PSUAE

Technical Report: One

ASHRAE COMPLIANCE REPORT

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2010

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 CO^2 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.

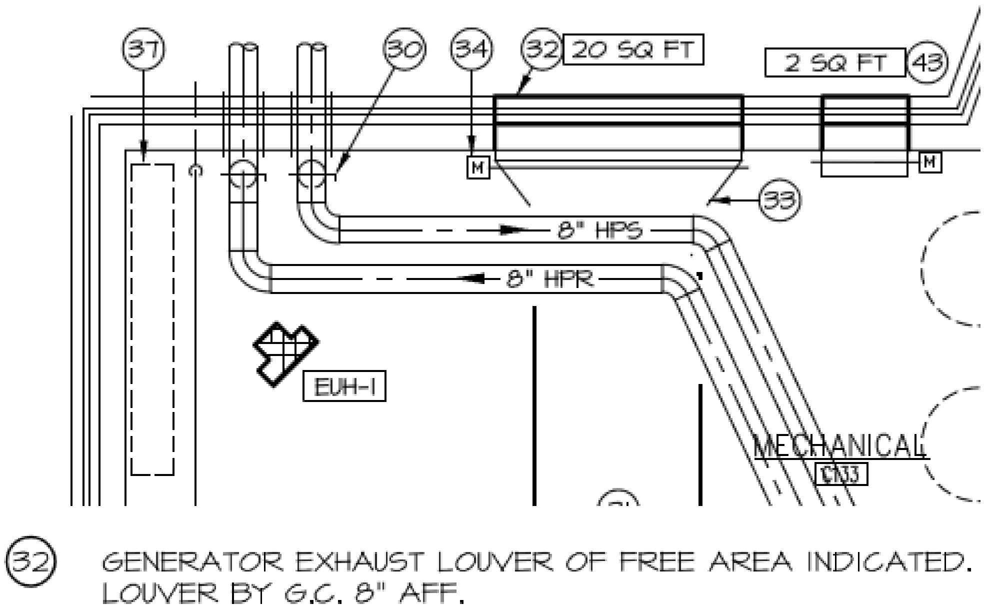

Figure-1: Generator Exhaust Detail

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.

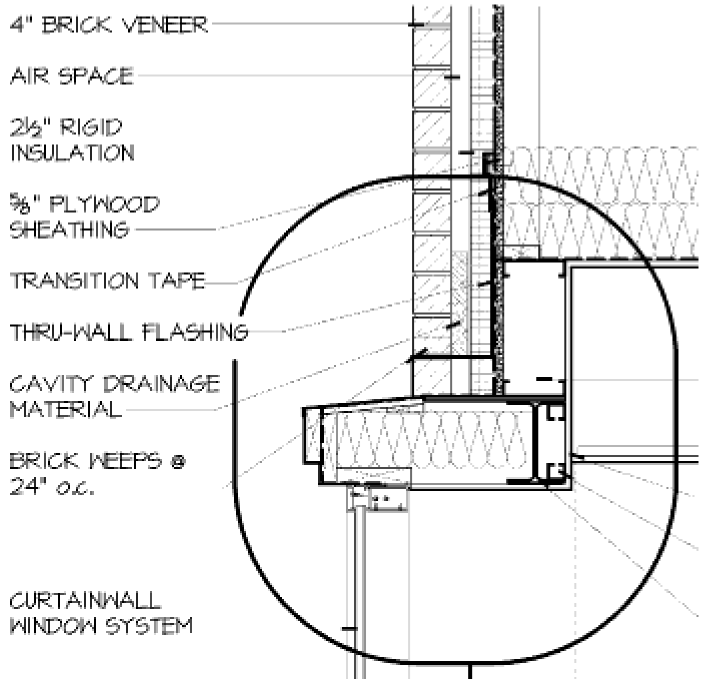

Figure 2: Wall Detail

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.

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

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 (V_{oz}): 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

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

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.

Space Name	ASHRAE 62.1-2007 Ventilation Requirements	Ventilation 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.

