



Mechanical Option-IP

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Executive Summary

The purpose of this document is to evaluate the compliance or non-compliance of The Sunshine Elementary School with the ASHRAE Standards 62.1-2007 and 90.1-2007.

The Sunshine Elementary School is primarily a one story building with a small two story section. The building consists of many different spaces typical of an elementary school. This includes classrooms, gymnasium, office spaces and kitchen among others. The architectural design was based around the concept of, "a school within a school," design. The kindergarten classrooms are surrounded by the 1st through 5th student spaces allowing the youngest of children to become acclimated quickly to the new environment.

The mechanical design utilizes a highly efficient system consisting of ground source heat pumps, air-to-air recovery units, advanced controls for lighting and ventilation and a well-insulated building envelope. The system has proved through an eQUEST model to be 47% more efficient than a baseline model. This is due to the high COP involved with the ground source heat pump drawling on the stable thermal properties of the ground. Also the air-to-air heat recovery system was chosen, even though not required, due to its energy saving capabilities. Finally the demand ventilation control using CO² detection was also a major source of success. By allowing the advanced control of the mechanical equipment energy savings are made possible and have allowed this building design to be in contention for a LEED Gold accreditation.

The ASHRAE 62.1 analysis revealed The Sunshine Elementary School to be compliant as designed. The air exhausts and intakes have been located and specified in accordance with ASHRAE standards. Drain pans and other equipment have been utilized in the correct manner and are of approved material. The ASHRAE 90.1 analysis also proved that the design is proficient and passes the required criteria. Overall the design of the building is above and beyond compliant in all areas of the analysis.

ASHRAE Standard 62.1 Overview

The evaluation of Section 5 and Section 6 proved that the building is compliant with all applicable parts of the standards. Calculations were performed for Section 6 for all parts of the building. The results showed the all areas of the building receive more than adequate ventilation. Default values for population densities were used in the calculation as are given by ASHRAE.

ASHRAE 62.1 SECTION 5 COMPLIANCE REPORT

The Sunshine Elementary School will be evaluated using ASHRAE Std. 62.1 section 5 to check for compliance. This will cover different points of ventilation, exhaust, controls and various other aspects of the mechanical design.

5.1: Natural Ventilation

Natural Ventilation was not considered as a method of ventilation for the building. The building utilizes a mechanical ventilation system which complies with the ASHRAE air quality standards.

5.2: Ventilation Air Distribution

All spaces of the building comply with the ventilation requirement of ASHRAE Standard 62.1. Air balancing has been designed to achieve minimum required ventilation according to Section 6 of ASHRAE 62.1. The documents specify the minimum requirements for air balance testing.

5.3: Exhaust Duct Location

All exhaust ducts are negatively pressured through all spaces. The exhaust fans, EF-1 through EF-9, are located on the roof of the building insuring sufficient disposal of contaminated exhaust air. All Fans except EF-6 and EF-7 are controlled by occupancy sensors to ensure proper removal while conserving energy.

5.4: Ventilation System Controls

Demand control ventilation was utilized were applicable throughout the building. All spaces are satisfying the minimum outdoor air flow requirements as will be further discussed and evaluated through Section 6 compliance evaluation.

5.5: Airstream Surfaces

Primarily all surfaces in contact with airstreams in this building are sheet metal. Where needed flexible duct was utilized to connect supply diffusers. Both of these materials comply with the resistance to mold growth and the resistance to erosion subsections. Fibrous-Glass Liner is also used but complies with NFPA 90A or NFPA 90B and with NAIMA AH124 and shall be treated to be resistant to moisture and microbial growth.

5.6: Outdoor Air Intakes

The minimum required distance, for all outdoor air intakes, is met by the mechanical design ensure no entry of contaminants to the building. Aluminum, ½ inch square mesh Bird Screening and 18-16 mesh Insect Screening are specified for the intakes.

5.7: Local Capture of Contaminants

All Exhaust fans are ducted directly outside at a high air velocity to ensure no re-entry of contaminants. Exhaust fans are used in all areas that contaminants are possible. Kitchen exhaust fans are ducted directly to KEF-1 and KEF-2 mounted on roof top.

5.8: Combustion Air

Emergency generator exhaust is ducted directly outdoors and is given a 20 sq. ft. free space for louvers complying with requirements of this section. All other combustion air is removed in accordance to manufactures instructions.



Figure-1: Generator Exhaust Detail

5.9: Particulate Matter Removal

Air-to-Air Recovery Units utilize Pre-Filters for return and outside air. They are specified to be 2" thick, pleated and disposable. The filter media is specified to have a minimum MERV 13 rating.

5.10: Dehumidification Systems

Relative humidity of all occupied space is maintained well below 65%. The air-to-air recovery units are designed to help remove the latent load. The air intake of the building is greater than exhaust, thus positively pressurizing the space with respect to the outside environment and preventing infiltration related problems.

5.11: Drain Pans

The Vertical-Stack water source heat pumps utilized on the project are specified to have plastic or stainless-steel drain pans pitched as required in ASHRAE 62 with draining directly to the exterior. The water source heat pumps will utilize stainless-steel drain pans with condensate drain piping projecting to unit exterior and complying with ASHRAE 62.1-2007. The drain pans are also provided with a float switch.

5.12: Finned-Tube Coils and Heat Exchangers

Air-to-Air energy recovery units are equipped with drain pans in compliance with ASHRAE 62.1-2007. In Air coil units the coils will be cleaned using materials and methods recommended in writing by manufacturers, and are specified to have the inside of casings and enclosures to be removed dust and debris.

5.13: Humidifiers and Water-Spray Systems

The design of the mechanical system does not utilize a humidification or water spray system.

5.14: Access for Inspection, Cleaning and Maintenance

The design of the mechanical is practical allowing space for all inspection, maintenance and cleaning to be performed with ease. There are access doors and panels to all ventilation equipment, ducts and plenums of sufficient size.

5.15: Building Envelope and Interior Surfaces

The building is equipped with an air barrier to prevent moisture problems. The brick covering has a drain system allowing moisture to be removed and thus

not enter the building. All pipes in the building are lined with insulation to prevent condensation related problems.



