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Penn State University

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Mechanical Option

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[TECHNICAL REPORT 1]

ASHRAE Standard 62.1 Ventilation and Standard 90.1 Energy Design Evaluations for Hotel Felix located at Chicago, Illinois

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EXECUTIVE SUMMARY

The purpose of this report is to determine if Hotel Felix is in compliance with ASHRAE Standard 62.1-2007 and ASHRAE Standard 90.1-2007.

Hotel Felix is a historical hotel located in the heart of downtown Chicago that was recently renovated to become the first hotel in the Chicago area to get LEED Silver certified. In order to earn the silver rating, the mechanical system designers had to strictly follow ASHRAE section 62.1's ventilation rate procedures and ventilation for acceptable indoor air quality to earn points towards indoor environmental quality.

The ASHRAE Standard 62.1-2007 compliance analysis shows that the building is mostly compliant with the standard. The two main AHU's were analyzed to make sure it meets minimum ventilation requirements and calculations showed that it does comply. Many aspects of the mechanical systems such as ducts, outdoor air intakes, drain pans, and controls do comply with the code.

The ASHRAE Standard 90.1-2007 compliance analysis shows that some parts of the mechanical system and lighting could use another review. The main air handling unit is above the maximum allowable motor horsepower by close to a factor of 2 while most of the lighting power density in the building is above maximum allowable value according to section 90.1

MECHANICAL SYSTEM OVERVIEW

Hotel Felix utilizes a several different systems to provide conditioned air to its spaces.

RTU-13.1 is a 100% outdoor air roof top unit that provides 7,500 CFM of air using a 7.5 HP motor. The roof top unit supplies air to the hotel corridors from floor 2 through 12 with both cooling and heating.

AHU-B.1 is a self contained air handling unit located in the basement that provides cooled air to the basement, 1st floor, and mezzanine floor areas. The cooled air from AHU-B.1 is sent to VAV boxes with individual electric heat coils. It uses 35% outside air and provides 8,000 CFM of conditioned air using a 15HP motor.

Hotel rooms are controlled using individual water source heat pumps in each room. By doing so, each guest will have the ability to control the set points of the room for comfort. Each heat pump can provide up to 300 or 400 CFM depending on the hotel room.

Electric cabinet unit heaters are located at stairwells and electric unit heaters at electrical room, fire pump room, gas meter room, recycling, and etc.

A 160ton cooling tower is located at the roof to provide chilled water for the heat pump and there are two 1100 MBH boilers also located on the roof to also provide hot water to the heat pump and hotel if needed.

ASHRAE SECTION 62.1 – 2007 ANALYSIS

SECTION 5 – SYSTEMS AND EQUIPMENT

5.1 – NATURAL VENTILATION

Natural ventilation is provided to the hotel rooms at a minimum of 4% of the floor area because it is categorized as a sleeping room with occupants. All spaces with natural ventilation requirements have been designed to exceed the ordinance requirements.

5.2 – VENTILATION AIR DISTRIBUTION

The roof top unit will easily meet the ventilation requirement due to it being 100% OA while the self contained unit meets the minimum ventilation requirement under any load condition shown by the calculations shown at section of the report.

5.3 – EXHAUST DUCT LOCATION

The building automation system will monitor pressure in the duct and vary VFD speed to maintain a negative pressure setpoint. This will ensure there will be no leak to the surrounding spaces around the duct. That satisfies section 5.3.

INSERT INFORMATION

5.4 – VENTILATION SYSTEM CONTROLS

The roof top unit brings in 100% OA which will always be running at all times regardless of occupancy. Thus, the system is designed to meet the minimum ventilation air flow as required by section 6.

The self contained air-conditioning system is controlled using a time of day schedule that meets the minimum ventilation rates throughout the day. Both the roof top unit and self contained air-conditioning system comes with a factory installed microprocessor with BACnet communications. The building automation system will monitor and change the setpoints of the systems.

5.5 – AIRSTREAM SURFACES

Ducts are made of sheet metal. Galvanized sheet steel with a mill-phosphatized finish is used for ducts exposed to view and aluminum sheet is used for concealed ducts. It meets section 5.5 as an exception for resistance to mold growth and erosion.

Other duct accessories are made to comply with standard test methods.

- Flexible connectors: comply with UL 181, class 1.
- Flexible ducts: comply with UL 181, Class 1.
- Turning vane: comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible"

5.6 – OUTDOOR AIR INTAKES

All pollution source exhaust to the outside of the building is directed away from any system intakes. Also, all system intakes are at minimum 30 feet above ground level to avoid the streets to meet section 5.6.

