust fans throughout the building are ducted directly to the outdoor. Exhaust fans are equipped with backdraft dampers to prevent re-entry of any contaminants.

5.8 Combustion Air

All combustion processes are provided with sufficient air for combustion, as specified by the manufacturer. Fuel burning equipment, such as the boilers, is forced draft directly to the outdoors, ensuring adequate removal of combustion products.

5.9 Particulate Matter Removal

Every air handling unit has filters upstream of all wetted surfaces that are at minimum 2 inches thick. All filters used were either MERV 8 or MERV 13, which both meet the minimum requirement of this section of MERV 6.

5.10 Dehumidification Systems

Air handling units were designed for 50% relative humidity (RH) which is less than the required 65%RH. A space of dehumidification concern is the pool. Due to the high humidity in this area an additional dehumidification unit was installed.

This section also addresses exfiltration and requires the design minimum outdoor air intake to be greater than the design maximum exhaust airflow. The complex meets these requirements as seen in Appendix A.

5.11 Drain Pans

Every drain pan is sealed, double wall, constructed of minimum 18-gauge stainless steel. The slope is no less than 0.25 inch in one foot, exceeding the slope requirement for this section. All cooling coils have drain pans under the entire coil section and all connections are to the side of the unit for proper trapping.

5.12 Finned-Tube Coils and Heat Exchangers

Drain pans are provided beneath all dehumidifying cooling coil assemblies as mentioned in section 5.11. All finned-tube coils meet the required access space of 18" as specified by this section.

5.13 Humidifiers and Water-Spray Systems

One space of high concern for humidity is the arena. The arena floor is comprised of all wood that must be kept within a certain range of humidity. Two additional humidifiers were installed for the units serving this area. The humidifiers use potable water for humidification which meets the requirements for this section. Turning vanes and other obstructions that are installed downstream of the humidifier are placed at distances which meet or exceed the manufacturers requirements.

5.14 Access for Inspection, Cleaning and Maintenance

All of the access door sizes for the air handling units are large enough to provide unobstructed access to each part that is maintained. Access doors are sized large enough to remove fan wheel, motor and drive of each unit. Where the filters are located the access doors are the full-height of the module. All of these features are in accordance with section 5.14.

5.15 Building Envelope and Interior Surfaces

The construction of the building envelope includes proper vapor barrier to avoid liquid water penetration into the building. There are vapor retarders where necessary as well as special retarders for under the slab on grade. All interior surfaces are insulated properly to prevent condensation from forming on the exterior surfaces and within the insulating material.

5.16 Buildings with Attached Parking Garages

There are no attached parking garages so this section does not apply to the complex.

5.17 Air Classification and Recirculation

The complex has both Air Class 1 and 2. The spaces such as the auxiliary gym, arena, pool, fitness center, and shops have Air Class 2 which is air with moderate contamination or is inappropriate to recirculate. The remaining spaces are Air Class 1 which has low contamination concentration and is able to recirculate. The locker rooms also have Air Class 2; due to the energy recovery used it can be classified as Air Class 1 as long as it is diluted with outdoor air such that no more than 10% of the remaining air is Class 2 air.

5.18 ETS Area and ETS-Free Areas

The building is a LEED Silver building and a perquisite for LEED2.2 is Environmental Tobacco Smoke (ETS) Control, therefore the complex meets all requirements for this section.

Section 6 – Procedures

Section 6 of ASHRAE Standard 62.1 summarizes the Ventilation Rate Procedure. This procedure is used to design the ventilation systems in the building. It looks at the outdoor air intake rates based on the space types/application, number of occupants and the floor area of each space.

Nine of the fourteen air handling units were analyzed for this section of the standard. The complex has multiple zones that are similar as previously explained. The nine units considered address each type of zone in order to reduce redundancy the remaining units were not analyzed.

Appendix B shows a sample analysis for the spaces considered for this procedure. The spreadsheet that was used determines the minimum ventilation rates required for each space considered. The following sets of equations, from ASHRAE Standard 62.1.2007 Section 6.2.2, were used to analyze this procedure.