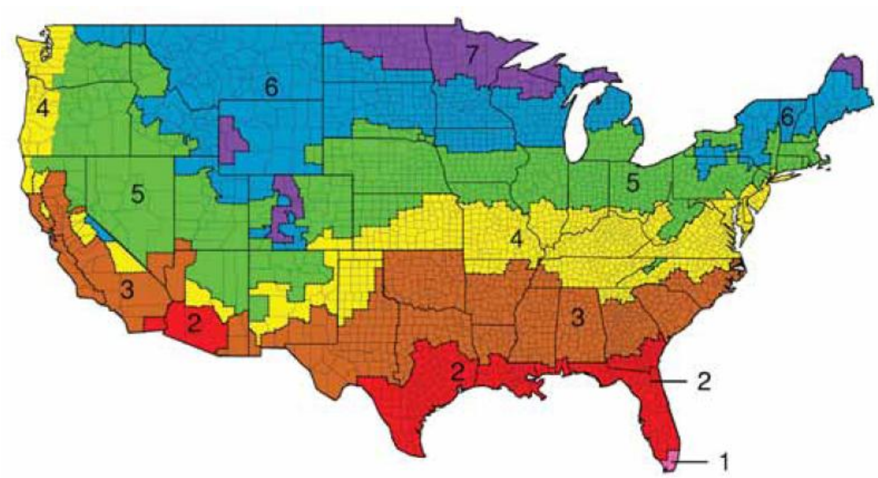

Figure-3: ASHRAE Climate Zone Chart

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 Specified Values		Specified Values		Compliance
		Max U	Min R	Max U	Min R	
Roofs	Attic	U-0.027	R-38.0	0.027	R-38	YES
Walls Above Grade	Mass	U-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

Roofs

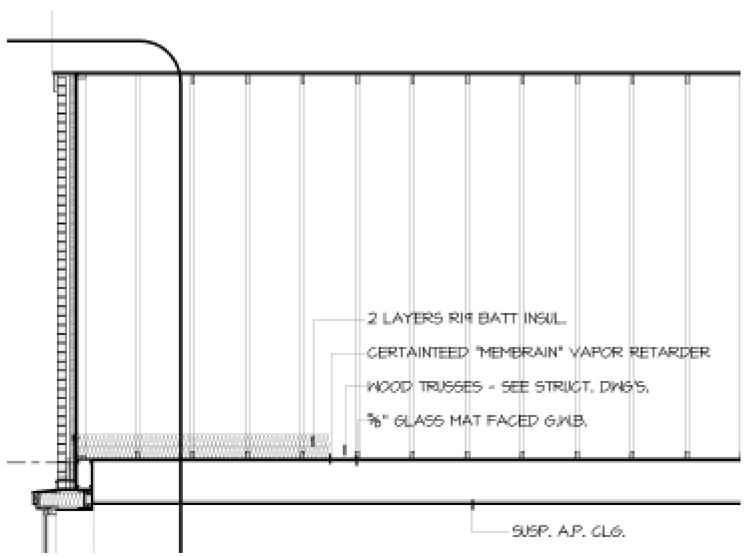

Figure-4: Roof Insulation Detail

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.

Walls, Above-Grade

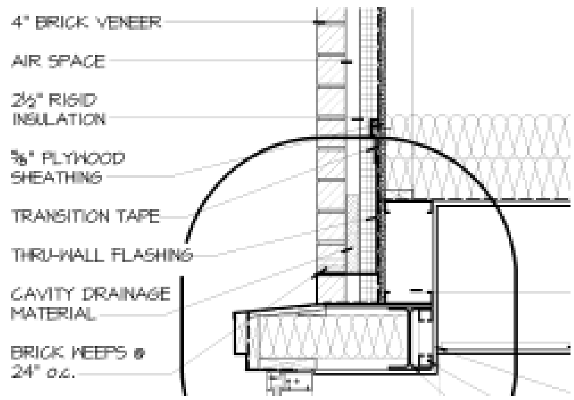

Figure-5: Typical Wall Detail

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.

Glazed Area on Building Exterior Façade				
	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 ft^2 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. CO^2 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

Equipment Analyzed	CFM	Motor HP	Variable Volume 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 ½”	1 ½” to less than 4”	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/ft^2), found using Table 9.5.1 of ASHRAE 90.1. The determined gross lighted area is estimated to be 88,650 ft^2.

Gross Lighted Floor Area X LPD = Interior Lighting Allowance

88,650 x 1.2 = 103,800 Watts

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.