Centrifugal roof ventilators have bird screens made from removable galvanized aluminum mesh. No rain hoods are mentioned but the ventilator has an up-blast unit with rain and snow drains.

5.7 – LOCAL CAPTURE OF CONTAMINANTS

Exhaust from the kitchen is directly exhausted to the roof. Also, the exhaust from the central laundry room is exhausted directly to the outside.

5.8 – COMBUSTION AIR

All fuel-burning appliances are supplied with adequate air supply and are directly exhausted to the outside to comply with section 5.8.

5.9 – PARTICULATE MATTER REMOVAL

Both the roof top unit and self contained air-conditioning unit use 2 inch think fiberglass throwaway with a rating of MERV 13 that easily meet the minimum requirement of MERV 6.

5.10 – DEHUMIDIFICATION SYSTEMS

The maximum relative humidity for supply air is set at 50% which is below the 65% limit. The building is positively pressured by supplying more supply air than it is exhausting.

5.11 – DRAIN PANS

Drain pans are installed under all coils where condensation will occur or any area where damage will occur to the building or its content as a result of an overflow from the equipment or appliance. The drain is made of stainless steel and the drain connection is installed at lowest point of housing, which is the middle.

5.12 – FINNED-TUBE COILS AND HEAT EXCHANGERS

There are no finned-tube coils so this section does not apply.

5.13 – HUMIDIFIERS AND WATER-SPRAY SYSTEMS

There are no humidifiers or water-spray systems so this does not apply.

5.14 – ACCESS FOR INSPECTION, CLEANING, AND MAINTENANCE

Access to all mechanical equipment is provided with adequate space with access doors to the units.

5.15 – BUILDING ENVELOPE AND INTERIOR SURFACES

To prevent liquid penetration into the building envelope, polyethylene vapor retarder with a laboratory-tested vapor transmission rating of less than 0.2 perms is installed on the warm side of construction. Also, joint in insulation is to be used as small as possible to reduce vapor transmission and loose mineral fiber insulation will be stuffed into miscellaneous voids and cavity spaces where shown.

Interior pipes that have the potential to drop below the dew point are insulated along with its hangers.

5.16 – BUILDINGS WITH ATTACHED PARKING GARAGES

Parking garage is not available for this building so this section does not apply.

5.17 – AIR CLASSIFICATION AND RECIRCULATION

Return air classification follows table 6-1 of ASHRAE 62.1 where all return air are classified as class except for the central laundry room where it is classified as class 2. The Kitchen is also classified as class 4 but it is directly exhausted to the outside with no recirculation. The return air from the laundry room is also exhausted directly outside so there is no recirculation into class 1 spaces. The building complies with section 5.17.

5.18 – REQUIREMENTS FOR BUILDINGS CONTAINING ETS / ETS-FREE AREAS

The hotel is a non-smoking to meet LEED accreditation. So ETS is not an issue for this building.

SECTION 6 – VENTILATION RATE PROCEDURES

For the purpose of these calculations, the roof top unit and the self contained unit are selected for analysis. Through the ventilation rate procedure, we will determine if the minimum ventilation rate is always met for the system designed for the hotel.

Equation:

$V_{bz} = R_p \cdot P_z + R_a \cdot A_z$ (Equation 6-1 from ASHRAE Standard 62.1)

R_p = Outdoor Air Flow Rate (CFM/person)

P_z = Zone Population (People)

R_a = Outdoor Air Flow Rate (CFM/ft^2)

A_z = Zone Floor Area

Zone Air Distribution Effectiveness:

$E_z = 1.0$ (Table 6-2)

Zone Outdoor Airflow:

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

Outdoor Air Intake Flow For Outside Air Units:

$V_{ot} = \sum_{allzones} \cdot V_{oz}$ (Equation 6-4)

Uncorrected Outdoor Air Intake:

$Vou = D \cdot \sum_{allzones} (R_p \cdot P_z) + \sum_{allzones} (R_a \cdot A_z)$ (Equation 6-6)

Occupant Diversity:

$D = P_s / (\sum_{allzones} \cdot \sum P_z)$ (Equation 6-7)

Primary Outdoor Air Fraction:

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

The ASHRAE Standard 62.1 user manual includes a Microsoft excel spreadsheet that computes ventilation rates based on inputs including square footage, room occupancy type, and room supply air. This spreadsheet will be used mainly to analyze the roof top unit and self contained unit to find the system compliant with the code. The result of the calculation is included in appendix A. Through the calculations and spreadsheet, we can see that hotel Felix is compliant with the ASHRAE standards.