Breathing Zone Outdoor Airflow

$$V_{bz} = (R_p)*(P_z) + (R_a)*(A_z)$$

where

A_z = Zone floor area (ft^2)

P_z = Zone population (people)

R_p = Outdoor airflow rate required per person (cfm/person)

R_a = Outdoor airflow rate required per unit area (cfm/ft^2)

Zone Air Distribution Effectiveness

$E_z = 1$ (determined by Table 6.2 of Standard 62.1.2007)

Zone Outdoor Airflow (V_{oz})

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

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

$V_{ot} = V_{oz}$

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

$V_{ot} = (\sum_{\text{all zones}})*(V_{oz})$

Primary Outdoor Air Fraction (Z_p)

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

where

V_{pz} = zone primary airflow, for VAV systems it is the minimum expected primary airflow for design purposes

System Ventilation Efficiency

$E_v = 1$ (determined by Table 6.3 of Standard 62.1.2007)

At the conclusion of the section 6 calculations it was revealed that not all units meet the ventilation requirements, as seen in Table 2. A reason for this finding can be from the occupancy values used. For these calculations a number given by the architect or the number of chairs/seats in an area were used for number of occupants in a given space. The zones that did not meet these requirements include high occupancy areas such as the dance studio and auxiliary gym. These areas will rarely be occupied at maximum level, but if they are the units may need to be resized or adjusted to meet these airflow rates.

Table 2- Ventilation Rate Procedure Analysis

Unit	Design Min CFM	ASHRAE 62.1 Min OA	Compliance
3	3800	1653	YES
4	3400	1599	YES
5	31000	13133	YES
6	31000	13133	YES
7	2800	1018	YES
8	7500	3593	YES
9	2300	8232	NO
10	2300	8232	NO
11	9150	11064	NO

ASHRAE Standard 62.1.2007 Summary

All systems and equipment followed the requirements of all subsections, so for section 5 of this standard the complex is completely complaint. All ventilation, exhaust and supply air systems were carefully and intricately designed to adhere to all these requirements.

At the conclusion of the ventilation rate procedure analysis in section 6, a majority of the complex is considered compliant. The main reason for the non-complaint areas is most likely due to the estimated number of occupants selected per zone. The numbers used for this calculation were either given by the architect or calculated by counting the number of chairs/seats in a room. The difference in the number of people in a room can drastically change the ventilation rates as seen in the calculations above. The design engineer most likely used a different compliance path where the building is considered 100% compliant with this section.

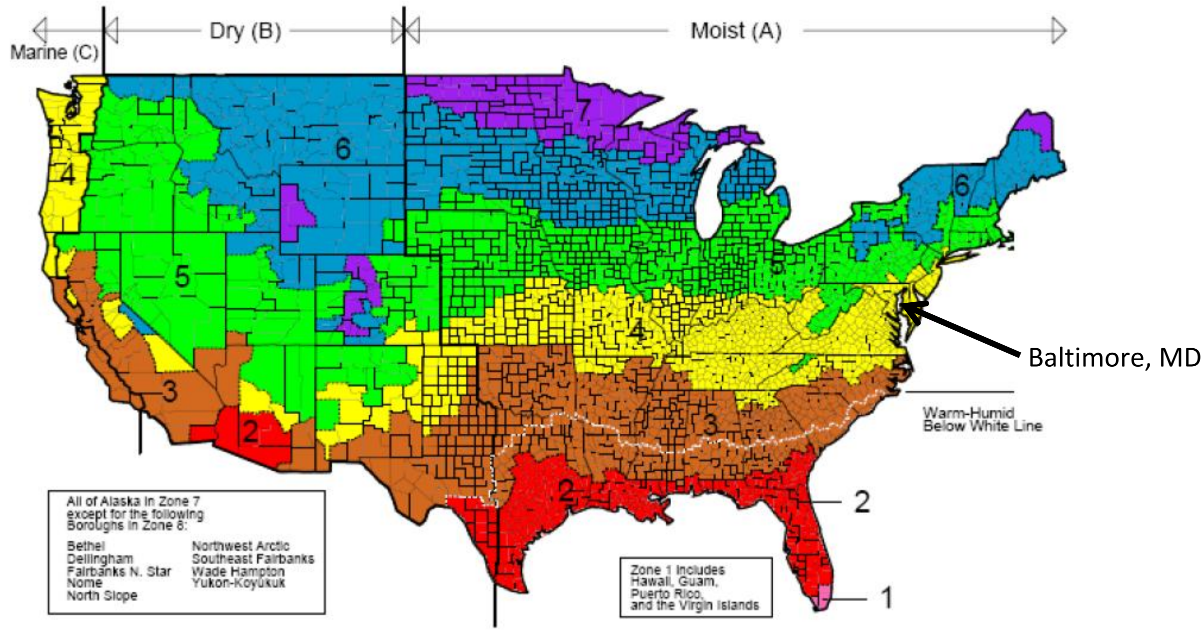
ASHRAE Standard 90.1.2007

Section 5 – Building Envelope

5.1.4 Climate

The Coppin State Physical Education Complex is located in Baltimore, MD. As seen in Figure 2 below, the complex is located in climate zone 4A. The climate in this zone is described as having mixed weather conditions with periods of high humidity.