Figure 2: Wall Detail

ASHRAE 62.1 SECTION 6 COMPLIANCE REPORT

In this section 6.2, Ventilation Rate Procedure, will be used in order to calculate the outdoor air requirements of the space. The procedure is a prescriptive measurement based on type/application, occupancy level, and floor area. In 6.2.2.1 an equation is given to complete this task.

Equation:
$$V_{bz} = R_p P_z + R_a A_z$$

R_p [cfm/person] = outdoor airflow rate required per person as determined from Table 6-1

R _a [cfm/ft ²]	= outdoor airflow rate required per unit area as determined from
	Table 6-1
$A_{z}[Ft^{3}]$	= zone floor area or net occupiable floor area of the zone

P_z [people] = zone population: largest density of population expected in zone

The spaces throughout the building are served with ceiling supply of warm air 15oF above space temperature and ceiling return. Table 6-2 denotes the Zones Air Distribution Effectiveness and demes this type of delivery as ceiling supply of cool air and therefore:

 $E_{z} = 0.8$

Zone Outdoor Airflow (Voz): Equation 6-2

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

Primary Outdoor Air Intake: Equation 6-5

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

Uncorrected Outdoor Air Intake: Equation 6-6

 $V_{ou} = D\sum_{all \ zones}(R_p \times P_z) + \sum_{all \ zones}(R_a \times A_c)$, where $D = P_s / \sum_{all \ zones} P_z$ by equation 6-7

Outdoor Air Intake

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

The result of the calculations for the spaces throughout the building is compliancy with ASHRAE Std. 62.1 section 6. All spaces are given adequate, if not generous ventilation. The table below is provided to clearly state the ventilation rates required and provided. Example spreadsheets used to create the calculations can be found in Appendix B. Assumptions were made when grouping the typical rooms together that the properties of these room were the same. For example this assumption was made for typical classrooms.

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	ASHRAE 62.1-	
	2007	
	Ventilation	Ventilation
Space Name	Requirements	Provided
Gym	3172	5070
Gym/Office/Storage	113	150
Gym Corridor	39	50
Faculty Break Room	83	240
Typical Classroom	358	375
Typical Classroom	362	375
Reading	160	375
Art	433	475
Typical SGI	194	195
Instructional	261	270
Classroom Corridor	186	300
Library	649	750
Multipurpose	4409	4410
Classroom Library	198	375
Nurse Area	77	125
Main Corridor	139	200
Receptionist	198	200
Conference	68	200
Office	20	100
Offices	21	100
Conference	55	120
Art/Music	447	475
Kinder. Multipurpose	1628	2160
Kinder. Small SGI	159	200
Kinder. Large SGI	871	900
Typical Kinder.		
Classroom	395	395
Computer Room	341	375
Second Floor		
Classroom	358	375

Table-1: CFM Chart

ASHRAE 90.1-2007 COMPLIANCE REPORT

This section of the report will conclude The Sunshine Elementary Schools compliance with ASHRAE Std. 90.1-2007. The criteria that will be evaluated are: The building Envelope, HVAC system, service water heating, lighting and electric motor efficiency.

Section 5- The Building Envelope

This section specifies the requirements for the building envelope. The building is a nonresidential space.



Figure-3: ASHRAE Climate Zone Chart

The Sunshine Elementary School is located in Hershey, Pa which as can be seen in Figure-3 is in ASHRAE Climate Zone 5 shown in green. The requirements of the building envelope will be evaluated using Table 5.5-5 in ASHRAE Standard 90.1. The standard lists requirements based on roofs, walls, opaque doors and fenestration arrangements.

Compliance with Envelope Prescriptive Requirements											
Element	Description	90.1 S V	Specified alues	Specifie	d Values	Compliance					
		Max U	Min R	Max U	Min R						
Roofs	A ++ic	U-	B-38 U	0.027							
NUUIS	Attic	0.027	N-38.0	0.027	R-38	YES					
Walls Above	U-		D 11 4 c i	0.042							
Grade	IVIDSS	0.090	R-11.4 C.I.	0.042	R-13.4	YES					
Opaque Doors	Swinging	U-0.7		0.345		YES					

Table-2: Compliance with Envelope Prescriptive Requirements





The roof of the building has an attic due to the gabled roofs. The requirement of the insulation is prescribed to be a minimum of R-38. The ceiling is layered with two layers of R-19 insulation equaling the required R-38 value. The U value minimum is also met by the design.

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Walls, Above-Grade



Figure-5: Typical Wall Detail

The walls above grade consist of a brick fenestration, air gap, 2-1/2" rigid insulation, and 8" CMU block. In Table 5.5 Mass walls must consist of U-0.090 and R-11.4 values, the designed walls have a maximum U value of 0.042 and a minimum R value of 13.4 easily complying with the standard.

Opaque Doors

The typical baseline doors throughout the building are compliant having a u value well below the minimum.

Fenestration

Section 5 of this standard also states that the glazing shall be less than 40% of the overall gross wall area. The Sunshine Elementary school meets this standard as can be seen by Table-3 below.

Glaze	d Area on E	Building E	xterior Fa	açade
	Glass Area (ft ²)	Wall Area (ft ²)	% Glass	Compliance
North	3219	9440	25%	YES
North-East	847	2859	23%	YES
East	432	5020	8%	YES
South-East	847	2880	23%	YES
South	3060	10343	23%	YES
South-				
West	847	2386	26%	YES
West	145	6448	2%	YES
North-				
West	847	2371	26%	YES
Total	10244	41746	20%	YES

Table-3: Glazed Area on Building Exterior Facade

Section 6- Heating, Ventilating and Air Conditioning

Section 6.1

The scope of this section is to check the compliance of the mechanical equipment and systems serving the heating, cooling, or ventilation needs. The building is under construction and therefore is a new building.

Section 6.2

This section of ASHRAE gives compliancy path options depending on the building size. The Sunshine Elementary School is more than 25,000 ft² and therefore Section 6.4, Mandatory Provisions, and Section 6.5, will be used to check compliance.

Section 6.4

This section gives mandatory provisions of the equipment efficiencies, verification and labeling requirement. The Sunshine Elementary School utilizes highly efficient mechanical system. Unfortunately, with the project still under construction and thus the verification of the equipment cannot be analyzed, but the design specifies for all equipment to meet minimum Equipment efficiencies, listed equipment, standard ratings, and operating conditions.