SECTION 62.1 – SUMMARY

We can see that Hotel Felix is compliant with ASHRAE Standard 62.1 section 5 and 6. Proper steps and were taken to select air quality control systems so it complies with the Ventilation Rate Procedures and Ventilation for Acceptable Indoor Air Quality to gain points towards LEED indoor environmental quality point.

ASHRAE SECTION 90.1 – 2007 ANALYSIS

SECTION 5 – BUILDING ENVELOPE

5.14 – UNITED STATES LOCATIONS

The climate zone for Hotel Felix falls under zone 5A according Figure B-1 of ASHRAE 90.1, as it is located in Chicago, Illinois.

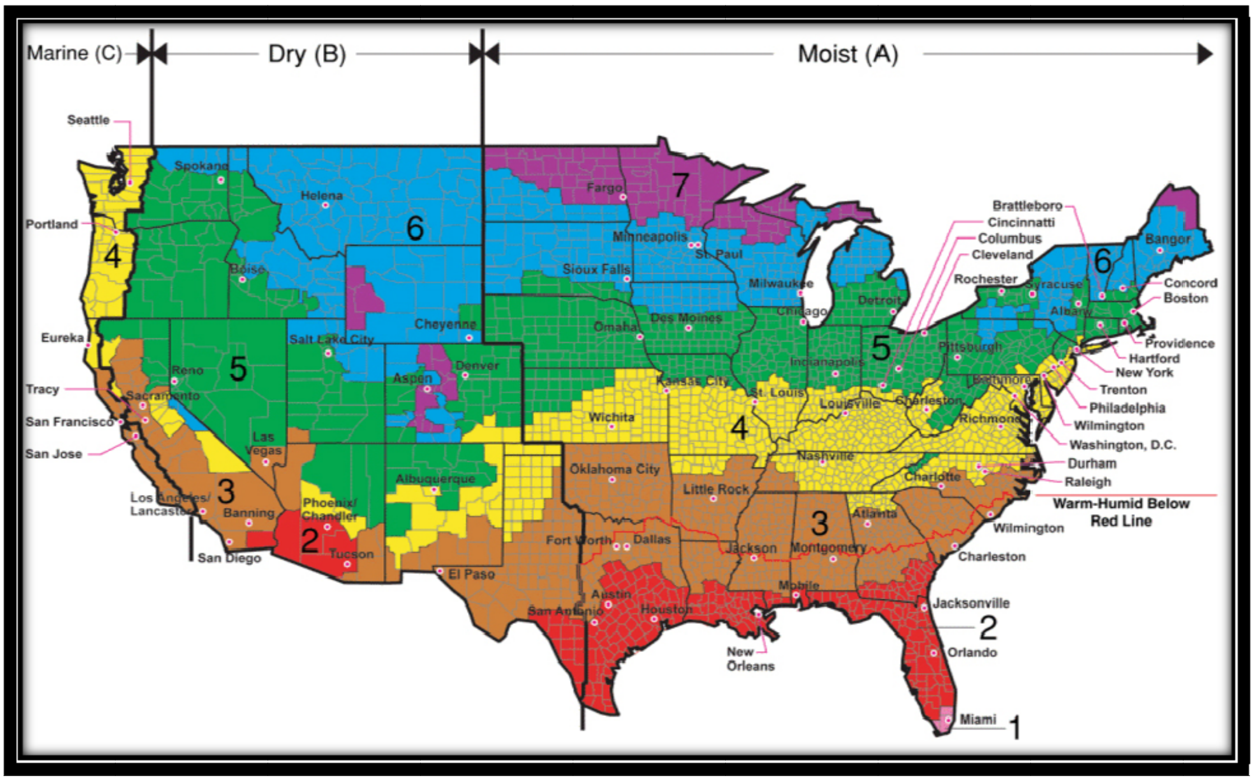

FIGURE 1. UNITED STATES CLIMATE REGIONS

5.2 – COMPLIANCE

	Wall Surface Area (SF)	Glazing Surface Area (SF)	Percentage Glazing / Wall
Values	49632	6699	19.88%

TABLE 1. GLAZING

The hotel has a 19.88% vertical fenestration area which is under the 40% requirement to follow the prescriptive building envelope compliance path.

