

Mechanical Tech Report 1

ASHRAE Standard 62.1 Compliance Evaluation

Altoona Area Junior High School
Altoona, PA

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Table of Contents

Executive Summary 3

System & Equipment Requirement Compliance 5

System Selection 7

Summary of Compliance 8

Identified Problems & Opportunities 9

Appendices & Calculations 10

Appendix A 11

Appendix B 14

Appendix C 17

Appendix D 19

Executive Summary

This report evaluates the compliance of the Altoona Area Junior High School building to ASHRAE Standard 62.1, which establishes minimum outdoor air ventilation requirements for buildings. The school is scheduled to open in 2008 with a predicted enrolment of over 1800 students. The building features a variety of spaces, many with varying uses. As such, the mechanical system utilizes varying systems to serve the space.

The system features seven direct expansion air handlers, nine chilled/hot water air handlers, several hundred unit ventilators, as well as a network of fan coil units for air delivery. Because of the variety of spaces in the school, it has proven difficult to accommodate each use, while attempting a semblance of consistency and order. This building has done both satisfactorily.

Not many significant discrepancies were found during the composition of this report, and where they do exist, a simple solution appears to be feasible. It is apparent that the designers of this system utilized the Ventilation Rate Procedure or an equivocal method for determining minimum outdoor air requirements for the systems. This is consistent with the data presented in this report.

This report suggests movement toward a simple, repetitious system design. While it can be predicted that cost was the determining factor for which systems were installed, there is an overwhelming sense of pragmatism and experience to the design.

In many cases, adjusting outdoor air levels to a space would only require a few equipment changes as a result of the adjustability built into the system. If upon further review there is an urgent need for adjustment, it is certain that these changes could occur swiftly and without interruption of the surrounding systems.

Part I

**ASHRAE Standard 62.1
Section 5 Analysis**

System & Equipment Requirement Compliance

Because of the nature of the building and the relative simplicity and repetitiveness of the HVAC system in this project, many of the provisions set forth by ASHRAE 62.1 Section 5 either do not apply or are inherent to the system. A brief overview of the building's Section 5 compliance is listed below.

5.3 Exhaust Duct Location

All exhaust ducts carrying contaminants, most notably chemical vapors from science classrooms, have been negatively pressurized in spaces through which they pass. Most exhaust ducts in this project have been designed to minimize this, with direct paths to outside fans or roof-mounted units.

5.5.1 Resistance to Mold Growth

As specified in the construction documents for the building, all material surfaces have been determined to resist the growth of mold by recognized testing methods.

5.11 Drain Pans

An examination of the design documentation has revealed that all drain pans in this building are compliant with section 5.11.

5.14 Access for Inspection, Cleaning, and Maintenance

Various means of access have been provided for the systems within the building. Most air-handling units are contained within mechanical rooms or provide rooftop access. Fans, coils, and VAV boxes located in the ceiling cavity provide easy and unobstructed access through access passages or the removal of ceiling tile.

5.15 Building Envelope and Interior Surfaces

All exterior surfaces of the building have been specified to retard liquid permeation. Pipe and ductwork has been insulated where needed with appropriate detailing provided in the construction documents.

Part II

**ASHRAE Standard 62.1
Section 6 Analysis**

System Selection

The systems selected to be analyzed in this report represent a majority of the areas supplied with outdoor air in the school building. Because of the nature of the project, many of the supplied zones are repetitive and an analysis involving all of the spaces is not needed to gain an understanding of the overall system.

An attempt has been made to analyze systems that serve rooms representing each occupancy category present in the building. A breakdown of each of these systems is provided below. Please refer to **Appendix A** for a further breakdown of each system.

AHU A-1 and A-2

These DX/gas air-handling units serve the larger of two gymnasiums present in the school. As per ASHRAE 62.1, this space falls under two occupant categories: a *play area* and a *spectator area*. In this analysis, both categories have been used to determine the outdoor air requirements for the space. Refer to **Tables A.1 and A.2** for full space characteristic details of the system.