Demand side controls are used throughout the design of the building ensuring an efficient use of energy. CO² sensors are specified to be used for ventilation control. Also the building, being an elementary school, has schedule which is met by the equipment controls. Setbacks are scheduled for all unoccupied periods, such as holidays and breaks, as well as nightly setbacks for when school is dismissed.

Dampers are specified on all outdoor air supplies to ensure closing when the spaces are not in use. Also insulation meeting the requirements of Table 6.8.2B is provided for all combined heating and cooling supply ducts and returns.

Section 6.5

The Preventive Path is an evaluation to prevent excess energy consumption of mechanical equipment. The Sunshine Elementary School is compliant with the standard. The fan horse power has been analyzed and can be seen below in Table-4. All energy recovery units have properly sized fans for the CFM supplied by ASHRAE requirements.

Equipment Analyzed	CFM	Motor HP	Variable Volume hp ≤ CFMs x 0.0015	Compliance
ERU-1	5070	3	7.605	YES
ERU-2	5730	5	8.595	YES
ERU-3	5660	5	8.49	YES
ERU-4	4410	3	6.615	YES
ERU-5	4950	5	7.425	YES
ERU-6	4300	3	6.45	YES
ERU-7	1750	1	2.625	YES

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Equipment			Variable Volume	
Analyzed	CFM	Motor HP	hp ≤ CFMs x 0.0015	Compliance
ERU-8	1400	2	2.1	NO
ERU-9	2160	1.5	3.24	YES

Table-4: Fan Power Analysis

Section 7-Service Water Heating

The Sunshine Elementary School will be analyzed for the compliance of ASHRAE Standard 90.1 in this section.

Section 7.2

The compliance path prescribed by 7.2.1 will be used to ensure compliance. This will include Section 7.4, Mandatory Provisions, Section 7.5, Prescriptive Path, section 7.7, Submittals, and Section 7.8, Product Information.

Section 7.4

The sizing of the systems and equipment was done using design loads according to the manufactures published sizing guidelines. The efficiency of all water heating equipment and hot water storage tanks meet the requirements of Table 7.8 of ASHRAE 90.1. The insulation of all hot water piping is to the levels of Section 6, Table 6.8.3, as can be seen below in Table-5.

Insulation Thickness In Inches for Pipe Sizes In Inches								
Interior Piping Service	Material	Less than 1"	1" to less than 1 1⁄2"	$ \begin{array}{c} 1 \\ \frac{1}{2^{2}} \\ \text{to} \\ \text{less} \\ \text{than} \\ 4^{"} \end{array} $	4" to less than 8"	8" and larger	Notes	Vapor Barrier Yes/No
Domestic Hot Water & Hot Water Recirculation	Jacketed Fiberglass	1	1	1 ½	1 ½	1 ½	3, 4, 5	No

Table-5: Insulation Thickness for Pipe Sizes

Temperature controls were utilized to hold storage water at a temperature below 120°F and to deliver the hot water at temperature below 110°F to all lavatory faucets, complying with Section 7. Also circulating pump controls are specified to operate a maximum of five minutes after the end of the heating cycle.

Section 7.5

The hot water heaters for the building are fuel fired domestic water heaters. LEED submittals have been made indicating the units comply with the ASHRAE 90.1-2004 Section 7- Service Water Heating Standards. Also, the Energy Efficient Design of New Buildings except Low-Rise Residential Buildings for commercial water heaters by AHSRAE 90.1 has been met.

Section 7.7

Submittals have been made to LEED for accreditation and will be available for submittal to the authority having jurisdiction, in accordance with Section 4.2.2 of this standard.

Section 7.8

ANSI Compliance has been met providing the gas water heaters of the building, therefore complying with Section 7.8 according to Table 7.8, performance Requirements for Water Heating Equipment.

Section 8- Power

This section applies to The Sunshine Elementary School building power distribution system.

Section 8.2

The compliance path for this section shall be met following Section 8.1, General; Section 8.4, Mandatory Provisions; and Section 8.7, Submittals.

Section 8.4

The feeder conductors are sized for a maximum voltage drop of 2% at design load, while the branch circuits are sized for a maximum voltage drop of 3%

at design load. The drawings and manuals for the power system will be provided to the building owner with minimum requirements. Thus The Sunshine Elementary School is compliant with this section of ASHRAE 90.1.

Section 9- Lighting

This section shall analyze compliance of indoor and outdoor lighting systems. For this analysis life safety and critical lighting is not considered. The analysis will include the installed interior lighting power including the luminaire its components and the maximum wattage of the luminaire.

Section 9.2

The Sunshine Elementary School will be analyzed using sections 9.1, General; 9.4 Mandatory Provisions; and 9.5 Building Area Method.

Section 9.4

Automatic lighting controls were utilized throughout the building. Occupancy sensors controlling all lighting shall shut off the luminaires when a room is empty ensuring energy savings.

Section 9.5

The Sunshine Elementary School is given an LPD (watts per unit area) value of 1.2 (W/ft²), found using Table 9.5.1 of ASHRAE 90.1. The determined gross lighted area is estimated to be 88,650 ft².

Gross Lighted Floor Area X LPD = Interior Lighting Allowance

Calculated Interior Lighting Power, as can be seen in Table-6 is 100,182 Watts which is lower than the Interior Lighting Allowance. Thus the buildings lighting system is compliant with ASHRAE 90.1 Section 9.5.