5.5 – PRESCRIPTIVE BUILDING ENVELOPE OPTION

	Minimum Roof Insulation (R-Value)	Minimum Wall Insulation (R-Value)	Heated Slab on Grade Floor Insulation (R-Value)	Fenestration Assembly MAximum U-Value
Required	R-20	R-13.3	R-15	U-0.048
Designed	R-36	R-15	N/A	N/A
Compliance	Achieved	Achieved	N/A	N/A

TABLE 2. BUILDING ENVELOPE INSULATION

The minimum insulation values were found from ASHRAE 90.1 table 5.5-5 for climate zone 5-A. After comparing the values for the hotel with the requirements, we found that they achieve the minimum R-value to meet standard 90.1. The roof is insulated with R-36 which is almost the double the minimum requirements while the wall has a R-15 insulation system.

The insulation properties for the heated slab on grade floor insulation and fenestration assembly U-value were not present because the renovation did not involve changing slab on grade floor and fenestration assembly.

SECTION 6 – HEATING, VENTILATION, AND AIR CONDITIONING

6.2 – COMPLIANCE

The hotel is bigger than 25,000 square feet which is required for the simplified approach option. The simplified approach option will be neglected.

6.4 – MANDATORY APPROACH

To meet section 6.4.3.1.1, there are individually controlled thermostat controls responding temperature at each zone for supply of heating and cooling energy.

Water source heat pumps in each hotel room are connected to a room thermostat with an occupancy sensor and the ability to adjust setpoint for heating and cooling and turn the fan on and off. If occupancy is sensed between the time of 8:00 pm and midnight, the system will remain on until a set time of 9:00AM. This is the off-hour controls for the water source heat pumps. The roof top unit is intended to operate continuously so off-hour controls do not apply. The self contained unit runs on a time of day schedule to control supply air during off-hours.

Ducts and pipes are insulated to meet section 6.4.4.1

6.5 – PRESCRIPTIVE PATH

According to Section 6.5.1, any cooling units with a cooling capacity greater than 135,000 BTU/H require an economizer for climate zone 5b. The cooling tower in the roof operates at 160 ton which is equivalent to 1.92E6 BTU/H so an economizer is operating between the cooling tower and heat pump condenser water with a capacity of 1950 MBH (≈162 tons).

For a water loop heat pump system, it must be capable of supplying a dead band of at least 20°F between initiation of heat rejection and heat addition by the central devices according to section 6.5.2.2.3. The heat pumps for the hotel will operate between a dead band of 65 degrees and 95 degrees so it meets the standards.

According to section 6.4.3.1.1, each HVAC system at fan system design conditions must not exceed allowable fan system motor hp shown in table 6.5.3.1.1A in ASHRAE 90.1.

	Designed HP	CFM	Allowable Motor HP (CFM * 0.0011)	Comply?
EF-B.1	0.33	300	0.33	Y
EF-B.2	0.125	150	0.165	Y
EF-B.3	0.33	750	0.825	Y
EF-B.4	0.33	300	0.33	Y
EF-1.1	0.33	500	0.55	Y
EF-13.1	0.33	1100	1.21	Y
TE-13.1	1.5	3025	3.328	Y
TE-13.2	1.5	2750	3.025	Y
EF-14.1	3	8000	8.8	Y
EF-14.2	0.25	500	0.55	Y
KEF-13.1	5	5000	5.5	Y
AHU-B.1	15	8000	8.8	N
RTU-13.1	7.5	7500	8.25	N

TABLE 3. MOTOR COMPLIANCE

Following the equation given by table 6.4.3.1.1A and calculating the power limit, it was found that all the fans in the building comply with the standard except the roof top unit.

6.7 – SUBMITTALS

Construction documents with system approval will be provided to the building owner. A test and balance contractor will balance and test heating, ventilating, and air conditioning systems for the building in accordance to the Associated Air Balance Council (AABC). The test and balance agency will submit a final report for review by all engineers.

SECTION 7 – SERVICE WATER HEATING

Section 7 of ASHRAE Standard 90.2 outlines requirements for service water heating systems and equipment. The hotel will need to comply with section 7.1.1.3 as a alteration to existing building instead of a new building system. All direct replacement of existing building service water heating equipment needs to comply with requirements for section 7.

According to table 7.8 of ASHRAE 90.1, the boiler needs to have a minimum performance rating of 80% efficiency. The two boilers at the hotel has a 96% thermal efficiency, easily complying the section 7.4

SECTION 8 – POWER

In section 8.4.1, the standard states feeder conductors shall be sized for a maximum voltage drop of 2% at design load. Also, the branch circuit conductors shall be sized for a maximum voltage drop of 3% at design load. However, none of the information could be found that complies with the above statements.