Figure 2 - ASHRAE 90.1.2007 Climate Zone Map



5.2 Compliance Paths

The vertical fenestration area is 23% and the skylight fenestrations are less than 1%, which do not exceed the requirements of 40% and 5%, respectively. Due to these values the prescriptive building envelope option will be used for the complex.

5.4 Mandatory Provisions

There are multiple building entrances throughout the building, each have a vestibule that meets the minimum requirements of 7 feet between exterior and interior doors. All loading dock doors are weathersealed to not allow any infiltration into the adjacent spaces.

5.5 Prescriptive Building Envelope Option

The complex easily satisfies the maximum allowable vertical glazing to wall ratio of 40%. All window types used in the complex are complaint with this section of the standard, as seen in Table 3.

Table 3 - Section 5 Compliance Summary

	Minimum Roof Insulation R-Value	Minimum Wall Insulation R-Value	Non-Heated Slab on Grade Floor Minimum Insulation	Fenestration Assemebly Maximum U-Value	Fenestration Maximum SHGC
Required	R-20	R-9.5	Not Required	0.55	0.4
Designed	R-25	R-14	Not Required	0.43	0.29
Compliance	YES	YES	YES	YES	YES

Section 6 – HVAC

6.2 Compliance Path

Out of the two options to evaluate the efficiency of a building's HVAC system, the perspective path, will be used for the complex. It meets the requirements of being taller than two stories and being over 25,000 square feet in size.

6.4 Mandatory Provisions

Standard 90.1.2007 provides minimum performance requirements that must be meet by all of the mechanical equipment in the building. Table 4 shows that all of the complex's HVAC equipment that is listed is compliant with this section. The boilers used in the complex are dual fuel boilers. The tables in this standard cannot be used to analyze them, however according to Section 6.4.1 the use of equipment not listed is acceptable.

Table 4 - Minimum Equipment Efficiencies

Equipment	Size	Minimum Efficiency Req'd by ASHRAE 90.1.2007	Equipment Eficiency	Compliance
Water Cooled Centrifugal Chillers (2)	> 300 Tons	6.1 COP	7.6 COP	YES
Axial Fan Cooling Tower	95°F EWT 85°F LWT 75°F WB	≥ 35 gpm/hp	41.6 gpm/hp	YES

Each zone is equipped with wall-mounted temperature sensors that can be individually controlled by the room occupants. There are off-hour controls for each zone to help decrease the amount of energy used by the building when the spaces are unoccupied. All large spaces in the complex that have an occupancy of 40 people or greater are provided with either an air-side economizer or a design outdoor air flow greater than 3000 cfm.

The minimum duct insulation R-Value for buildings located in climate zone 4, utilizing combined heating and cooling supply and return ducts, are listed in Table 5 below.

Table 5 - Duct Insulation Requirements

	Exterior	Ventilated Attic	Unvented Attic Above Insulated Ceiling	Unvented Attic with Roof Insulation	Unconditioned Space	Indirectly Conditioned Space	Buried
Supply Required	R-6	R-6	R-6	R-3.5	R-3.5	none required	R-3.5
Supply Installed	R-4.5	R-3.7	N/A	N/A	N/A	none required	N/A
Compliance	NO	NO	YES	YES	YES	YES	YES
Return Required	R-3.5	R-3.5	R-3.5	none required	none required	none required	none required
Return Installed	R-4.5	R-3.7	N/A	none required	none required	none required	none required
Compliance	YES	YES	YES	YES	YES	YES	YES

All of the previously mentioned criteria are required for this section, so the complex is complaint with the majority of this section.

6.5 Prescriptive Path

Section 6.5.1 of ASHRAE Standard 90.1, economizers, specifies that each cooling system that has a fan must include either an air or water economizer. Table 6.5.1 of this standard specifies that within climate zone 4a there are no economizer requirements.

Fan efficiency limitations are specified in section 6.5.3. Appendix C shows the calculations for each of the exhaust fans were performed using Table 6.5.3.1.1A from ASHRAE Standard 90.1.2007.

Section 6.5.5 addresses heat rejection equipment. The complex has cooling towers with fans rated at 30HP, because of their capacity they must have the capability of operating at two-thirds of full speed according to this section. The fans that are installed are capable of this, so they are compliant with this section of the standard.

The complex utilizes two energy recovery systems in the locker rooms throughout the complex. Both of these units have capacities greater than 5000 cfm, so they must use exhaust energy recover as stated in section 6.5.6.1. The exhaust air energy recovery system must be at least 50% effective in the transfer of enthalpy between air streams. The energy recovery systems in the complex are 55% and 60% efficient which qualifies as being complaint.