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Room Type	Areas	W/ft ²	Watts	Room Type	Areas	W/ft ²	Watts
Nurse's Suite	935.2	0.989	925	SGI 37	628.9	1.347	847
Electrical	251.2	0.000	0	SGI E105	2366.2	0.117	277
Restrooms	361.2	1.619	585	Music 22	1049.6	1.281	1345
Corridor/Vest.	1354.2	0.912	1235	Supply	352.6	0.496	175
Vestibules B	92.2	1.410	130	Classrooms 1 st & 2 nd	8341.2	1.290	10760
Vestibules A	89.3	1.456	130	Art 23	1035.7	1.298	1344
Vestibule D103	66.8	1.945	130	Read 25	1049.6	1.530	1606
Vestibule	580.4	1.120	650	Office C151	202.4	1.284	260
Library	3993.1	0.845	3374	Office C150	135.3	0.961	130
Faculty 9	338.6	1.418	480	Office C149	134.5	0.966	130
Kindergarten 1-8	9040.0	1.186	10721	Office C145/C146	314.5	1.447	455
Gym Storage	988.6	0.000	0	Office C144	559.5	1.394	780
Corridor C110	99.4	1.308	130	Reception	748.5	1.077	806
Corridor C143a	533.6	1.679	896	Conference C147	177.6	1.464	260
CorridorC102C	453.9	1.727	784	Conference C152	237.9	1.093	260
Corridor C102b	587.9	1.715	1008	Faculty 10	338.6	1.417	480
Corridor	440.1	1.782	784	Faculty 35	655.3	1.319	864
Corridor B101	3204.2	0.774	2480	Faculty 51	655.3	1.200	786
Corridor D110	1315.3	0.593	780	Art 20	1232.5	0.171	211
Storage Spaces	1383.0	0.000	0	Multi Use	1665.5	0.062	103
Cafeteria	5010.8	2.062	10332	Kindergarten 11-18	9024.2	1.190	10739
Gym	6494.8	1.229	7982	Kitchen	2575.0	0.302	778
SGI B140 B141	709.3	1.624	1152	Faculty Dining	1151.9	0.573	660
SGI 34	686.1	1.679	1152	Mechanical	1194.6	0.000	0
SGI D117	265.1	0.981	260	Receiving	347.8	0.604	210
SGI 19	396.9	1.935	768	Serving Kitchen	956.7	0.815	780
SGI D11	2366.3	0.117	277	Library Classroom	662.6	1.355	898
SGI 36	684.2	1.684	1152	Gang Bathroom	706.1	1.925	1359
SGI 50	682 0	1 687	1150	3 rd -5 th &	9//1 /	1 280	12085
	62.9	1 2/7	115Z	Computers 49	9441.4 1025 0	1 200	12005
SCI 5105	226.9	1.54/	04/	Total	20251	1.298	100102
201 5102	2300.2	0.11/	2//	TOLAT	00051.4		100195

Table-6: Lighting Power Densities

Summary

The Sunshine Elementary School has proved to be completely compliant to both AHRAE Standard 62.1 and Standard 90.1, for systems analyzed. The design is proficient from the envelope to the mechanical equipment to the lighting design. The building envelope proved insulated beyond requirements in areas such as the walls and just met compliancy with R-38 insulation in the roof. The building is designed to have much less than the allotted 40% exterior glazing with a total of only half that at 20%. The mechanical design is suburb supplying more than required ventilation air allowing for productive and healthy activity within the building, while still reducing the energy by up to 47% less than a baseline building. The lighting design met the required power density and also uses advanced controls to reduce energy usage. Submittals have been made to LEED with the building expecting Gold accreditation.

Appendix A

- Figure-1 Generator Exhaust Detail
- Figure-2 Wall Detail
- Figure-3 ASHRAE Climate Zone Chart
- Figure-4 Roof Insulation Detail
- Figure-5 Typical Wall Detail
- Table-1 CFM Chart
- Table-2
 Compliance with Envelope Prescriptive Requirements
- Table-3 Glazed Area on Building Exterior Façade
- Table-4 Fan Power Analysis
- Table-5 Insulation Thickness for Pipe Sizes
- Table-6 Lighting Power Densities

