Technical Report 1: *(Code Compliance with ASHRAE 62.1 & 90.1)*

Due Date: October 4, 2010

The Mirenda Center for Sports, Spirituality, and Character Development

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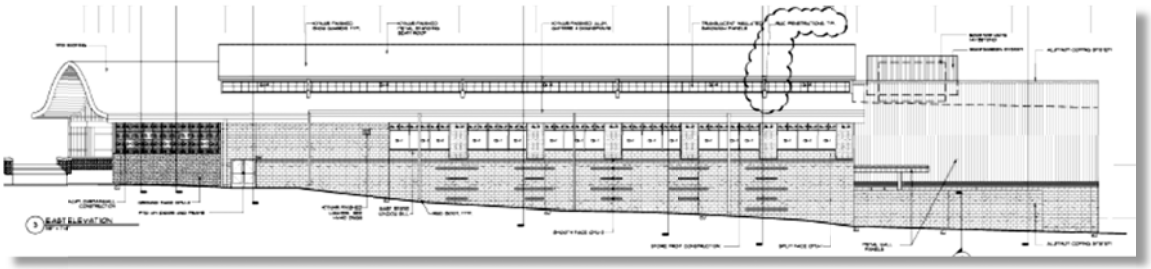
Executive Summary

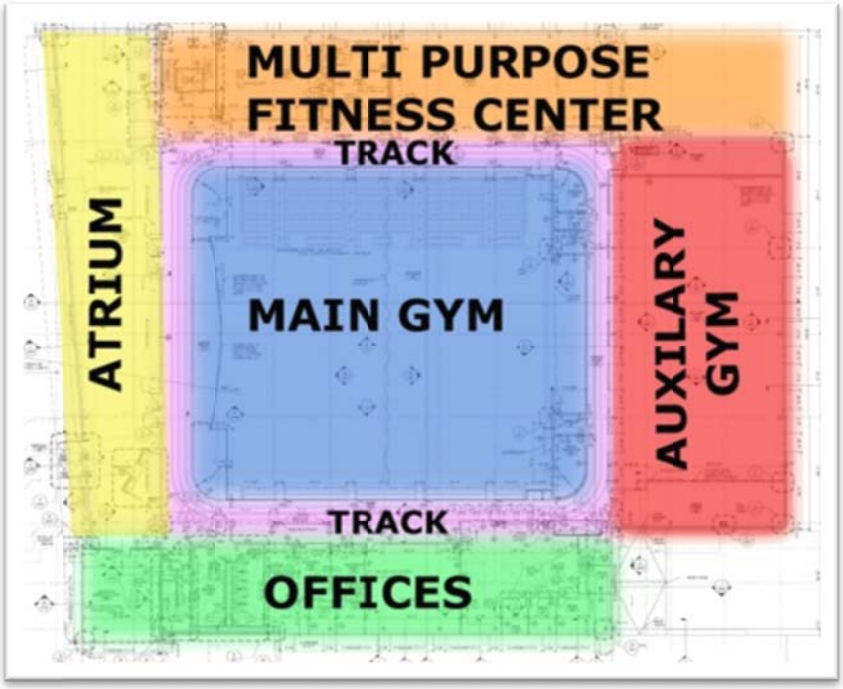
General Building Overview

The Mirenda Center for Sports, Spirituality, and Character Development (CSSCD) is a two story building. The ground floor entrance is at the second level in the front of the building, while the lower level is underground at the front of the building while the sloping topography brings the lower level to exit at ground level in the rear of the building. See East Elevation below for orientation.



East Elevation

The core of the building is the main gymnasium that seats up to 1450 spectators at the lower level. Wrapped around the main gym at the second level is an indoor running track. The outer most perimeter is as follows: Offices on the east side, Auxiliary gym on the north side, multipurpose and fitness center on the west side, and open glazed atrium on the south side. See Layout below for orientation.