SECTION 9 – LIGHTING

Section 9 covers lighting for the interior spaces of the buildings, exterior building components, and exterior building ground lights. There are two different methods to calculate interior lighting power allowance, the building area method and the space-by-space method. The building area method will be used specifically for this report because of its simplified approach to demonstrate compliance. The installed interior lighting power shall not exceed the interior lighting power allowance developed by this building area method.

The building type allows a maximum power density of 1.0 W/ft^2 for a hotel area type.

Fixture	Lamp	Watts	Fixture	Lamp	Watt
F1	F32T8	68	SK	Q50MR16	50
F2	F32T8	68	SL	Q50MR16	50
F3	F32T8	68	SM	F28T5	28
FB1	F32T8	68	SQ	Q50MR16	50
FB3	CFM32W	38	SR	F26TBX	26
SB	F26TBX	26	SW	F26TBX	26
SC	F28T5	28	SX	FxxT5	28
SD	F28T5	28	SY	F26TBX	26
SF	Q50MR16	50	401	Owner Supplied	50
SJ1	50PAR20	50	701	Owner Supplied	28

TABLE 4. LIGHT FIXTURE SCHEDULE

For simplification for the building area calculation method, lamps with same wattage have been grouped together to create a fixture group shown in the table below.

Fixture Group	Watt	Lamps
Fixture A	68	F1+F2+F3+FB1
Fixture B	28	SD+SC+SM+SX+701
Fixture C	26	SB+SR+SW+SY
Fixture D	38	FB3
Fixture E	50	SF+SJ1+SK+SL+SQ+401

TABLE 5. LIGHT FIXTURE GROUPS

Below the calculations to find compliance.

Floor	Area	Fixture A	Fixture B	Fixture C	Fixture D	Fixture D	Total Watts	
		# Count	# Count	# Count	# Count	# Count		W/SF
basement	7260	116	5	18	4	0	8648	1.19
1st	7260	32	6	12	0	66	5956	0.82
Mezzanine	7260	10	6	21	0	106	6694	0.92
2nd	6798	5	31	62	0	99	7770	1.14
3rd	6798	5	31	62	0	99	7770	1.14
4th	6798	5	31	62	0	99	7770	1.14
5th	6798	5	31	62	0	99	7770	1.14
6th	6798	5	31	62	0	99	7770	1.14
7th	6798	5	31	62	0	99	7770	1.14
8th	6798	5	31	62	0	99	7770	1.14
9th	6798	5	31	62	0	99	7770	1.14
10th	6798	5	31	62	0	99	7770	1.14
11th	6798	5	31	62	0	99	7770	1.14
12th	6798	5	31	62	0	99	7770	1.14

TABLE 6. LIGHTING COMPLIANCE

From the construction documents and the lighting layout, we can see that the building does not comply with the lighting code from section 9 of ASHRAE 90.1. Only the 1st floor and Mezzanine are below the 1 Watt/SF maximum while the rest are a bit over the maximum that is given by the code.

SECTION 90.2 – SUMMARY

Overall, the building complied with the majority of ASHRAE standard 90.1. The prescriptive building envelope option was chosen and found to exceed the ASHRAE standard values. For the HVAC system design section, the only part that was an issue was the design motor HP for the roof top unit where it exceeded the allowable HP value.

The biggest issue was the lighting design for the interior spaces for the building. The lighting power density was too high to comply with the standard. This section will most likely be looked at again for the proposal to see if anything could have been changed and find out why this happened during the design process.

REFERENCES

ASHRAE Standard 62.1-2007

ASHRAE Standard 90.1-2007

APPENDIX

Appendix A

Building:	Hotel Felix
System Tag/Name:	AHU-B.1
Operating Condition Description:	
Units (select from pull-down list)	IP

Inputs for System	**Name**	**Units**		**System**
Floor area served by system	As	sf		5,298
Population of area served by system (including diversity)	Ps	P	100% diversity	114
Design primary supply fan airflow rate	Vpsd	cfm		8,450
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.07
OA req'd per person for system area (Weighted average)	Rps	cfm/p		7.8

Inputs for Potentially Critical zones	Name	Units		System							
Zone Name			*Zone title turns purple italic for critical zone(s)*		**Exercise**	**Office space**	**Office Space**	**Reception**	**Office space**	**Office Space**	**Shop**
Zone Tag					**B04**	**B09**	**B10**	**B11**	**B12**	**B13**	**B16**
Space type		Select from pull-down list			**Health club/aerobics room**	**Office space**	**Office space**	**Reception areas**	**Office space**	**Office space**	**Wood/metal shop**
Floor Area of zone	Az	sf			366	171	101	222	81	130	172
Design population of zone	Pz	P	(default value listed; may be overridden)		14.64	0.855	0.505	6.66	0.405	0.65	3.44
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			750	150	125	250	125	150	250
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				75%	75%	75%	75%	75%	75%	75%
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		**0.58**
Outdoor air intake required for system	Vot	cfm	**2192**
Outdoor air per unit floor area	Vot/As	cfm/sf	**0.41**
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	**19.3**
Outdoor air as a % of design primary supply air	Ypd	cfm	**26%**