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Appendix B

Buildin	a:			Suns	hine El	eme	ntary Sc	hool			1		I		I
System	Tag/Name:		Delete Zone	Туріс	al Clas	sroc	om								
Operating Condition Description:															
Units (s	select from pull	-down list)	Add Zone	IP	IP										
Inputs	for System			Name	Units					System			Check f	igures	
	Floor area serve	d by system		As	sf	_			_	921					
	Population of are	ea served by system (i	including diversity	I Ps	Р		100%	diversity		21			23.3	P/1000 sf	
	Design primary s	upply fan airflow rate		Vpsd	cfm	_				1,090			1.18	ofm/sf	
	OA reg'd per uni	t area for system (Weij	ghted average)	Ras	ofm/sf					0.12			0.12	ave ofm/s	f
	OA reg'd per per	son for system area ('	Weighted average) Rps	ofm/p					10.0			10.00	ave ofm/p	
Inputs	for Potentially (<u>Critical zones</u>									Potentially C	ritical Zone:	s		
	Zone Name										2nd	Closet			
				Zone i	title turn.	s puŋ	ole italic foi	r crítical zone	els)		Grade 31	B112	Totals/a	averages	
	Zone Tag	Show Values	per Zone						_		19	20			
	Space type										Classroom	Storage			
	opdot ()pt				Selec	t from	n pull-dowr	n list			s (ages	rooms			
	Floor Area of zor	ne		Az	sf						857	64	921	total sf	
	Design population	on of zone		Pz	P	(de	fault value	listed; may b	e ove	erridden)	21.425	0	21.425	total P	
	Design total sup	ply to zone (primary pl	us local recirculat	ed) Vdzd	ofm						990	100	1090	total ofm	
	Induction Termin	ial Unit, Dual Fan Dua	I Duct or Transfer	Fan?	Selec	t from	n pull-dowr	n list or leave	blank	if N/A					
	Local recirc, air 3	% representative of as	ve system return a	r Er							75%	75%	1.00	average	
Inputs	for Operating C	ondition Analyzed	1												
	Percent of total (design airflow rate at o	conditioned analy:	ed Ds	1					100%	100%	100%	100%	average	
	Air distribution ty	pe at conditioned ana	alyzed		Selec	t from	n pull-dowr	n list 🔔			CSCRH	CSCRH	1		
	Zone air distribut	ion effectiveness at c	conditioned analyz	ed Ez				Show	code	s for Ez	0.80	0.80	80%	average	Primary airf
	Primary air fractio	on of supply air at con	ditioned analyzed	Ep									1.00	average	109
Results	ī														
	Ventilation Syste	em Efficiency		Ev						0.90					
	Outdoor air intak	e required for system		Vot	cfm					362					
	Outdoor air per u	init floor area		Vot/As	cfm/sf					0.39					
	Outdoor air per p	erson served by syste	em (including dive	sity Vot/Ps	cfm/p					16.9					
	Outdoor air as a	% of design primary s	upply air	Yod	cfm					33%					
Detaile	d Calculations														
Initial C	alculations for	the System as a v	hole												
	Primary supply a	ir flow to system at co	nditioned analyze	d Vps	ofm	=	VpdDs		=	1090			21.425	System p	opulation with
	UncorrectedOA	requirement for syste	m .	Vou	ofm	=	Rps Ps +	· Ras As	=	325			1.00	System p	opulation div
	Uncorrected OA	regid as a fraction of	primary SA	Xs		=	Vou/Vp	s	=	0.30					1
Initial C	alculations for	individual zones													
	OA rate per unit -	area for zone		Raz	ofm/sf						0.12	0.12	2		
	OA rate per pers	on		Rpz	ofm/p						10.00	0.00	1		
	Total supply air to	o zone (at condition b	eing analyzed)	Vdz	cfm						990	100	1090	1	
	Unused OA regio	d to breathing zone		Vbz	ofm	=	Rpz Pz +	- Raz Az	=		317.1	7.7	325	i	
	Unused OA reau	irement for zone		Voz	ofm	=	Vbz/Ez		=		396	10	406	i	
	Fraction of zone	supply not directly re-	circ. from zone	Fa		=	Ep + (1-E	D)Er	=		1.00	1.00	1		
	Fraction of zone	supply from fully mixe	d primary air	Fb		=	Ep		=		1.00	1.00	1		
	Eraction of zone	DA not directly recirc	from zone	Ec		=	1-(1-Ez)(1-En)(1-Er)	=		100	100	1		
	Unused OA fract	tion required in supply	uair to zone	Zd		=	VozIVd	7	=		0.40	0.10	0.40	Masimum	Zd
	Unused OA fract	tion required in primar	v air to zone	Zn		=	Voz / Vo	- z	=		0.40	0.10	0.40	Masimum	Zn
Sustem	Ventilation Eff	iciencu	y dir to corre	-P			••••••	-			0.10	0.10	0.10	1 Ioniniani	
	Zone Ventilation	Efficiency (App A Me	thod)	Fuz		=	(Ea + Eb)	Xs - EoZI/E:			0.90	1.20	1		
	Sustem Ventilati	on Efficiency (App A M	Method)	Fu		=	min (Euz))		0.90	0.00				
	Ventilation Susta	m Efficiency (Table 8	(3 Method)	Eu		-	Value fre	m Table 6.3	-	0.75					
Minimu	m outdoor air in	take airflow					a calce a c			0.10					
	Outdoor Airlotal	re Flow required to Su	stem	Vot	ofm	-	VouVE		-	362					
	Dů iotake regid	es a fraction of primar	u SA	V.	onn	-	VotWer	-	-	0.33					
	Dutdoer Airletel	e Elow required to Su	stern (Table 6-2 M	athe Vet	ofm		Mou / En		-	422					
	DA intake regid	er now required to by	u SA (Table 6.3 M	tho Y	onn		Vot Wex		1	0.40					
	on at which Mis	OA provides all a	ooling				voci vps			0.40					
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October 4, 2010