Layout

Mechanical System Overview

The Mirenda Center is primarily heated and cooled by 6 roof top air handling units, their location is above the auxiliary gym. RTU-5&6 serve the main gymnasium and the indoor running track in unison. RTU-3 & 4 are Aaon type and serve only the auxiliary gym. RTU-1 and 2 serve the remaining perimeter spaces: the multipurpose and fitness center, the offices, and atrium. There is a secondary split system to cool specified office areas and other specialty spaces. The condensing unit for the split system is located on the roof of the auxiliary gym with the RTU's. Liquid refrigerant is pipe to the locations of each individual load point. The concept is a smaller secondary system will be used more frequently for the daily office cooling. This is because there will not be a large scale sports event every day. Thus it would be inefficient to run the large roof top units daily. There is natural gas burners for heating of the RTU's and reheats for each zone in the constant air volume boxes. There is also electric resistant strip heat around the perimeter of the building. This electric strip heat is primarily to keep condensation from forming on the glazing.

ASHRAE 62.1 Section 5 Compliance Report

ASHRAE Standard 62.1is used to specify measures that will improve the indoor air quality in a building that is both acceptable for the human occupants and will minimize health effects. Section 5 details these measures for systems and equipment.

5.1 Natural Ventilation

There is no opportunity for occupant controlled natural ventilation in the form of operable windows.

5.2 Ventilation Air Distribution

Variable Air Volume boxes are used to control the ventilation airflow to each space as required by Section 6 of this standard. An analysis of the compliance with this section is included in this report.

5.3 Exhaust Duct Location

All air exhaust ducts are sealed following the requirements of SMACNA Seal Class A, therefore this section does not apply. Also all exhaust ducts are on the east and west side of the building which are in a safe location.

5.4 Ventilation System Controls

Run conditions of the air handling units are based upon an operator adjustable schedule in one of the following modes: occupied, unoccupied, & disabled. The roof top units are equipment with manual and automatic controls to enable the fan system to operate whenever the space being served is occupied.

5.5 Airstream Surfaces

The duct systems installed are specifically called out to comply with ASTM C 1071 which prevents any erosion due to direct contact of airstream surfaces. This is achieve by applying a coating to the ducts with glass fibers. The ducts also comply with NFPA 90A&B which insures correct installation to protect against possibility of mold growth due to warm air.

5.6 Outdoor Air Intakes

The location of exhaust fans relative to outdoor air intakes was analyzed using Table 5.1. Results are as follows:

EF-3 Auxiliary Gym Restrooms Contaminated within 30ft of RTU 2 and RTU 4

Exhaust fan number 3 is at the rear of the building within 30 feet of the intake of RTU 2 and RTU 4.This could lead to bringing contaminated lavatory air into Auxiliary Gym and Perimeter Zones but is highly unlikely.

Discussion 1 –*(Filtration)*

The Mirenda Center has two stages of filtration. Stage one is located at the point of entry for outdoor air. All air that is brought in from outdoors is filtered with a Merv 13 filter. Merv filtration is described more in depth in ASHRAE Standard 52.5. Merv filters range from 1 to 20; 1 being the least effective only able to filter as much as a carpet fiber, and 20 being the most effective able to filter particulate matter as small as 10^{-12} meters. The Merv 13 filter is 89-90% efficient in filtering particulate matter as small as the range of (0.3-1.0) $x10^{-12}$ meters. The second stage of filtration is at the site of the contaminant source. There are multiple constant volume boxes that have Merv 13 filters on the return air (induced air) side that also receive air from a variable air supply damper which was already filtered at stage one. The filtration process for any and every room reaches the maximum cleanliness in approximately 30 mins or 3 complete air changes. Having two stages of filtration ensures a high standard indoor air quality, assuming consistent maintenance of filter replacement once full.

5.7 Local Capture of Contaminants

All potentially harmful exhaust is ducted to the roof and exhausted from here, meeting the requirements of the section.