6.7 Submittals

Construction documents, operation and maintenance manuals and submittals were turned over to the owner at the completion of construction. Commissioning was and will be continued to be performed on the complex. The initial commissioning was done due to LEED2.2 perquisite requirements.

Section 7 – Water Heating

This section of ASHRAE Standard 90.1.2007 analyzes the building's service hot water heating system. The standard requires an 80% efficiency for hot-water gas and oil supply boilers. The system designed for the complex consists of three boilers each with an efficiency of 80%, which meet the minimum efficiencies of this section.

Section 8 – Power

Section 8 outlines requirements for the building's power distribution system. Feeder conductors shall be sized for a maximum voltage drop of 2% design load and branch circuit conductors shall be sized for a maximum voltage drop of 3% design load. The electrical engineer designed the complex's system to adhere to this standard, so the complex is assumed to be compliant with this section.

Section 9 – Lighting

This section addresses all lighting equipment, both interior and exterior.

Automatic lighting shutoff is required for the complex because it is larger than 5,000 square feet. The specifications state that there are wall and ceiling mounted occupancy sensors located throughout the building in order to comply with this standard. The exterior lighting is operated by an automatic light-level sensor which makes all exterior lighting compliant with this section.

The building area method was used for the lighting power density (LPD) calculation for the complex, as seen in Table 6. A building type area of a school or university was used at 1.2 W/ft^2. The fourth floor was not evaluated because it is mainly mechanical rooms. It is assumed that this floor will also be compliant considering the rest of the building is.

Table 6 - Lighting Power Density (LPD) Calculations

	Floor Area (sq. ft.)	Wattage (per floor)	LPD Designed	LPD Required	Compliance
First Floor	152580	138710	1.1	1.2	YES
Second Floor	41920	46580	0.9	1.2	YES
Third Floor	25600	32000	0.8	1.2	YES
Overall	220100	217290	0.99	1.2	YES

ASHRAE Standard 90.1.2007 Summary

Coppin State University's Physical Education Complex received a LEED® Silver rating. Due to this qualification the energy efficiency of the complex was heavily influenced. The majority of the complex was complaint with the sections analyzed. The only non-complaint section included the duct insulation requirements which are not a huge concern, the current owner and facility maintenance crew will just have to be aware of the small consequences associated with this.

Appendix A – Exhaust Air Exfiltration and Outdoor Air Exfiltration

Unit	Duty	Airflow (CFM)
EF -1	Generator Room Exhaust	1225
EF -2	Main Electric Room Exhaust	7000
EF - 2A	Main Electric Room Exhaust	7000
EF -3	Fume Hood Exhaust	475
EF - 4	General Exhaust	650
EF -5	General Exhaust	500
EF -6	General Exhaust	1300
EF -7	General Exhaust	750
EF -8	General Exhaust	800
EF -9	General Exhaust	1100
EF -10	General Exhaust	750
EF -11	General Exhaust	1000
EF -12	General Exhaust	1000
EF -13	General Exhaust	120
EF -14	General Exhaust	2200
EF -15	General Exhaust	500
EF -16	General Exhaust	200
EF -17	General Exhaust	2250
EF -18	General Exhaust	1000
EF -19	General Exhaust	2180
EF -20	General Exhaust	500
EF -21	General Exhaust	850
EF -22	General Exhaust	1000
EF -23	Chiller Room Exhaust	5100
EF -24	Chiller Room Ventilation	4000
EF -25	General Exhaust	1530
EF -26	General Exhaust	1475
EF -27	General Exhaust	1475
EF -28	General Exhaust	1500
EF -29	Ventilation	5100
EF -30	Ventilation	5100
Total		**59630**

Unit	Min. Outdoor Air (CFM)
AHU - 1	4400
AHU - 2	1975
AHU - 3	3800
AHU - 4	3400
AHU - 5	31000
AHU - 6	31000
AHU - 7	2800
AHU - 8	7500
AHU - 9	2300
AHU - 10	2300
AHU - 11	9150
AHU - 12	2600
AHU - 13	2500
AHU - 14	480
Total	**105205**