System Deletit 2 One Gym Comparing Condition Description: Add Zone IP Zone Name Commany Example state for colors and condition of an example state for colors and condition of contemportation o	Building:			Sunst	nine Ele	emei	ntary School			1		Į	
Operating Condition Description: Add Zone P Zone Name Zone Name Come Na	System Tag/Name:		Delete Zone	Gym			- í						
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Fraction of zone supply not directly recirc. from zoneFa=Ep + (1-Ep)Er=1.001.00Fraction of zone supply from fully mixed primary airFb=Ep=1.001.00Fraction of zone OA not directly recirc. from zoneFo= $1-(1-Ez)(1-Ep)(1-Er)$ =1.001.00Unused OA fraction required in supply air to zoneZd=Voz / Vdz=0.270.440.44Maximum 2Unused OA fraction required in primary air to zoneZp=Voz / Vpz=0.270.440.44Maximum 2System Ventilation EfficiencyZp=Voz / Vpz=0.730.561.00System Ventilation Efficiency (App A Method)Evz=(Fa + FbXs - FoZ) / Fa=0.730.56System Ventilation Efficiency (App A Method)Evz=min (Evz)=0.711.00Minimum outdoor air intake airfloxEv=win (Fable 6.31.001.00Outdoor Air Intake Flow required to SystemVotofm=Vou / Ev=1.001.00Outdoor Air Intake Flow required to System (Table 6.3 Method)V=Vot / Vps=1.001.001.00Outdoor Air Intake Flow required to System (Table 6.3 Method)V=Vot / Vps=1.001.001.00OA Teepo w which OA browdes all coolingDA Teepo w which OA browdes all coolingDate for (Table 6.3 Method)Image for (Table 6.3 Method)Image for (Table 6.3 Method)Image	Unused OA requirem	ient for zone		Voz	ofm	=	Vbz/Ez	=		1915	1326	3241	
Fraction of zone supply from fully mixed primary air Fb = Ep = 1.00 1.00 Fraction of zone OA not directly recirc. from zone Fo = 1-(1-Ez)(1-Ep)(1-Er) = 1.00 1.00 Unused OA fraction required in supply air to zone Zd = Voz / Vbz = 0.27 0.44 0.44 Maximum Z System Ventilation Efficiency Zp = Voz / Vbz = 0.27 0.44 0.44 Maximum Z System Ventilation Efficiency (App A Method) Evz = (Fa + FbXs - FoZ) / Fa = 0.73 0.56 System Ventilation Efficiency (App A Method) Evz = min (Evz) = 0.56 Ventilation System Efficiency (Table 6.3 Method) Ev = min (Evz) = 0.71 Minimum outdoor Air Intake Flow required to System Vot ofm Vou / Ev = **DIV/0! = Outdoor Air Intake Flow required to System (Table 6.3 Method) Y = Vot / Vps = **DIV/0! = = Outdoor Air Intake Flow required to System (Table 6.3 Method) Y = Vot / Vps	Fraction of zone sup	ply not directly reci	irc. from zone	Fa		=	Ep + (1-Ep)Er	=		1.00	1.00		
Fraction of zone OA not directly recirc. from zone Fo = 1-(1-Ep)(1-Ep)(1-Er) = 1.00 1.00 Unused OA fraction required in supply air to zone Zd = Voz / Vdz = 0.27 0.44 0.44 Maximum Z System Ventilation Efficiency Zp = Voz / Vpz = 0.27 0.44 0.44 Maximum Z System Ventilation Efficiency Zp = Voz / Vpz = 0.27 0.44 0.44 Maximum Z Zone Ventilation Efficiency (App A Method) Evz = (Fa + FbXs - FoZ) / Fa = 0.73 0.56 System Ventilation System Efficiency (Table 6.3 Method) Ev = min (Evz) = 0.56 Ventilation System Efficiency (Table 6.3 Method) Ev = Value from Table 6.3 = 0.71 Minimum outdoor Air Intake airflox Vot ofm Vou / Ev = * * = * Outdoor Air Intake Flow required to System (Table 6.3 Method) Y = Vot / Vps = * * * * * * * * <	Fraction of zone sup	ply from fully mixed	primary air	FЬ		=	Ep	=		1.00	1.00		
Unused OA fraction required in supply air to zone Zd = Voz / Vdz = 0.27 0.44 0.44 Maximum Z Unused OA fraction required in primary air to zone Zp = Voz / Vpz = 0.27 0.44 0.44 Maximum Z System Ventilation Efficiency (App A Method) Ev = (Fa + FbXs - FoZ) / Fa = 0.73 0.56 Ventilation System Efficiency (App A Method) Ev = min (Evz) = 0.56 Ventilation System Efficiency (Table 6.3 Method) Ev = Value from Table 6.3 = 0.71 Minimum outdoor Air Intake airflow Outdoor Air Intake Flow required to System (Table 6.3 Method) Vot ofm = Vou / Ev = *DIV/0! Outdoor Air Intake Flow required to System (Table 6.3 Method) Y = Vot / Vps = *DIV/0! Outdoor Air Intake Flow required to System (Table 6.3 Method Vot ofm = Vou / Ev = 0 * DIV/0! OA intake req'd as a fraction of primary SA (Table 6.3 Method Y = Vot / Vps = *DIV/0! OA Thelpw which OA horake flow is @ minimum Dep E = /(Tar-dTaft=f1=f1=Y)*(Tr+d = *#DIV/0! Da Tablew which OA horake flow is @ minimum Dep E = /(Tar-dTaft=f1=f1=Y)*(Tr+d = *#DIV/0! Da Tablew which OA horake flow is @ minimum Dep E = /(Tar-dTaft=f1=f1=Y)*(Tr+d = *#DIV/0! Da Tablew which OA horake flow is @ minimum Dep E = /(Tar-dTaft=f1=f1=Y)*(Tr+d = *#DIV/0! Da Tablew which OA horake flow is @ minimum Dep E = /(Tar-dTaft=f1=f1=Y)*(Tr+d = *#DIV/0! Da Tablew which OA horake flow is @ minimum Dep E = /(Tar-dTaft=f1=f1=Y)*(Tr+d = *#DIV/0! Da Tablew which OA horake flow is @ minimum Dep E = /(Tar-dTaft=f1=f1=Y)*(Tr+d = *#DIV/0! Da Tablew which OA horake flow is @ minimum Dep E = /(Tar-dTaft=f1=f1=Y)*(Tr+d = *#DIV/0! Da Tablew which OA horake flow is @ minimum Da Tablew which OA horake flow is @ minimum Datablew bishon OA horake flow is @ minimum Datablew b	Fraction of zone OA	not directly recirc. f	from zone	Fo		=	1-(1-Ez)(1-Ep)(1-	-Er) =		1.00	1.00		
Unused DA fraction required in primary air to zone Zp = Voz / Vpz = 0.27 0.44 0.44 Maximum 2 System Ventilation Efficiency Zone Ventilation Efficiency (App A Method) Ev = (Fa + FbXs - FoZ) / Fa = 0.73 0.56 System Ventilation System Efficiency (App A Method) Ev = min (Evz) = 0.56 Ventilation System Efficiency (Table 6.3 Method) Ev = Value from Table 6.3 = 0.71 Minimum outdoor air Intake airflow Outdoor Air Intake Flow required to System (Table 6.3 Method Vot ofm = Vou / Ev = *DIV/0! Outdoor Air Intake Flow required to System (Table 6.3 Method Vot ofm = Vou / Ev = *DIV/0! Outdoor Air Intake Flow required to System (Table 6.3 Method Vot ofm = Vou / Ev = *DIV/0! Outdoor Air Intake Flow required to System (Table 6.3 Method Vot ofm = Vou / Ev = *DIV/0! Outdoor Air Intake Flow required to System (Table 6.3 Method Vot ofm = Vou / Ev = *DIV/0! OA Temp at which Min OA provides all cooling OAT below which OA brake flow is @ minimum	Unused OA fraction	required in supply a	air to zone	Zd		=	Voz / Vdz	=		0.27	0.44	0.44	Maximum 2