5.8 Combustion Air

All heating is in Natural Gas Burners in the Roof Top Units that are certified by the manufacturer, and is exterior to the building thus the requirement for combustion air is met. Auxiliary heat is provided by electric resistance strip heat along perimeter of building.

5.9 Particulate Matter Removal

All air handling units are equipped with two sets of replaceable type MERV 8 prefilters and two sets of cartridge type MERV 13 final filters. During construction only one set of filters is to be installed until after the final clean up of the area after which the second set will be installed. Both filters exceed the minimum requirement of this section of MERV 6.

5.10 Dehumidification Systems

Other than the dehumidification that is within the roof top units, no other system is installed. The installed roof top units dehumidify to 53/53 °F with is above 65%, however upon mixing with the room air, the RH decrease to meet the requirement for 65% RH. Thus this section complies.

5.11 Drain Pans

Specifications call for a double-sloped, insulated, stainless steel drain pan is to be provided with the cooling coil and will extend beyond the leaving side of the coil and under the cooling coil connections. These specifications meet the sections requirements. All drain connections must be used and individually trapped to ensure a minimum amount of condensate accumulation in the drain pans. ABS type cement should be used to join the drain pipe connections.

5.12 Finned-Tube Coils and Heat Exchangers

Aluminum-plate fin and seamless copper tube will be provided with stainless steel drain pan underneath. Heat Exchanger: Stainless-steel construction for natural-gas-fired burners. The coils and heat exchangers are spaced at a minimum of 18 inches for access to maintain. The access to the coils has been met by manufacturer, and bears ARI Certification.

5.13 Humidifiers and Water-Spray Systems

There is no steam or direct evaporation humidifiers, air washers or other water spray systems used in this project so this section does not apply.

5.14 Access for Inspection, Cleaning, and Maintenance

All ventilation equipment is installed with adequate space to facilitate routine maintenance and inspection. All air handling units and fan powered boxes are equipped with access doors or panels for easy access, meeting the requirements of the standard.

5.15 Building Envelope and Interior Surfaces

A vapor barrier coupled with airspace behind the brick finish provides an adequate means of preventing condensation from forming on cold surfaces of the building envelope. Extensive details for vapor barrier are described thoroughly in the specifications. The requirement for the building envelope has been met.

5.16 Buildings with Attached Parking Garages

The Mirenda Center does not have an attached parking garage so this section does not apply.

5.17 Air Classification and Recirculation

A majority of the building air can be classified as Class 1 and recirculated. Exhaust fall into Classes 3 & 4 and is directly exhausted with no recirculation. Any Class 2 air can be re-designated as Class 1 air by circulating through the energy recovery ventilator. These classifications meet the requirements of the section.

5.18 Requirements for Buildings Containing ETS Areas and ETS-Free Areas

The Mirenda Center is a smoke-free facility therefore this section does not apply.

ASHRAE 62.1 Section 6 Compliance Report

ASHRAE Standard 62.1 Section 6 is a prescriptive procedure to calculate the minimum outdoor air intakes required based on contaminant sources and source strengths typical for the particular space type. This calculation requires an analysis of the spaces served, occupancy level and square footage.

6 Minimum Outdoor Air Requirement

The minimum ventilation requirement is in place to ensure that occupants will have acceptable air. The code derives a system for supplying ventilation air (Outdoor Air) to space as a function of number of people and square floor area. The equation is as follows: $V_{bz}=(R_p*P_z)+(R_a*A_z)$ where;

V_{bz} is the breathing zone outdoor airflow
R_p is the outdoor airflow rate required per person
P_z is the number of people of in the zone that is being considered
R_a is the outdoor airflow rate required per square foot of floor area
A_z is the square foot area of the zone being considered.
E_z is the zone air distribution effectiveness, for the building is unity
V_{oz} is the zone outdoor airflow
V_{ot} is the outdoor air intake airflow
V_{pz} is the minimum expected primary airflow for design purposes
Z_p is the zone primary outdoor air fraction
V_{ou} is the uncorrected outdoor air intake
D is the occupant diversity
P_s is the system population

$$V_{bz} = R_p \cdot P_z + R_a \cdot A_z \qquad V_{ot} = \Sigma_{all\ zones} V_{oz}$$

Discussion 2 –(Ventilation Rate Calculation Procedure)

According to the prescribed Ventilation Rate Calculation Procedure the building complies. Each air handling unit exceeds the minimum value required for their cooling zones. See appendix A for spreadsheet calculation data.