Appendix B – Sample Minimum Ventilation Calculation

Building:	Coppin State Phys Ed Complex											
System Tag/Name:	AHU- 11											
Operating Condition Description:	Classrooms, HPERD, Dance											
Units (select from pull-down list)	IP											
Inputs for System	**Name**	**Units**			**System**							
Floor area served by system	As	sf			24225							
Population of area served by system (including diversity)	Ps	P	100% diversity		490							
Design primary supply fan airflow rate	Vpsd	cfm			32,280							
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf			0.08							
OA req'd per person for system area (Weighted average)	Rps	cfm/p			10.4							
Inputs for Potentially Critical zones												
Zone Name	*Zone title turns purple italic for critical zone(s)*					Corridor	PE Lab Stu B	PE Comp Lab	Corridor	PE Lab Stu A	Mens	Womens
Zone Tag						45	114	115	116	117	118	119
Space type		Select from pull-down list				Corridors	Classrooms (age 9 plus)	Computer lab	Corridors	Classrooms (age 9 plus)	Storage rooms	Storage rooms
Floor Area of zone	Az	sf				700	160	860	795	145	255	255
Design population of zone	Pz	P	(default value listed; may be overridden)			0	6	45	0	6	0	0
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm				280	400	2250	430	400	125	125
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					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list				CS	CS	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez					1.00	1.00	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Results												
Ventilation System Efficiency	Ev				0.63							
Outdoor air intake required for system	Vot	cfm			11064							
Outdoor air per unit floor area	Vot/As	cfm/sf			0.46							
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p			22.6							
Outdoor air as a % of design primary supply air	Ypd	cfm			34%							
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	32280							
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	6989							
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	0.12	0.12	0.06	0.12	0.12	0.12
OA rate per person	Rpz	cfm/p				0.00	10.00	10.00	0.00	10.00	0.00	0.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm				280	400	2250	430	400	125	125
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=		42.0	79.2	553.2	47.7	77.4	30.6	30.6
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	=		42	79	553	48	77	31	31
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	=		0.15	0.20	0.25	0.11	0.19	0.24	0.24
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	=		0.15	0.20	0.25	0.11	0.19	0.24	0.24
System Ventilation Efficiency												
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	=		1.07	1.02	0.97	1.11	1.02	0.97	0.97
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=	0.63							
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	=	11064							
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	0.34							
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	=	22							

	Name	Units	Formula	System	Classroom	Corridor	Corridor	South Lobby Open Stair	Control	Classroom 1	Classroom 2
Building:	Coppin State Phys Ed Complex										
System Tag/Name:	AHU- 11										
Operating Condition Description:	Classrooms, HPERD, Dance										
Units (select from pull-down list)	IP										
Inputs for System	**Name**	**Units**		**System**							
Floor area served by system	As	sf		24225							
Population of area served by system (including diversity)	Ps	P	100% diversity	490							
Design primary supply fan airflow rate	Vpsd	cfm		32,280							
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.08							
OA req'd per person for system area (Weighted average)	Rps	cfm/p		10.4							
Inputs for Potentially Critical zones											
Zone Name			*Zone title turns purple italic for critical zone(s)*		Classroom	Corridor	Corridor	South Lobby Open Stair	Control	Classroom 1	Classroom 2
Zone Tag					120	121	122	123	124	125	126
Space type			Select from pull-down list		Classrooms (age 9 plus)	Corridors	Corridors	Lobbies	Office space	Classrooms (age 9 plus)	Classrooms (age 9 plus)
Floor Area of zone	Az	sf			1410	1396	865	1040	170	940	940
Design population of zone	Pz	P	(default value listed; may be overridden)		50	0	0	0	3	40	40
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			1520	3000	630	1500	160	2100	2100
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				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Inputs for Operating Condition Analyzed											
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed			Select from pull-down list		CS	CS	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep										
Results											
Ventilation System Efficiency	Ev			0.63							
Outdoor air intake required for system	Vot	cfm		11064							
Outdoor air per unit floor area	Vot/As	cfm/sf		0.46							
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		22.6							
Outdoor air as a % of design primary supply air	Ypd	cfm		34%							
Detailed Calculations											
Initial Calculations for the System as a whole											
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	32280							
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	6989							
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	0.06	0.06	0.06	0.06	0.12	0.12
OA rate per person	Rpz	cfm/p			10.00	0.00	0.00	5.00	5.00	10.00	10.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			1520	3000	630	1500	160	2100	2100
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		669.2	83.7	51.9	62.4	25.2	512.8	512.8
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		669	84	52	62	25	513	513
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er =		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep =		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.44	0.03	0.08	0.04	0.16	0.24	0.24
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.44	0.03	0.08	0.04	0.16	0.24	0.24
System Ventilation Efficiency											
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		0.78	1.19	1.13	1.17	1.06	0.97	0.97
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	0.63							
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 =	11064							
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	0.34							
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 =	22							