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 1st & 2nd	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	682.9	1.687	1152	3rd-5th& Sp.EdClassrooms	9441.4	1.280	12085
SGI 37	628.9	1.347	847	Computers 48	1035.8	1.298	1344
SGI E105	2366.2	0.117	277	Total	88651.4		100182

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

Appendix B

Building:	Delete Zone		**Sunshine Elementary School**						
System Tag/Name:			**Typical Classroom**						
Operating Condition Description:	Add Zone								
Units (select from pull-down list)			IP						
Inputs for System	**Name**	**Units**		**System**			**Check Figures**		
Floor area served by system	As	sf		921					
Population of area served by system (including diversity)	Ps	P	100% diversity	21			23.3	P/1000 sf	
Design primary supply fan airflow rate	Vpsd	cfm		1,090			1.18	cfm/sf	
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.12			0.12	ave cfm/sf	
OA req'd per person for system area (Weighted average)	Rps	cfm/p		10.0			10.00	ave cfm/p	
Inputs for Potentially Critical zones					**Potentially Critical Zones**				
Zone Name			*Zone title turns purple italic for critical zone(s)*		*2nd Grade 31*	Closet B112	**Totals/averages**		
Zone Tag	Show Values per Zone				19	20			
Space type			Select from pull-down list		Classroom s (ages	Storage rooms			
Floor Area of zone	Az	sf			857	64	921	total sf	
Design population of zone	Pz	P	(default value listed; may be overridden)		21.425	0	21.425	total P	
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			990	100	1090	total cfm	
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						1.00	average	
Inputs for Operating Condition Analyzed									
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	average	
Air distribution type at conditioned analyzed			Select from pull-down list		CSCRH	CSCRH			
Zone air distribution effectiveness at conditioned analyzed	Ez		Show codes for Ez		0.80	0.80	80%	average	Primary airflo
Primary air fraction of supply air at conditioned analyzed	Ep						1.00	average	1090
Results									
Ventilation System Efficiency	Ev			**0.90**					
Outdoor air intake required for system	Vot	cfm		**362**					
Outdoor air per unit floor area	Vot/As	cfm/sf		**0.39**					
Outdoor air per person served by system (including diversity	Vot/Ps	cfm/p		**16.9**					
Outdoor air as a % of design primary supply air	Ypd	cfm		**33%**					
Detailed Calculations									
Initial Calculations for the System as a whole									
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	1090			21.425	System population witho	
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	325			1.00	System population diver	
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.30					
Initial Calculations for individual zones									
OA rate per unit area for zone	Raz	cfm/sf			0.12	0.12			
OA rate per person	Rpz	cfm/p			10.00	0.00			
Total supply air to zone (at condition being analyzed)	Vdz	cfm			990	100	1090		
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		317.1	7.7	325		
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		396	10	406		
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 =		0.40	0.10	0.40	Maximum Zd	
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.40	0.10	0.40	Maximum Zp	
System Ventilation Efficiency									
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		0.90	1.20			
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.90**					
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	0.75					
Minimum outdoor air intake airflow									
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**362**					
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.33**					
Outdoor Air Intake Flow required to System (Table 6.3 Methc	Vot	cfm	= Vou / Ev =	433					
OA intake req'd as a fraction of primary SA (Table 6.3 Metho	Y		= Vot / Vps =	0.40					
OA Temp at which Min OA provides all cooling									

Building:	Delete Zone	Sunshine Elementary School					
System Tag/Name:		Gym					
Operating Condition Description:	Add Zone						
Units (select from pull-down list)		IP					
Zone Name		*Zone title turns purple italic for critical zone(s)*			Gym (Gym)	*Gym (Spectato*	Totals/averages
Zone Tag	Show Values per Zone				1	2	
Space type			Select from pull-down list		Gym, stadium (play area)	Spectator areas	
Floor Area of zone	Az	sf			5,107	895	6002 total sf
Design population of zone	Pz	P	(default value listed; may be overridden)		153.21	134.25	287.46 total P
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			7,000	3000	10000 total cfm
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						1.00 average
Inputs for Operating Condition Analyzed							
Percent of total design airflow rate at conditioned analyzed	Ds	%		#######	100%	100%	100% average
Air distribution type at conditioned analyzed		Select from pull-down list			CSCRH	CSCRH	
Zone air distribution effectiveness at conditioned analyzed	Ez		Show codes for Ez		0.80	0.80	80% average
Primary air fraction of supply air at conditioned analyzed	Ep						1.00 average
Results							
Ventilation System Efficiency	Ev			#DIV/0!	#DIV/0!		
Outdoor air intake required for system	Vot	cfm		#DIV/0!			
Outdoor air per unit floor area	Vot/As	cfm/sf		#DIV/0!			
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		#DIV/0!			
Outdoor air as a % of design primary supply air	Ypd	cfm		#DIV/0!	#DIV/0!		
Detailed Calculations							
Initial Calculations for the System as a whole							
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	= 0			287.46 System po
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	= 0			0.00 System po
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	= 0.00			
Initial Calculations for individual zones							
OA rate per unit area for zone	Raz	cfm/sf			0.30	0.06	
OA rate per person	Rpz	cfm/p			0.00	7.50	
Total supply air to zone (at condition being analyzed)	Vdz	cfm	##		7000	3000	10000
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=	1532.1	1060.6	2593
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	=	1915	1326	3241
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	=	0.27	0.44	0.44 Maximum
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	=	0.27	0.44	0.44 Maximum
System Ventilation Efficiency							
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / 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							
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	= #DIV/0!			
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	= #DIV/0!			
Outdoor Air Intake Flow required to System (Table 6.3 Metho	Vot	cfm	= Vou / Ev	= 0	#DIV/0!		
OA intake req'd as a fraction of primary SA (Table 6.3 Metho	Y		= Vot / Vps	= #DIV/0!	#DIV/0!		
OA Temp at which Min OA provides all cooling							
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+d	= #DIV/0!			