	Calculated Outdoor Air	Design Minimum Outdoor Air	Percent Exceeded	Design Supply Air Flow	ASHRAE 62.1 Compliance
RTU_1	8800	3812	43%	22000	yes
RTU_2	8500	5054	59%	17000	yes
RTU_3	3600	1123	31%	8000	yes
RTU_4	3600	1249	35%	8000	yes
RTU_5	12100	4750	39%	20100	yes
RTU_6	12100	4193	35%	20100	yes

Figure 1

ASHRAE 90.1 COMPLIANCE

ASHRAE Standard 90.1 is the energy standard for buildings with the exception of low-rise residential buildings. The Mirenda Center is an educational building therefore it qualifies for analysis using this standard. The prescriptive requirements for this standard include the building envelope, mechanical equipment efficiencies, service hot water, power and lighting density. Included below is an analysis of these prescriptive requirements applied to The Mirenda Center.

5. Building Envelope

Section 5 of this standard is dedicated to describing the performance requirements for a structure's building envelope. These requirements are dependent on both the location of the building and the space conditioning category.

To assess the compliance to this standard, the climate category first needs to be determined. Using Table A-1 in the Normative Appendix A of this standard it was determined that Aston Pennsylvania, which is situated in Delaware County, is classified as Climate **Zone 4A**.

The method to be used to analyze the building envelope is detailed in Section 5.5: Prescriptive Building Envelope Option. In order to use this method two prerequisites must be met. Firstly the total vertical fenestration area cannot exceed 40% of the gross wall area. The table below shows that the building, with a total of 39.7% glazing meets this requirement. The second prerequisite is that skylight fenestration cannot exceed 5% of the gross roof area. The Mirenda Center does not have any skylights, therefore this requirement is met. Because both of these prerequisites are met, the building envelope can be analyzed using the Prescriptive Building Envelope Option.

Fenestrations West	1305 ft^2
Walls West	4525 ft^2
Fenestrations South	3672 ft^2
Walls South	438 ft^2
Fenestrations East	1338 ft^2
Walls East	5204 ft^2
Fenestrations North	626 ft^2
Walls North	7283 ft^2
Wall Total	17450 ft^2

Fenestrations Total	6941 ft^2
Ratio	0.397765

Figure 2

5.4 Air Leakage

The building envelope is sealed, caulked, gasketed, and weather-stripped with prescribed methods according to ASTM C1193. This standard allows for LEED Accreditation for Sustainable Design. There were laboratory Pre-Construction Test and Field Pre-Construction Testing done. No certification found by the National Fenestration Rating Council was found in the specifications.

5.5 Prescriptive Building Envelope Option

The building envelope consists of face brick, air space, and masonry cmu block with fenestration opening on the east and west walls. The south wall is completely covered in store front gazing with a U-factor of 0.33. The roof assembly is built up type consisting of metal deck with 6 inch rigid insulation that resists a majority of the thermal heat transfer consisting of an R- value of 29. The slab size varies from 4 to 6 inches in depth with 2" rigid insulation underneath. The 2 inch insulation accounts for a majority of the thermal resistance to heat flow of R-value of 12.

The variation in wind speed with decrease the Resistance values for all assemblies exposed to the outdoor environment. This decrease is significant an was considered in the design. See figure 3 below for ASHRAE 90.1 for compliance.