AHU A-3 and A-4

Similar to AHU A-1 and AHU A-2, these DX/gas units also serve a gymnasium space. Again, both occupancy categories have been used in the calculation of outdoor air requirements. Refer to **Tables A.3 and A.4** for full space characteristic details of this system.

AHU A-7

This DX/gas AHU serves several athletic spaces within the school. Of the spaces identified, the fitness room and wrestling room have been categorized as *weight rooms* in the calculation of outdoor air requirements. Refer to **Table A.5** for full space characteristic details.

AHU C-1

This CW/HW air-handling unit serves the library spaces of the school. All occupancy categories were taken from ASHRAE 62.1, as specified in the design documentation. Refer to **Table A.6** for full space characteristics.

AHU C-2

AHU C-2 serves the stage area of the school's auditorium. This space was categorized under *studios/stages* in calculating OA requirements. Refer to **Table A.7** for further details.

AHU C-3

This AHU serves the school's band room. This space has been categorized under *music/theater/dance*. Characteristics of the space are listed in **Table A.8**.

AHU C-4 and C-5

These units serve the school's two cafeteria dining areas. For calculation purposes, the *cafeteria/fast-food dining* category has been used. Refer to **Tables A.9 and A.10** for further information.

AHU B-1

This air-handling unit serves eight VAV boxes utilized in the school's office suite. Refer to **Table A.11** for a breakdown of the system.

AHU D-1

Air-handling unit D-1 serves the school's auditorium. A full list of space characteristics is listed in **Table A.12**.

AHU D-2

This unit serves the school's library classroom. Refer to **Table A.13** for a detailed listing of the space characteristics.

UV-109

This is an example of a unit ventilator used to serve multiple spaces within the building, which is common throughout the design. This unit serves the uniform storage room, the music library, and a small office. Refer to **Table A.14** for space characteristics.

UV Examples

Many individual areas of this building, most notably classrooms, are provided with outdoor air by single unit ventilators. While not all of the classrooms have been analyzed, many of these types of areas are listed and characterized in **Table A.15**.

Summary of Compliance

In general, the Altoona Area Junior High School features an overall system that is in compliance with ASHRAE 62.1 outdoor air requirements. Most major spaces are designed with adequate ventilation, with an emphasis placed on spaces most used by the student population. An examination of primary outdoor air fractions, as provided in **Appendix C**, validates this claim.

A detailed listing of how analysis using the ASHRAE 62.1 Ventilation Rate Procedure was carried out and evaluated is provided in **Appendix B**. Equations from the standard were utilized with the assumption that Zone Air Distribution Effectiveness (E_z) equals 1.

It is useful to note that trends in the design documentation reveal that an effort has been made to maintain a simple, standardized methodology in regards to equipment sizing. The equipment schedules for the building indicate that many units have been designed to deliver the same amount of outdoor air to similar spaces. This indicates that an averaging of space characteristics was likely to have occurred. While it is unknown that ASHRAE 62.1 was upheld during the design of this building's system, the data does suggest that the methodology has kept the designed values close to the ASHRAE requirements for the most part.

A comparison of results has been provided in **Appendix D**, where it can be noted that many of the OA requirements have been calculated at or around the design values. Among the differences, those occurring in AHU C-2, AHU C-3, and AHU D-1 are the most glaring, and will be discussed in the next section.

Identified Problems & Opportunities

As mentioned in the previous section, the three main discrepancies have occurred in AHU C-2, which serves the school's stage, AHU C-3, which serves the band room, and AHU D-1, which serves the auditorium. A listing of comparable data has been provided in **Appendix D**.

AHU C-2

As shown in **Table D.1**, the outdoor air calculated to be delivered to the space is 1189 cfm over what the design documents specify. This could be due to a number of reasons, most notably and probably, the occupancy classification of the space. Because the space is utilized as a stage, it may be safe to err on the side of higher OA delivery. It may also be difficult to predict the density of occupation and frequency of use for such a space, making interpreting ASHRAE 62.1 a difficult task. Most likely, the designers of the system used their experience to judge what was appropriate in this situation. That is not to say that some idiomatic design methods may have been implemented, suggesting the need to examine the requirements of the space in greater detail.