Detailed Calculations														
Initial Calculations for the System as a whole														
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	VpdDs	=	8450								
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	1281								
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.15								
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	0.06	0.18	
OA rate per person	Rpz	cfm/p					20.00	5.00	5.00	5.00	5.00	5.00	10.00	
Total supply air to zone (at condition being analyzed)	Vdz	cfm					750	150	125	250	125	150	250	
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		314.8	14.5	8.6	46.6	6.9	11.1	65.4	
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		315	15	9	47	7	11	65	
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	=		0.42	0.10	0.07	0.19	0.06	0.07	0.26	
Unused OA fraction required in primary air to zone	Zp		=	Voz / Vpz	=		0.42	0.10	0.07	0.19	0.06	0.07	0.26	
System Ventilation Efficiency														
Zone Ventilation Efficiency (App A Method)	Evz		=	(Fa + FbXs - FcZ) / Fa	=		0.73	1.05	1.08	0.97	1.10	1.08	0.89	
System Ventilation Efficiency (App A Method)	Ev		=	min (Evz)	=	**0.58**								
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	=	**2192**								
OA intake req'd as a fraction of primary SA	Y		=	Vot / Vps	=	**0.26**								
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	=	6								

Building:	**Hotel Felix**
System Tag/Name:	**AHU-B.1**
Operating Condition Description:	
Units (select from pull-down list)	**IP**

	Name	Units	Notes / Formula	System	Engineers Office	Mens Locker	Womens Lockers	Laundry	Housekeeping	Break Room	Office
Inputs for System	**Name**	**Units**		**System**							
Floor area served by system	As	sf		5,298							
Population of area served by system (including diversity)	Ps	P	100% diversity	114							
Design primary supply fan airflow rate	Vpsd	cfm		8,450							
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.07							
OA req'd per person for system area (Weighted average)	Rps	cfm/p		7.8							
Inputs for Potentially Critical zones					**Potentially Critical Zones**						
Zone Name			*Zone title turns purple italic for critical zone(s)*		**Engineers Office**	**Mens Locker**	**Womens Lockers**	**Laundry**	**Housekeepin g**	**Break Room**	**Office**
Zone Tag					**B17**	**B23**	**B24**	**B31**	**B35**	**B37**	**B40**
Space type			Select from pull-down list		**Office space**	**Break rooms**	**Break rooms**	**Laundry rooms, central**	**Office space**	**Break rooms**	**Office space**
Floor Area of zone	Az	sf			105	67	90	518	239	330	84
Design population of zone	Pz	P	(default value listed; may be overridden)		0.525	1.675	2.25	5.18	1.195	8.25	0.42
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			150	100	100	800	150	500	150
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				75%	75%	75%	75%	75%	75%	75%
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			**0.58**							
Outdoor air intake required for system	Vot	cfm		**2192**							
Outdoor air per unit floor area	Vot/As	cfm/sf		**0.41**							
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		**19.3**							
Outdoor air as a % of design primary supply air	Ypd	cfm		**26%**							
Detailed Calculations											
Initial Calculations for the System as a whole											
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	8450							
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	1281							
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.15							
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	0.06
OA rate per person	Rpz	cfm/p			5.00	5.00	5.00	5.00	5.00	5.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			150	100	100	800	150	500	150
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		8.9	12.4	16.7	88.1	20.3	61.1	7.1
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		9	12	17	88	20	61	7
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er =		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep =		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.06	0.12	0.17	0.11	0.14	0.12	0.05
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.06	0.12	0.17	0.11	0.14	0.12	0.05
System Ventilation Efficiency											
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		1.09	1.03	0.99	1.04	1.02	1.03	1.10
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.58**							
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 =	**2192**							
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.26**							
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 =	6							

Building:	Hotel Felix
System Tag/Name:	AHU-B.1
Operating Condition Description:	
Units (select from pull-down list)	IP