	Actual	90.1 Req.	Comply
Fenestration U-Value	0.33	0.5	yes
SHGC	0.33-0.55	0.55	yes
Wall Type #1 R_Value	15	13	yes
Wall Type #2 R_Value	16	13	yes
Roof R_Value	29	20	yes
Slab R_Value	12	NR	yes

Figure 3

6. Heating, Ventilation, and Air Conditioning

The purpose of section 6 of this code is to ensure that The Mirenda Center HVAC mechanical equipment complies with the mandated efficiencies: specifically the Horsepower and Energy Efficiency Ratio for the Roof Top Units, Ducts, and refrigerant piping. Duct insulation is minimum of 1 inch thick with a R-Value of 3.85 (h ft2 F)/(BTU). This meets the minimum 90.1 requirement of 3.5 (h ft2 F)/(BTU) for Duct insulation. All roof top units have a minimum of 1.5 thick insulation with a R-Value of 5.8 (h ft2 F)/(BTU). All ducts are exposed to interior heated spaces thus all ducts do not have a minimum insulation requirement. See figure 4 below for Air handling equipment power and efficiency compliance. Also see Appendix A table B for 90.1 requirements for duct insulation.

Equipment	hp		CFMs*0.0011	Comply	Design	EER	Comply
RTU_1	15.6	≥	24.2	yes	9.8	9.0	yes
RTU_2	10.8	≥	18.7	yes	9.4	9.0	yes
RTU_3	6.2	≥	8.8	yes	11.8	9.3	yes
RTU_4	6.2	≥	8.8	yes	11.8	9.3	yes
RTU_5	14.7	≥	22.1	yes	9.4	9.0	yes
RTU_6	14.7	≥	22.1	yes	9.4	9.0	yes
AC_1	0.412	≥	0.4	yes	10.8	10.0	yes
AC_2	0.412	≥	0.6	yes	10.8	10.0	yes
AC_3	0.558	≥	0.6	yes	10.8	10.0	yes
AC_4	0.558	≥	0.6	yes	10.8	10.0	yes
AC_5	0.558	≥	0.6	yes	10.8	10.0	yes
AC_6	0.866	≥	0.9	yes	10.8	10.0	yes
AC_7	0.076	≥	0.8	yes	10.8	10.0	yes

Figure 4

7 Service Water

There are 2 Lochinvar domestic hot water heaters with an 85% thermal fuel to water efficiency. This meets 90.1 section 7 requirements for 80% or better efficiency.

8 Power

This section prescribes the allowable voltage drop for a building's power system. The building designer designed based on this standard and sized all feeders and branch circuits to comply with the required 3% and 3% respective with the total 5% voltage drops at the design load. The two main distribution feeders comply with 3%. Branch circuiting could vary, because it is out of control of the designer. Feeder 1 comes from the main transformer and feed the main distribution paned which is approximately 85 feet in length. This complies with the max length of 161 feet allowable for 3% voltage drop. See figure below for feeder 2 which also complies.

Type	Length actual ft	Length max ft	Current	Vd %	Constant	Conductivity	Area cm
Feeder 1	85	161	2000	3	1.73	12.9	2400000
Feeder 2	120	161	1000	3	1.73	12.9	1200000

9 Lighting

The majority of light loads meet the power density requirements. See table 5 below for results.

Space Classification	**Lights**, W/sf	90.1 Compliance	
Main Gym	2.26	2.4	yes
Aux Gym	1.27	2.4	yes
Stairs	0.3	0.6	yes
PE Lockers	0.9	0.6	no
Varsity Lockers	0.9	0.6	no
Mech/Elec	0.44	1.5	yes
Student Lounge	0.85	1.2	yes
Corridor	1	0.5	no
Lobby	1.4	1.3	no
Coach Lockers	0.78	0.6	no
Office	1	1.1	yes
Training Room	0.84	1.2	yes
Equipment Storage	0.5	0.3	no
Gym Storage	0.5	0.3	no
Restroom	0	0.9	yes
Hospitality Suite	1.6	1.1	no
CSSCD Offices	0.9	1.1	yes
Classroom	0.8	1.4	yes
Athletics Office	0.7	1.1	yes