AHU C-3

As listed in **Table D.1**, 1071 cfm was calculated as an adequate amount to ventilate the space, but is 1234 cfm under the design-specified minimum. Factors contributing to this discrepancy are most likely similar to the ones noted for AHU C-2, but do not account for why the difference is so high. Because of the band room's close proximity to the auditorium stage, this suggests that a reconfiguration of the system in this area of the building may be more feasible. If upon further inspection it was determined that more outdoor air needs to be delivered to the stage, it can easily be diverted from the band room.

AHU D-1

Because of the expected large occupancy of the auditorium space, it may be difficult to determine how to apply the provisions of ASHRAE 62.1 to the design. In this case, shown in **Table D.1**, the calculated outdoor air rate was 1302 cfm under design specifications. This affords the opportunity to more closely examine the outdoor air requirements of large, densely-occupied space and find a reasonable design solution.

Appendices & Calculations

Appendix A

Space Characteristics

Table A.1 (AHU A-1)				
Room	Description	Category	Area (sf)	Occupancy
A117	Comp. Gym 1	<i>play area</i>	7912	-
		<i>spectator area</i>	1654	248

Table A.2 (AHU A-2)				
Room	Description	Category	Area (sf)	Occupancy
A117	Comp. Gym 1	<i>play area</i>	7912	-
		<i>spectator area</i>	1654	248

Table A.3 (AHU A-3)				
Room	Description	Category	Area (sf)	Occupancy
B102	Comp. Gym 2	<i>play area</i>	3237	-
		<i>spectator area</i>	463	70

Table A.4 (AHU A-4)				
Room	Description	Category	Area (sf)	Occupancy
B102	Comp. Gym 2	<i>play area</i>	3237	-
		<i>spectator area</i>	463	70

Table A.5 (AHU A-7)				
Room	Description	Category	Area (sf)	Occupancy
B211	Fitness Room	<i>weight rooms</i>	2246	22
B201	Wrestling Room	<i>weight rooms</i>	2493	25
B206	Corridor	<i>corridors</i>	1052	-

Table A.6 (AHU C-1)				
Room	Description	Category	Area (sf)	Occupancy
D112	Library	<i>libraries</i>	4051	72
D113	Work Room	<i>conference/meeting</i>	259	2
D114	Storage	<i>storage rooms</i>	268	-
D115	Conference Room	<i>conference/meeting</i>	242	7

Table A.7 (AHU C-2)				
Room	Description	Category	Area (sf)	Occupancy
D110	Stage	<i>stages</i>	1824	128

Table A.8 (AHU C-3)				
Room	Description	Category	Area (sf)	Occupancy
D108	Band Room	<i>music/theater/dance</i>	2851	90

Table A.9 (AHU C-4)				
Room	Description	Category	Area (sf)	Occupancy
C177	Cafeteria	<i>cafeterias</i>	4200	310

Table A.10 (AHU C-5)				
Room	Description	Category	Area (sf)	Occupancy
C185	Cafeteria	<i>cafeterias</i>	4200	298

Table A.11 (AHU B-1)				
Room	Description	Category	Area (sf)	Occupancy
C160	Office	<i>office space</i>	152	3
C161	Waiting Room	<i>reception area</i>	422	6
C156	Office	<i>office space</i>	133	3
C157	Office	<i>office space</i>	130	3
C158	Office	<i>office space</i>	133	3
C151	Mailroom	<i>storage rooms</i>	125	-
C152	Work Room	<i>office space</i>	223	1
C153	Waiting Room	<i>reception area</i>	437	10
C145	Conference Room	<i>conference/meeting</i>	188	-
C143	Vice Principal	<i>office space</i>	174	5
C144	Principal	<i>office space</i>	178	5
C146	Corridor	<i>corridors</i>	320	-
C147	Receptionist	<i>reception area</i>	70	1
C148	I.T. Office	<i>office space</i>	67	1
C149	I.T. Office	<i>office space</i>	76	1
C130	Maintenance	<i>wood/metal shop</i>	384	8
C136	Cots	<i>sick room</i>	162	4
C131	Incl. Tech	<i>electrical equipment</i>	131	-
C132	Waiting Area	<i>reception area</i>	453	7
C134	Office	<i>office space</i>	80	1
C135	Office	<i>office space</i>	80	1
C139	Exam. Room	<i>sick room</i>	134	2