Inputs for System	**Name**	**Units**		**System**							
Floor area served by system	As	sf		5,298							
Population of area served by system (including diversity)	Ps	P	100% diversity	114							
Design primary supply fan airflow rate	Vpsd	cfm		8,450							
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.07							
OA req'd per person for system area (Weighted average)	Rps	cfm/p		7.8							
Inputs for Potentially Critical zones											
Zone Name			*Zone title turns purple italic for critical zone(s)*		**Lobby/Reception**	***Bar***	**Bar Equipment**	**Office**	**Operator**	**Conference Room**	**Conference Room**
Zone Tag					**102,114**	**103**	**109**	**110**	**111**	**120**	**M02**
Space type			Select from pull-down list		**Main entry lobbies**	**Bars, cocktail lounges**	**Storage rooms**	**Office space**	**Office space**	**Conference/meeting**	**Conference/meeting**
Floor Area of zone	Az	sf			1213	183	71	116	60	120	305
Design population of zone	Pz	P	(default value listed; may be overridden)		12.13	18.3	0	0.58	0.3	6	15.25
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			2100	300	350	200	100	400	400
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A									
Local recirc. air % representative of ave system return air	Er				75%	75%	75%	75%	75%	75%	75%
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			**0.58**							
Outdoor air intake required for system	Vot	cfm		**2192**							
Outdoor air per unit floor area	Vot/As	cfm/sf		**0.41**							
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		**19.3**							
Outdoor air as a % of design primary supply air	Ypd	cfm		**26%**							
Detailed Calculations											
Initial Calculations for the System as a whole											
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	8450							
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	1281							
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.15							
Initial Calculations for individual zones											
OA rate per unit area for zone	Raz	cfm/sf			0.06	0.18	0.12	0.06	0.06	0.06	0.06
OA rate per person	Rpz	cfm/p			5.00	7.50	0.00	5.00	5.00	5.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			2100	300	350	200	100	400	400
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		133.4	170.2	8.5	9.9	5.1	37.2	94.6
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		133	170	9	10	5	37	95
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	0.57	0.02	0.05	0.05	0.09	0.24
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.06	0.57	0.02	0.05	0.05	0.09	0.24
System Ventilation Efficiency											
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		1.09	0.58	1.13	1.10	1.10	1.06	0.92
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.58**							
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 =	**2192**							
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.26**							
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 =	6							

Building:	Hotel Felix
System Tag/Name:	AHU-B.1
Operating Condition Description:	
Units (select from pull-down list)	IP

Inputs for System	**Name**	**Units**		**System**
Floor area served by system	As	sf		5,298
Population of area served by system (including diversity)	Ps	P	100% diversity	114
Design primary supply fan airflow rate	Vpsd	cfm		8,450
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.07
OA req'd per person for system area (Weighted average)	Rps	cfm/p		7.8

Inputs for Potentially Critical zones					
Zone Name			*Zone title turns purple italic for critical zone(s)*	**Prefunction**	**Business Center**
Zone Tag				**M05**	**M07**
Space type		Select from pull-down list		**Lobbies/prefunction**	**Office space**
Floor Area of zone	Az	sf		463	91
Design population of zone	Pz	P	(default value listed; may be overridden)	13.89	0.455
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm		600	250
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			System		
Percent of total design airflow rate at conditioned analyzed	Ds	%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list		CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez			1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep				

Results			
Ventilation System Efficiency	Ev		**0.58**
Outdoor air intake required for system	Vot	cfm	**2192**
Outdoor air per unit floor area	Vot/As	cfm/sf	**0.41**
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p	**19.3**
Outdoor air as a % of design primary supply air	Ypd	cfm	**26%**

Detailed Calculations

Initial Calculations for the System as a whole								
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	VpdDs	=	8450		
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	1281		
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.15		
Initial Calculations for individual zones								
OA rate per unit area for zone	Raz	cfm/sf					0.06	0.06
OA rate per person	Rpz	cfm/p					7.50	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm					600	250
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		132.0	7.7
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		132	8
Fraction of zone supply not directly recirc. from zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		=	Ep	=		1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00
Unused OA fraction required in supply air to zone	Zd		=	Voz / Vdz	=		0.22	0.03
Unused OA fraction required in primary air to zone	Zp		=	Voz / Vpz	=		0.22	0.03
System Ventilation Efficiency								
Zone Ventilation Efficiency (App A Method)	Evz		=	(Fa + FbXs - FcZ) / Fa	=		0.93	1.12
System Ventilation Efficiency (App A Method)	Ev		=	min (Evz)	=	**0.58**		
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	=	**2192**		
OA intake req'd as a fraction of primary SA	Y		=	Vot / Vps	=	**0.26**		
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	=	6		