Track	1.5	2.7	yes
Fitness Center	0.3	0.9	yes
Studio	0.26	1	yes
Multipurpose	0.3	1.3	yes
Dining	0.9	1	yes
Alumni Hall	1.1	1.2	yes
IT/Media Rooms	2.3	1.2	yes

Table 5

Discussion 3 – *(Overall Compliance)*

The building as a whole complies with the ASHRAE standards 62.1 and 90.1-2007. Expect for the lighting power per square foot of area. These values may have been changes since the 2004 version of the 90.1 code. However the areas where the values exceed the maximum allowable are justified by other areas that are significantly lower than the maximum.

A potential risk taken on by the mechanical designer pertains to the split-system. According to there is no opportunity to drain condensation from the evaporative coils placed in there specified rooms. If the latent load in any specific room were to get exceedingly large, moisture could form on the coil and condense directly into the space. Example would be for open office space to have an annual family holiday party for employees.

Appendix A

RTU_1 –Minimum Airflow Calculation

Description	System	Total Flr Area	No. People	Rp cfm/per	Ra cfm/ft^2	Vbz = Total
116 Equipment Storage	RTU-1	1,250	0	0	0.12	150
115 Gym Storage	RTU-1	1,200	0	0	0.12	144
114 Laundry room	RTU-1	250	2	5	0.12	40
108 Training Room	RTU-1	1,000	10	20	0.06	260
113 Office	RTU-1	110	1	5	0.06	11.6
112 Exam	RTU-1	100	1	10	0.18	28
111 Office	RTU-1	50	1	5	0.06	8
110 Training Storage	RTU-1	140	0	0	0.12	16.8
105 Womens referee Toilet	RTU-1	335	4	0	0.5	167.5
106 Mens referee Toilet	RTU-1	335	4	0	0.5	167.5
102 Elevator Lobby	RTU-1	320	0	5	0.06	19.2
101 Stair	RTU-1	320	0	0	0.06	19.2
142 Corridor West	RTU-1	980		0	0.06	58.8
142 Lower lounge	RTU-1	860	5	5	0.06	76.6
232 Fitness Ctr	RTU-1	3,275	33	20	0.06	856.5
233 Performance Studio	RTU-1	600	24	20	0.06	516
235 Multi Purpose	RTU-1	1,210	42	5	0.06	282.6
238 Corridor West	RTU-1	480	0	0	0.06	28.8
237 Elevator Lobby	RTU-1	200	0	5	0.06	12
203 Lobby/Lounge	RTU-1	3,000	90	5	0.06	630
204 Café	RTU-1	410	13	7	0.06	115.6
141 Corridor	RTU-1	540	0	0	0.06	32.4
121 122 Exteroir storage	RTU-1	560	0	0	0.12	67.2
148 Gym Storage	RTU-1	300	0	0	0.12	36
145 Gym Storage	RTU-1	563	0	0	0.12	67.56
	Total					3811.86