System Ventilation Efficiency Zone Ventilation Efficiency (App A Method) Evz = (Fa + FbXs - FcZ) / Fa = 0.73 0.56 System Ventilation Efficiency (App A Method) Evz = min (Evz) = 0.56 Ventilation System Efficiency (Table 6.3 Method) Evz = Value from Table 6.3 = 0.71 Minimum outdoor air intake airflow Evz = Value from Table 6.3 = 0.71 Outdoor Air Intake Flow required to System Vot cfm Vou / Evz = **DIV/0! = Outdoor Air Intake Flow required to System (Table 6.3 Method) Vot cfm Vou / Evz = 0 **DIV/0! = Outdoor Air Intake Flow required to System (Table 6.3 Method) Vot cfm Vou / Evz = 0 **DIV/0! = Outdoor Air Intake Flow required to System (Table 6.3 Method) Vot cfm Vou / Evz = 0 **DIV/0! = Outdoor Air Intake regid as a fraction of primary SA (Table 6.3 Method) Vot cfm = Vot / Vps = *DIV/0! = OA Teeplow which OA provides all cooling Dep E = (TaredTable1-11-V1!)(Tr	Unused OA fraction	required in primary	air to zone	Zp		=	Voz / Vpz	=		0.27	0.44	0.44	Maximum
Zone Ventilation Efficiency (App A Method) Evz = (Fa + FbXs - Fo2)/Fa = 0.73 0.56 System Ventilation Efficiency (App A Method) Ev = min (Evz) = 0.56 Ventilation System Efficiency (Table 6.3 Method) Ev = Value from Table 6.3 = 0.71 Minimum outdoor air intake airflow Vot ofm Vou/Ev = *DIV/0! Outdoor Air Intake Flow required to System Vot ofm Vou/Ev = *DIV/0! Outdoor Air Intake Flow required to System (Table 6.3 Method) V = Vot / Vps = *DIV/0! Outdoor Air Intake Flow required to System (Table 6.3 Method) Vot ofm = Vot / Vps = *DIV/0! Outdoor Air Intake Flow required to System (Table 6.3 Method) Vot ofm = Vot / Vps = *DIV/0! = OA Temp at which Min OA provides all cooling Den E = (Ta-dTaf)-(1-V)'(T+d') = #DIV/0!	System Ventilation Efficie	ncy		_									
System Ventilation Efficiency (App A Method) Ev = min (Evz) = 0.56 Ventilation System Efficiency (Table 6.3 Method) Ev = Value from Table 6.3 = 0.71 Minimum outdoor air intake airflow Vot ofm = Vou / Ev = *DIV/0! Outdoor Air Intake Flow required to System Vot ofm = Vou / Ev = *DIV/0! Outdoor Air Intake Flow required to System (Table 6.3 Method) V = Vot / Vps = *DIV/0! Outdoor Air Intake Flow required to System (Table 6.3 Method) Vot ofm = Vou / Ev = 0 * DIV/0! OA intake reg'd as a fraction of primary SA (Table 6.3 Method) Vot ofm = Vou / Ev = 0 * DIV/0! OA Temp at which Min OA provides all cooling Den E = *(Ta-dTaf)-(1-Y)*(T+d) = *#DIV/0! =	Zone Ventilation Effic	ciency (App A Meth	nod)	Evz		=	(Fa+FbXs-Fo	2)/Fa =		0.73	0.56		
Ventilation System Ethiciency (Table 6.3 Method) Ev = Value from Table 6.3 = 0.71 Minimum outdoor Air Intake Flow required to System Vot cfm = Vou / Ev = *#DIV/0! Outdoor Air Intake Flow required to System (Table 6.3 Method) Y = Vot / Vps = *#DIV/0! Outdoor Air Intake Flow required to System (Table 6.3 Method) Vot cfm = Vou / Ev = *#DIV/0! Outdoor Air Intake Flow required to System (Table 6.3 Method) Vot cfm = Vou / Ev = *#DIV/0! OA intake req'd as a fraction of primary SA (Table 6.3 Method) Y = Vot / Vps = *#DIV/0! #DIV/0! OA Temp at which Min OA provides all cooling Dep E = *(Tp-dTsft)-(1-Y)*(T+d) = *#DIV/0! #DIV/0!	System Ventilation E	fficiency (App A Me	ethod)	Ev		=	min (Evz)		0.56				
Pinnimum outdoor air intake airflow Outdoor Air Intake Flow required to System Vot cfm Vot cfm OA intake reg'd as a fraction of primary SA OA intake reg'd as a fraction of primary SA (Table 6.3 Method Vot cfm Vot cfm OA intake reg'd as a fraction of primary SA (Table 6.3 Method Vot cfm Vot vot / Ev Vot vot / Vps	Ventilation System E	molency (Table 6.3	piriethod)	EV		=	value from Tabl	ie 6.3 =	0.71				
Outdoor All intake now required to System Vot crm = Vot crm = Vot = <th< td=""><td>Pinimum outdoor air intak</td><td>e airliow</td><td></td><td>U.,</td><td>- (</td><td></td><td>U</td><td></td><td></td><td></td><td></td><td></td><td></td></th<>	Pinimum outdoor air intak	e airliow		U.,	- (U						
OW intake regid as a fraction or primary SA Y = Vot / Vps = *DIV/0: Outdoor Air Intake Flow required to System (Table 6.3 Method Vot ofm = Vot / Vps = 0 * *DIV/0: OA intake regid as a fraction of primary SA (Table 6.3 Method Vot ofm = Vot / Vps = * #DIV/0! OA Temp at which OA Intake flow which OA Intake flow which OA Intake flow is @ minimum Dep E = (Tp-dTef)-(1-Y)*(T+d') = *#DIV/0!	Othershear and the Fi	ow required to Syst	em CA	Vot	cim	=	VOUTEV Val IVal	=					
OA intrake regid as a fraction of primary SA (Table 6.3 Methy Vitic and Carlos) = 0 •DIV/0! OA Temp at which OA brake flow is @ minimum Dep E = (Ta-dTef)-(1-Y)*(T+d') =	Overlage Airland - El	rraction or primary:	on (Table 6.2 Made	No.	-	=	Votrivps	=	=DIVIU:				
OA Temp at which DA Intake feg us a maction of printary OA (Table 0.5 metric) OA Temp at which DA Intake flow is @ minimum Deg E = /(To-dTef)-(1-Y)*(Tr+d' = "#DIV/0!	Outdoor Ainhtake ni Qû intake res'd as a	fraction of primary (SA (Table 6.3 Meth)	Voc	orm	1	VotiVec						
$DaT below which DA brake flow is @ minimum Deg E = (T_{D-}dT_{C})(-1-Y)(T_{C+}d') = ["#DIW0]$	OA Temp at which Min OA	provides all co	oling	1			voci vps		WDIVIO:	PDIVIO:			
	OAT below which OA	Intake flow is @ mi	inimum		DealE	=	(Tp-dTs0-(1-Y	"(Tr+d) =	#DIV/0!				