Building:	Hotel Felix
System Tag/Name:	RTU-13.1
Operating Condition Description:	
Units (select from pull-down list)	IP

	Name	Units			System							
Inputs for System	**Name**	**Units**			**System**							
Floor area served by system	As	sf			9750							
Population of area served by system (including diversity)	Ps	P	100% diversity		20							
Design primary supply fan airflow rate	Vpsd	cfm			8,650							
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			5.0							
Inputs for Potentially Critical zones												**Potentially Critical Zones**
Zone Name			*Zone title turns purple italic for critical zone(s)*			***Conference Room***	**Corridors**	**Corridors**	**Corridors**	**Corridors**	**Corridors**	**Corridors**
Zone Tag						**M01**	**second floor**	**third floor**	**Forth Floor**	**Fifth Floor**	**Sixth Floor**	**Seventh**
Space type			Select from pull-down list			**Conference/meeting**	**Corridors**	**Corridors**	**Corridors**	**Corridors**	**Corridors**	**Corridors**
Floor Area of zone	Az	sf				400	850	850	850	850	850	850
Design population of zone	Pz	P	(default value listed; may be overridden)			20	0	0	0	0	0	0
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm				400	750	750	750	750	750	750
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					75%	75%	75%	75%	75%	75%	75%
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				**0.77**							
Outdoor air intake required for system	Vot	cfm			**891**							
Outdoor air per unit floor area	Vot/As	cfm/sf			**0.09**							
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p			**44.5**							
Outdoor air as a % of design primary supply air	Ypd	cfm			**10%**							
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	8650							
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	685							
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.08							
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	0.06	0.06
OA rate per person	Rpz	cfm/p				5.00	0.00	0.00	0.00	0.00	0.00	0.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm				400	750	750	750	750	750	750
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=		124.0	51.0	51.0	51.0	51.0	51.0	51.0
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	=		124	51	51	51	51	51	51
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	=		0.31	0.07	0.07	0.07	0.07	0.07	0.07
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	=		0.31	0.07	0.07	0.07	0.07	0.07	0.07
System Ventilation Efficiency												
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	=		0.77	1.01	1.01	1.01	1.01	1.01	1.01
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=	**0.77**							
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	=	0.84							
Minimum outdoor air intake airflow												
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	=	**891**							
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	**0.10**							
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev	=	815	**75.07**						
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps	=	0.09	**0.08**						
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	=	-93							

Building:	**Hotel Felix**							
System Tag/Name:	**RTU-13.1**							
Operating Condition Description:								
Units (select from pull-down list)	**IP**							

Item	Name	Units		System					
Inputs for System	**Name**	**Units**		**System**					
Floor area served by system	As	sf		9750					
Population of area served by system (including diversity)	Ps	P	100% diversity	20					
Design primary supply fan airflow rate	Vpsd	cfm		8,650					
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		5.0					
Inputs for Potentially Critical zones									
Zone Name			*Zone title turns purple italic for critical zone(s)*		**Corridors**	**Corridors**	**Corridors**	**Corridors**	**Corridors**
Zone Tag					**Eith Floor**	**Ninth Floor**	**Tenth Floor**	**Eleventh Floor**	**Twelth Floor**
Space type		Select from pull-down list			**Corridors**	**Corridors**	**Corridors**	**Corridors**	**Corridors**
Floor Area of zone	Az	sf			850	850	850	850	850
Design population of zone	Pz	P	(default value listed; may be overridden)		0	0	0	0	0
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			750	750	750	750	750
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				75%	75%	75%	75%	75%
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			**0.77**					
Outdoor air intake required for system	Vot	cfm		**891**					
Outdoor air per unit floor area	Vot/As	cfm/sf		**0.09**					
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		**44.5**					
Outdoor air as a % of design primary supply air	Ypd	cfm		**10%**					

Item	Name	Units	Formula	System					
Detailed Calculations									
Initial Calculations for the System as a whole									
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	8650					
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	685					
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.08					
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
OA rate per person	Rpz	cfm/p			0.00	0.00	0.00	0.00	0.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			750	750	750	750	750
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		51.0	51.0	51.0	51.0	51.0
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		51	51	51	51	51
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 =		0.07	0.07	0.07	0.07	0.07
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.07	0.07	0.07	0.07	0.07
System Ventilation Efficiency									
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		1.01	1.01	1.01	1.01	1.01
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.77**					
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	0.84					
Minimum outdoor air intake airflow									
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**891**					
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.10**					
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	= Vou / Ev =	815					
OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vot / Vps =	0.09					
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 =	-93					