Building:	Delete Zone	Sunshine Elementary School						
System Tag/Name:		Computer Room						
Operating Condition Description:	Add Zone							
Units (select from pull-down list)		IP						

Description	Name	Units			System			Check Figures
Inputs for System	**Name**	**Units**			**System**			**Check Figures**
Floor area served by system	As	sf			921			
Population of area served by system (including diversity)	Ps	P	100% diversity		21			23.3 P/1000 sf
Design primary supply fan airflow rate	Vpsd	cfm			2,000			2.17 cfm/sf
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf			0.12			0.12 ave cfm/sf
OA req'd per person for system area (Weighted average)	Rps	cfm/p			10.0			10.00 ave cfm/p
Inputs for Potentially Critical zones						Potentially Critical Zones		
Zone Name			*Zone title turns purple italic for critical zone(s)*			*Computer s 48*	Closet	**Totals/averages**
Zone Tag (Show Values per Zone)						201	202	
Space type			Select from pull-down list			Computer lab	Storage rooms	
Floor Area of zone	Az	sf				857	64	921 total sf
Design population of zone	Pz	P	(default value listed; may be overridden)			21.425	0	21.425 total P
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm				1,900	100	2000 total cfm
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							1.00 average
Inputs for Operating Condition Analyzed								
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100% average
Air distribution type at conditioned analyzed			Select from pull-down list			CSCRH	CSCRH	
Zone air distribution effectiveness at conditioned analyzed	Ez		Show codes for Ez			0.80	0.80	80% average
Primary air fraction of supply air at conditioned analyzed	Ep							1.00 average
Results								
Ventilation System Efficiency	Ev				**0.95**			
Outdoor air intake required for system	Vot	cfm			**341**			
Outdoor air per unit floor area	Vot/As	cfm/sf			**0.37**			
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p			**15.9**			
Outdoor air as a % of design primary supply air	Ypd	cfm			**17%**			

Description	Name	Units		Formula		System	Zone 201	Zone 202	
Detailed Calculations									
Initial Calculations for the System as a whole									
Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	VpdDs	=	2000			21.425 System po
UncorrectedOA requirement for system	Vou	cfm	=	Rps Ps + Ras As	=	325			1.00 System po
Uncorrected OA req'd as a fraction of primary SA	Xs		=	Vou / Vps	=	0.16			
Initial Calculations for individual zones									
OA rate per unit area for zone	Raz	cfm/sf					0.12	0.12	
OA rate per person	Rpz	cfm/p					10.00	0.00	
Total supply air to zone (at condition being analyzed)	Vdz	cfm					1900	100	2000
Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		317.1	7.7	325
Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		396	10	406
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	=		0.21	0.10	0.21 Maximum z
Unused OA fraction required in primary air to zone	Zp		=	Voz / Vpz	=		0.21	0.10	0.21 Maximum z
System Ventilation Efficiency									
Zone Ventilation Efficiency (App A Method)	Evz		=	(Fa + FbXs - FcZ) / Fa	=		0.95	1.07	
System Ventilation Efficiency (App A Method)	Ev		=	min (Evz)	=	**0.95**			
Ventilation System Efficiency (Table 6.3 Method)	Ev		=	Value from Table 6.3	=	0.94			
Minimum outdoor air intake airflow									
Outdoor Air Intake Flow required to System	Vot	cfm	=	Vou / Ev	=	**341**			
OA intake req'd as a fraction of primary SA	Y		=	Vot / Vps	=	**0.17**			
Outdoor Air Intake Flow required to System (Table 6.3 Metho	Vot	cfm	=	Vou / Ev	=	345			
OA intake req'd as a fraction of primary SA (Table 6.3 Metho	Y		=	Vot / Vps	=	0.17			
OA Temp at which Min OA provides all cooling									