Building:	Coppin State Phys Ed Complex				
System Tag/Name:	AHU- 11				
Operating Condition Description:	Classrooms, HPERD, Dance				
Units (select from pull-down list)	IP				

Inputs for System	Name	Units		System
Floor area served by system	As	sf		24225
Population of area served by system (including diversity)	Ps	P	100% diversity	490
Design primary supply fan airflow rate	Vpsd	cfm		32,280
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.08
OA req'd per person for system area (Weighted average)	Rps	cfm/p		10.4

Pote

Inputs for Potentially Critical zones	Name	Units		System							
Zone Name			*Zone title turns purple italic for critical zone(s)*		Conference Room	Chair's Office	Corridor	Mens	Womens	Admin Workroom	Corridor
Zone Tag					127	128	129	130	131	132	133
Space type			Select from pull-down list		Conference/meeting	Office space	Corridors	Storage rooms	Storage rooms	Office space	Corridors
Floor Area of zone	Az	sf			325	200	600	210	210	170	575
Design population of zone	Pz	P	(default value listed; may be overridden)		14	4	0	0	0	2	0
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			560	590	1160	200	200	500	170
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%	100%
Air distribution type at conditioned analyzed			Select from pull-down list		CS	CS	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep										

Results	Name	Units		Value
Ventilation System Efficiency	Ev			0.63
Outdoor air intake required for system	Vot	cfm		11064
Outdoor air per unit floor area	Vot/As	cfm/sf		0.46
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		22.6
Outdoor air as a % of design primary supply air	Ypd	cfm		34%

Detailed Calculations	Name	Units		Formula		System	127	128	129	130	131	132	133
Initial Calculations for the System as a whole													
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	VpdDs	=	32280							
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	6989							
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	0.12	0.06	0.06
OA rate per person	Rpz	cfm/p					5.00	5.00	0.00	0.00	0.00	5.00	0.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm					560	590	1160	200	200	500	170
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		89.5	32.0	36.0	25.2	25.2	20.2	34.5
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		90	32	36	25	25	20	35
Fraction of zone supply not directly recirc. from zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		=	Ep	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		=	Voz / Vdz	=		0.16	0.05	0.03	0.13	0.13	0.04	0.20
Unused OA fraction required in primary air to zone	Zp		=	Voz / Vpz	=		0.16	0.05	0.03	0.13	0.13	0.04	0.20
System Ventilation Efficiency													
Zone Ventilation Efficiency (App A Method)	Evz		=	(Fa + FbXs - FcZ) / Fa	=		1.06	1.16	1.19	1.09	1.09	1.18	1.01
System Ventilation Efficiency (App A Method)	Ev		=	min (Evz)	=	0.63							
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	=	11064							
OA intake req'd as a fraction of primary SA	Y		=	Vot / Vps	=	0.34							
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	=	22							

Building:	Coppin State Phys Ed Complex										
System Tag/Name:	AHU- 11										
Operating Condition Description:	Classrooms, HPERD, Dance										
Units (select from pull-down list)	IP										
Inputs for System	**Name**	**Units**			**System**						
Floor area served by system	As	sf			24225						
Population of area served by system (including diversity)	Ps	P	100% diversity		490						
Design primary supply fan airflow rate	Vpsd	cfm			32,280						
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf			0.08						
OA req'd per person for system area (Weighted average)	Rps	cfm/p			10.4						
Inputs for Potentially Critical zones						ntially Critical Zones					
Zone Name			Zone title turns purple italic for critical zone(s)			Rec Dir Office	Corridor	HPERD Lab	Admin Office	Faculty Office	Faculty Office	Faculty Office
Zone Tag						134	135	136	137	138	139	140
Space type			Select from pull-down list			Office space	Corridors	Computer lab	Office Space	Office Space	Office Space	Office Space
Floor Area of zone	Az	sf				180	950	900	200	160	160	160
Design population of zone	Pz	P	(default value listed; may be overridden)			2	0	45	3	2	2	2
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm				315	390	2160	150	315	315	315
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%	100%
Air distribution type at conditioned analyzed			Select from pull-down list			CS	CS	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez					1.00	1.00	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
Ventilation System Efficiency	Ev				0.63							
Outdoor air intake required for system	Vot	cfm			11064							
Outdoor air per unit floor area	Vot/As	cfm/sf			0.46							
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p			22.6							
Outdoor air as a % of design primary supply air	Ypd	cfm			34%							
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	32280							
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	6989							
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	0.12	0.06	0.06	0.06	0.06
OA rate per person	Rpz	cfm/p				5.00	0.00	10.00	5.00	5.00	5.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm				315	390	2160	150	315	315	315
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=		20.8	57.0	558.0	27.0	19.6	19.6	19.6
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	=		21	57	558	27	20	20	20
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	=		0.07	0.15	0.26	0.18	0.06	0.06	0.06
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	=		0.07	0.15	0.26	0.18	0.06	0.06	0.06
System Ventilation Efficiency												
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	=		1.15	1.07	0.96	1.04	1.15	1.15	1.15
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=	0.63							
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	=	11064							
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	0.34							
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	=	22							