October 4, 2010

Building:		Suns	nine El	eme	ntary Sch	ool			L I		I		
System Tag/Name: Delete Zone		Comp	Computer Room										
Operating Condition Description:													
Units (select from pull-down list)			IP										
Inputs for System			Name	Units	-			Sus	tem			Check F	ioures
Floor area served by	sustem		As	<f< td=""><td>-</td><td></td><td></td><td></td><td>921</td><td></td><td></td><td>Oneoki</td><td>igares</td></f<>	-				921			Oneoki	igares
Population of area served by system (including diversity)			Pe	P	-	100%	diuersitu		21			23.3	P/1000 ef
Design primary supply fan airflow rate			Word	cfm	-		differency	2	000			2 17	ofm/sf
DA regid per unit area for sustem (Weighted auerage)			Dag	ofmlef	-			-	0.12			0.12	aug of m/cf
DA regid per ank a consistent (megned average)			Pos	ofm/n	-				10.0			10.00	ave ofm/n
Inputs for Potentially Critical zones			- ips	onnip	-				10.0	Potentiallu C	ritical Zone	10.00	aveoimp
inputs for Fotermany Critical Zones										Camautar	Closet		
Zone Name			Zanal	inta trans		nla italin hnc.	critical popals	,		< 48	Closet	Totals/a	Sone Jone
Zope Tag		Lories	Re com a		ne kano ror e	onnodr zonietoj			201	202	Totalsia	verages	
Lone rag	Show Values pe	er Zone								Computer	Storage		
Space type —	Space type			Salaat	from	ا مسمله السم	i			Ish	John		
El A (0.2	delect	nom	ipai-dowin	150			14D 857	100ms 64	921	total of
			D-	D	(de	المرباه برماريم ال	at a du an a cuba a	و او او در د	-1	21.425		21/25	total D
Design population or zone Design population or zone				-	(de	rault value li	isted; may be t	overnade	4U)	1 900	100	21.423	total P
Design total supply to zone (primary plus local recirculated)			- D	Select	6	ault dauget	interlanus bla	-L KNUA		1,300	100	2000	totarcim
Leaster size size size size size size size size	nit, Duair an Duait	Ductor transferra		Select	nom	i pull-down i	ist of leave bia			75+2	7512	1.00	
Local recirc. air 7, rep	presentative of ave	e system return alf			-	-		-		107.	rə7,	1.00	average
Inputs for Operating Cond	Kion Analyzed		10-	•/	-			-	0012	1001/	10014	100*/	
Air distribution total desig	n airriow rate at co	onditioned analyze		Z.	6		1-1		00%	CSCDU	007	100%	average
Air distribution type a	(conditioned anal)	yzea		Select	rrom	i pull-down i	Showco	desfor	Ez	LOURN	LOURN	001/	
Zone air distribution e	errectiveness at co	inditioned analyze			-					0.00	0.00	100/.	average
Primary air fraction or	supply air at cond	itioned analyzed	Ep		-							1.00	average
Hesuits	<i>.</i>		-		-				05				
Ventilation System Efficiency			EV		-			U.	35				
Uutdoor air intake required for system			Vot	crm	-				241				
Outdoor air per unit rioor area			Vot/As	ctm/st	-			U.	31				
Uutdoor air per person served by system (including diversity			ty Vot/Ps	ctm/p				1	5.9				
Uutdoor air as a % of design primary supply air			Ypd	ctm	-				17%				
					_				_				
Detailed Calculations													
Initial Calculations for the System as a whole			.									01.405	
Primary supply air flow to system at conditioned analyzed			Vps	otm ,	=	VpdDs		= 2	2000			21.425	System po
UncorrectedUA requirement for system		Vou	ctm	=	HpsPs+H	Has As	=	325			1.00	System po	
Uncorrected UA regid as a fraction of primary SA		Xs		=	Vou/Vps		=	0.16					
Initial Calculations for individual zones			_										
UA rate per unit area	tor zone		Haz	ctm/st						0.12	0.12		
UA rate per person			Hpz	ctm/p						10.00	0.00		
l otal supply air to zor	i otal supply air to zone (at condition being analyzed) Usuas d OA as s'd to be sit is seen.		Vdz	ctm						1900	100	2000	
Unused UA regid to breathing zone		Vbz	ctm	=	Hpz Pz + H	Haz Az	=		317.1	(. (325		
Unused UA requirem	Unused UA requirement for zone		Voz	ctm	=	Vbz/Ez		=		396	10	406	
Fraction of zone sup	Fraction of zone supply not directly recirc. from zone				=	Ep + (1-Ep)Er	=		1.00	1.00		
Fraction of zone supp	Fraction of zone supply from fully mixed primary air		Fb		=	Ep		=		1.00	1.00		
Fraction of zone UA	not directly recirc. I	from zone	Fc		=	1-(1-Ez)(1-	-Ep)(1-Er)	=		1.00	1.00		
Unused UA fraction r	equired in supply a	air to zone	Zd		=	Voz / Vdz		=		0.21	0.10	0.21	Maximum
Unused UA fraction required in primary air to zone			2p		=	Voz / Vpz		=		0.21	0.10	0.21	Maximum
ovstem Ventilation Efficie	ncy	D.	-			-							
Zone Ventilation Efficiency (App A Method)		Evz		=	(Fa+FbX	s-Fc2]/Fa	= _	~-	0.95	1.07			
System Ventilation Efficiency (App A Method)			Ev		=	min (Evz)		= 0.	95				
Ventilation System El	ficiency (Table 6.3	3 Method)	Ev		=	Value from	n fable 6.3	= (1.94				
Minimum outdoor air intak	e airflow												
Outdoor Air Intake Flo	ow required to Syst	tem	Vot	cfm	=	Vou/Ev		=	341				
UA intake regid as a fraction of primary SA			Y		=	Vot / Vps		= (J. 17				
Uutdoor Air Intake Flow required to System (Table 6.3 Metho			nd Vot	otm	=	Vou/Ev		=	345				
UA intake regid as a l	raction of primary	SALLADIe 6.3 Meth	iοΥ		=	Vot / Vps		=	0.17				
114 Lown at which Min OA	provides all co	aluna											

OA Temp at which Min OA provides all cooling