RTU_2 –Minimum Airflow Calculation

Description	System	Total Flr Area	No. People	Rp cfm/per	Ra cfm/ft^2	Vbz = Total
138 Corridor East	RTU-2	980	0	0	0.06	58.8
132 Womens Varsity Toilet	RTU-2	1050	12	0	0.5	525
133 Mens Varsity Toilet	RTU-2	1050	10	0	0.5	525
134 Womens PE Toilet	RTU-2	1050	12	0	0.5	525
135 Mens PE Toilet	RTU-2	1050	10	0	0.5	525
136 Storage	RTU-2	125	0	0	0.12	15
140 Lower Lounge	RTU-2	860	5	5	0.06	76.6
217 Athletic Offices	RTU-2	1160	7	5	0.06	104.6
218 Office	RTU-2	150	1	5	0.06	14
219 Office	RTU-2	110	1	5	0.06	11.6
220 Office	RTU-2	220	1	5	0.06	18.2
221 Office	RTU-2	120	1	5	0.06	12.2
222 Office	RTU-2	110	1	5	0.06	11.6
223 Copy	RTU-2	150	1	10	0.5	85
216 Classroom	RTU-2	1100	73	10	0.12	862
224 Corridor East	RTU-2	1000	0	0	0.06	60
215 Conference room	RTU-2	280	17	5	0.06	101.8
210 CSSCD Offices	RTU-2	135	3	5	0.06	23.1
212 CSSCD Offices	RTU-2	120	1	5	0.06	12.2
211 CSSCD Offices	RTU-2	120	1	5	0.06	12.2
214 CSSCD Offices	RTU-2	265	1	5	0.06	20.9
207 Mens Room	RTU-2	290	4	0	0.5	145
208 Womens Room	RTU-2	290	4	0	0.5	145
205 Reflection Center	RTU-2	1250	52	5	0.06	335
203 Lobby Lounge	RTU-2	3000	87	5	0.06	615
123 Mens Restroom	RTU-2	140	2	0	0.5	70
124 Womens Restroom	RTU-2	140	2	0	0.5	70
126 Caterer (as Break Room)	RTU-2	250	6	5	0.06	45
146 Gym Storage	RTU-2	240	0	0	0.12	28.8
	Total					5053.6

RTU_3 –Minimum Airflow Calculation

Description	System	Total Flr Area	No. People	Rp cfm/per	Ra cfm/ft^2	Vbz = Total
119 Vestibule	RTU-3	204	0	0	0.06	12.24
120A Aux Gym	RTU-3	3348	100	7.5	0.06	950.88
121 Ext Storage	**RTU-3**	**300**	**0**	**0**	**0.12**	**36**
122 Storage	RTU-3	247	0	0	0.12	29.64
230 Storage	RTU-3	785	31	0	0.12	94.2
	Total					1122.96

RTU_4–Minimum Airflow Calculation

Description	System	Total Flr Area	No. People	Rp cfm/per	Ra cfm/ft^2	Vbz = Total
120B Aux Gym	RTU-4	3348	100	7.5	0.06	950.88
123 Men's Room	RTU-4	210	3	0	0.5	105
124 Women's Room	RTU-4	210	5	0	0.5	105
126 Catering Kitchen	RTU-4	168	0	7.5	0.18	30.24
127 Vestibule	RTU-4	187	0	0	0.06	11.22
225 Cardio Fitness	RTU-4	785	0	20	0.06	47.1
	Total					1249.44

RTU_5 –Minimum Airflow Calculation

Description	System	Total Flr Area	No. People	Rp cfm/per	Ra cfm/ft^2	Vbz = Total
117 IT Room	RTU-5	72	0	10	0.12	8.64
118 Elec Room	RTU-5	88	0	0	0.06	5.28
144A Main Gym	RTU-5	7362	221	7.5	0.06	2099.22
146 Stage	RTU-5	1300	39	10	0.06	468
224A Jog Track	RTU-5	3200	96	20	0.06	2112
228 Electric Room	RTU-5	135	0	10	0.12	16.2
229 IT Room	RTU-5	169	0	10	0.12	20.28
229A Storage	RTU-5	169	0	0	0.12	20.28
	Total					4749.9

RTU_6 –Minimum Airflow Calculation

Description	System	Total Flr Area	No. People	Rp cfm/per	Ra cfm/ft^2	Vbz = Total
144B Main Gym	RTU-6	7038	211	7.5	0.06	2004.78
147 Storage	RTU-6	303	0	0	0.12	36.36
224B Jog Track	RTU-6	3200	96	20	0.06	2112
226 Media Production	RTU-6	175	1	10	0.12	31
227 Electric Room	RTU-6	155	0	0	0.06	9.3
	Total					4193.44