Building:	Coppin State Phys Ed Complex			
System Tag/Name:	AHU- 11			
Operating Condition Description:	Classrooms, HPERD, Dance			
Units (select from pull-down list)	IP			

	Name	Units			System							
Inputs for System												
Floor area served by system	As	sf			24225							
Population of area served by system (including diversity)	Ps	P	100% diversity		490							
Design primary supply fan airflow rate	Vpsd	cfm			32,280							
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf			0.08							
OA req'd per person for system area (Weighted average)	Rps	cfm/p			10.4							
Inputs for Potentially Critical zones												
Zone Name			*Zone title turns purple italic for critical zone(s)*			Faculty Office	Faculty Office	Faculty Office	File Storage	Lounge	Help Desk	Storage
Zone Tag						141	142	143	144	145	146	147
Space type			Select from pull-down list			Office Space	Office Space	Office Space	Storage rooms	Break rooms	Office space	Storage rooms
Floor Area of zone	Az	sf				160	160	160	135	1335	190	190
Design population of zone	Pz	P	(default value listed; may be overridden)			2	2	2	1	30	3	0
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm				315	315	315	75	1800	220	80
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%	100%
Air distribution type at conditioned analyzed			Select from pull-down list			CS	CS	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez					1.00	1.00	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
Ventilation System Efficiency	Ev				0.63							
Outdoor air intake required for system	Vot	cfm			11064							
Outdoor air per unit floor area	Vot/As	cfm/sf			0.46							
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p			22.6							
Outdoor air as a % of design primary supply air	Ypd	cfm			34%							
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	32280							
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	6989							
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	0.06	0.12
OA rate per person	Rpz	cfm/p				5.00	5.00	5.00	0.00	5.00	5.00	0.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm				315	315	315	75	1800	220	80
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=		19.6	19.6	19.6	16.2	230.1	26.4	22.8
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	=		20	20	20	16	230	26	23
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	=		0.06	0.06	0.06	0.22	0.13	0.12	0.29
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	=		0.06	0.06	0.06	0.22	0.13	0.12	0.29
System Ventilation Efficiency												
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	=		1.15	1.15	1.15	1.00	1.09	1.10	0.93
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=	0.63							
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	=	11064							
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	0.34							
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	=	22							

Building:			Coppin State Phys Ed Complex							
System Tag/Name:			AHU- 11							
Operating Condition Description:			Classrooms, HPERD, Dance							
Units (select from pull-down list)			IP							
Inputs for System	**Name**	**Units**		**System**						
Floor area served by system	As	sf		24225						
Population of area served by system (including diversity)	Ps	P	100% diversity	490						
Design primary supply fan airflow rate	Vpsd	cfm		32,280						
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.08						
OA req'd per person for system area (Weighted average)	Rps	cfm/p		10.4						
Inputs for Potentially Critical zones										
Zone Name			*Zone title turns purple italic for critical zone(s)*		Costume Storage	Faculty Office	Faculty Office	Aux Gym Corridor	Fitness Storage	South Lobby	South Lobby Level 2
Zone Tag					148	149	150	152	153	154	155
Space type		Select from pull-down list			Storage rooms	Office Space	Office Space	Corridors	Storage rooms	Lobbies	Lobbies
Floor Area of zone	Az	sf			380	155	155	1600	185	1180	480
Design population of zone	Pz	P	(default value listed; may be overridden)		0	2	2	0	0	8	72
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			160	110	110	700	100	1100	810
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%	100%
Air distribution type at conditioned analyzed		Select from pull-down list			CS	CS	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep										
Results										
Ventilation System Efficiency	Ev			0.63							
Outdoor air intake required for system	Vot	cfm		11064							
Outdoor air per unit floor area	Vot/As	cfm/sf		0.46							
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		22.6							
Outdoor air as a % of design primary supply air	Ypd	cfm		34%							
Detailed Calculations										
Initial Calculations for the System as a whole										
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	32280							
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	6989							
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	0.06	0.06	0.06	0.12	0.06	0.06
OA rate per person	Rpz	cfm/p			0.00	5.00	5.00	0.00	0.00	5.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			160	110	110	700	100	1100	810
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		45.6	19.3	19.3	96.0	22.2	110.8	388.8
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		46	19	19	96	22	111	389
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er =		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep =		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.29	0.18	0.18	0.14	0.22	0.10	0.48
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.29	0.18	0.18	0.14	0.22	0.10	0.48
System Ventilation Efficiency										
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		0.93	1.04	1.04	1.08	0.99	1.12	0.74
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	0.63							
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 =	11064							
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	0.34							
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 =	22							

Building:	Coppin State Phys Ed Complex						
System Tag/Name:	AHU- 11						
Operating Condition Description:	Classrooms, HPERD, Dance						
Units (select from pull-down list)	IP						
Inputs for System	**Name**	**Units**				**System**	
Floor area served by system	As	sf				24225	
Population of area served by system (including diversity)	Ps	P		100% diversity		490	
Design primary supply fan airflow rate	Vpsd	cfm				32,280	
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf				0.08	
OA req'd per person for system area (Weighted average)	Rps	cfm/p				10.4	
Inputs for Potentially Critical zones							
Zone Name		*Zone title turns purple italic for critical zone(s)*					*Dance Studio*
Zone Tag							156
Space type		Select from pull-down list					Disco/dance floors
Floor Area of zone	Az	sf					2830
Design population of zone	Pz	P		(default value listed; may be overridden)			100
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm					3710
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A					
Local recirc. air % representative of ave system return air	Er						
Inputs for Operating Condition Analyzed							
Percent of total design airflow rate at conditioned analyzed	Ds	%				100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list					CS
Zone air distribution effectiveness at conditioned analyzed	Ez						1.00
Primary air fraction of supply air at conditioned analyzed	Ep						
Results							
Ventilation System Efficiency	Ev					0.63	
Outdoor air intake required for system	Vot	cfm				11064	
Outdoor air per unit floor area	Vot/As	cfm/sf				0.46	
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p				22.6	
Outdoor air as a % of design primary supply air	Ypd	cfm				34%	
Detailed Calculations							
Initial Calculations for the System as a whole							
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	VpdDs	=	32280	
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	6989	
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
OA rate per person	Rpz	cfm/p					20.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm					3710
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		2169.8
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		2170
Fraction of zone supply not directly recirc. from zone	Fa		=	Ep + (1-Ep)Er	=		1.00
Fraction of zone supply from fully mixed primary air	Fb		=	Ep	=		1.00
Fraction of zone OA not directly recirc. from zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00
Unused OA fraction required in supply air to zone	Zd		=	Voz / Vdz	=		0.58
Unused OA fraction required in primary air to zone	Zp		=	Voz / Vpz	=		0.58
System Ventilation Efficiency							
Zone Ventilation Efficiency (App A Method)	Evz		=	(Fa + FbXs - FcZ) / Fa	=		0.63
System Ventilation Efficiency (App A Method)	Ev		=	min (Evz)	=	0.63	
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	=	11064	
OA intake req'd as a fraction of primary SA	Y		=	Vot / Vps	=	0.34	
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	=	22	

Appendix C – Sample Calculations of Fan Efficiency Limitations

	HP	CFM	CFM*0.0011	Compliance
EF-1	0.33	1225	1.35	YES
EF-2	1.5	7000	7.70	YES
EF-2A	1.5	7000	7.70	YES
EF-3	0.25	475	0.52	YES
EF-4	0.25	650	0.72	YES
EF-5	0.25	500	0.55	YES
EF-6	0.5	1300	1.43	YES
EF-7	0.33	750	0.83	YES
EF-8	0.25	800	0.88	YES
EF-9	0.5	1100	1.21	YES
EF-10	0.33	750	0.83	YES
EF-11	0.5	1000	1.10	YES
EF-12	0.33	1000	1.10	YES
EF-13	0.1	120	0.13	YES
EF-14	0.75	2200	2.42	YES
EF-15	0.25	500	0.55	YES
EF-16	0.1	200	0.22	YES
EF-17	1	2250	2.48	YES
EF-18	0.5	1000	1.10	YES
EF-19	1	2180	2.40	YES
EF-20	0.33	500	0.55	YES
EF-21	0.5	850	0.94	YES
EF-22	0.5	1000	1.10	YES
EF-23	0.75	5100	5.61	YES
EF-24	0.75	4000	4.40	YES
EF-25	0.5	1530	1.68	YES
EF-26	0.75	1475	1.62	YES
EF-27	0.75	1475	1.62	YES
EF-28	0.75	1500	1.65	YES
EF-29	0.75	5100	5.61	YES
EF-30	0.75	5100	5.61	YES

References

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

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

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