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.173	R-5.0 c.i.
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above-Grade						
Mass	U-0.104	R-9.5 c.i.	U-0.090	R-11.4 c.i.	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-0.134	R-10.0
Steel-Framed	U-0.064	R-13.0 + R-7.5 c.i.	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
Wood-Framed and Other	U-0.089	R-13.0	U-0.064	R-13.0 + R-3.8 c.i.	U-0.089	R-13.0
Walls, Below-Grade						
Below-Grade Wall	C-1.140	NR	C-0.119	R-7.5 c.i.	C-1.140	NR
Floors						
Mass	U-0.087	R-8.3 c.i.	U-0.074	R-10.4 c.i.	U-0.137	R-4.2 c.i.
Steel-Joist	U-0.038	R-30.0	U-0.038	R-30.0	U-0.069	R-13.0
Wood-Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.066	R-13.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.540	R-10 for 24 in.	F-0.730	NR
Heated	F-0.860	R-15 for 24 in.	F-0.860	R-15 for 24in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Nonswinging	U-1.500		U-0.500		U-1.450	
Fenestration	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**
Vertical Glazing, 0%–40% of Wall						
Nonmetal framing (all)[b]	U-0.40		U-0.40		U-1.20	
Metal framing (curtainwall/storefront)[c]	U-0.50	SHGC-0.40 all	U-0.50	SHGC-0.40 all	U-1.20	SHGC-NR all
Metal framing (entrance door)[c]	U-0.85		U-0.85		U-1.20	
Metal framing (all other)[c]	U-0.55		U-0.55		U-1.20	
Skylight with Curb, Glass, % of Roof						
0%–2.0%	U_{all}-1.17	$SHGC_{all}$-0.49	U_{all}-0.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-NR
2.1%–5.0%	U_{all}-1.17	$SHGC_{all}$-0.39	U_{all}-0.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic, % of Roof						
0%–2.0%	U_{all}-1.30	$SHGC_{all}$-0.65	U_{all}-1.30	$SHGC_{all}$-0.62	U_{all}-1.90	$SHGC_{all}$-NR
2.1%–5.0%	U_{all}-1.30	$SHGC_{all}$-0.34	U_{all}-1.30	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All, % of Roof						
0%–2.0%	U_{all}-0.69	$SHGC_{all}$-0.49	U_{all}-0.58	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-NR
2.1%–5.0%	U_{all}-0.69	$SHGC_{all}$-0.39	U_{all}-0.58	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

[a]The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[b]Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[c]Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

Table A

Climate Zone	Duct Location						
	Exterior	Ventilated Attic	Unvented Attic Above Insulated Ceiling	Unvented Attic with Roof Insulation[a]	Unconditioned Space[b]	Indirectly Conditioned Space[c]	Buried
Heating-Only Ducts							
1, 2	none	none	none	none	none	none	none
3	R-3.5	none	none	none	none	none	none
4	R-3.5	none	none	none	none	none	none
5	R-6	R-3.5	none	none	none	none	R-3.5
6	R-6	R-6	R-3.5	none	none	none	R-3.5
7	R-8	R-6	R-6	none	R-3.5	none	R-3.5
8	R-8	R-8	R-6	none	R-6	none	R-6
Cooling-Only Ducts							
1	R-6	R-6	R-8	R-3.5	R-3.5	none	R-3.5
2	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
3	R-6	R-6	R-6	R-3.5	R-1.9	none	none
4	R-3.5	R-3.5	R-6	R-1.9	R-1.9	none	none
5, 6	R-3.5	R-1.9	R-3.5	R-1.9	R-1.9	none	none
7, 8	R-1.9	R-1.9	R-1.9	R-1.9	R-1.9	none	none
Return Ducts							
1 to 8	R-3.5	R-3.5	R-3.5	none	none	none	none

[a] Insulation R-values, measured in (h-ft²-°F)/Btu, arefor the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior walls are used as plenum walls, wall insulation shall be as required by the most restrictive condition of Section 6.4.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75°F at the installed thickness.
[b] Includes crawlspaces, both ventilated and nonventilated.
[c] Includes return air plenums with or without exposed roofs above.

Table B