Table A.12 (AHU D-1)				
Room	Description	Category	Area (sf)	Occupancy
D111	Auditorium	<i>auditorium seating area</i>	5387	650

Table A.13 (AHU D-2)				
Room	Description	Category	Area (sf)	Occupancy
C126	Library Classroom	<i>classrooms (age 9 plus)</i>	856	30

Table A.14 (UNIT VENTILATOR UV-109)				
Room	Description	Category	A _z (sf)	P _z (occ)
C110	Uniform Storage	<i>storage rooms</i>	473	-
C111	Music Library	<i>storage rooms</i>	303	-
C112	Office	<i>office space</i>	186	3

Table A.15 (UNIT VENTILATOR EXAMPLES)				
Room	Description	Category	Area (sf)	Occupancy
C103	Tech. Ed.	<i>wood/metal shop</i>	1405	36
C251	Foreign Language	<i>classrooms (age 9 plus)</i>	943	26
C204	Business Ed.	<i>computer lab</i>	877	26
C324	Special Ed.	<i>classrooms (age 9 plus)</i>	869	34
C433	Soc. Studies	<i>classrooms (age 9 plus)</i>	910	28
C212	FCS Classroom	<i>classrooms (age 9 plus)</i>	973	30
C301	Math	<i>classrooms (age 9 plus)</i>	873	30
C373	English	<i>classrooms (age 9 plus)</i>	871	26
C305	Reading	<i>classrooms (age 9 plus)</i>	797	30
C238	Faculty Lounge	<i>break rooms</i>	1015	30
C108	Music Classroom	<i>classrooms (age 9 plus)</i>	750	33
C451	Science	<i>science labs</i>	958	25

Appendix B

Outside Air Requirements

Table B.1 (AHU A-1)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
A117	Comp. Gym 1	<i>play area</i>	7912	0.3	-	-	2374
		<i>spectator area</i>	1654	0.06	248	7.5	1959
Total:							4333

Table B.2 (AHU A-2)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
A117	Comp. Gym 1	<i>play area</i>	7912	0.3	-	-	2374
		<i>spectator area</i>	1654	0.06	248	7.5	1959
Total:							4333

Table B.3 (AHU A-3)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
B102	Comp. Gym 2	<i>play area</i>	3237	0.3	-	-	971
		<i>spectator area</i>	463	0.06	70	7.5	553
Total:							1524

Table B.4 (AHU A-4)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
B102	Comp. Gym 2	<i>play area</i>	3237	0.3	-	-	971
		<i>spectator area</i>	463	0.06	70	7.5	553
Total:							1524

Table B.5 (AHU A-7)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
B211	Fitness Room	<i>weight rooms</i>	2246	0.06	22	20	575
B201	Wrestling Room	<i>weight rooms</i>	2493	0.06	25	20	650
B206	Corridor	<i>corridors</i>	1052	0.06	-	-	63
Total:							1288

Table B.6 (AHU C-1)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
D112	Library	<i>libraries</i>	4051	0.12	72	5	846
D113	Work Room	<i>conference/meeting</i>	259	0.06	2	5	26
D114	Storage	<i>storage rooms</i>	268	0.12	-	-	32
D115	Conference Room	<i>conference/meeting</i>	242	0.06	7	5	50
Total:							954

Table B.7 (AHU C-2)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
D110	Stage	<i>stages</i>	1824	0.06	128	10	1389

Table B.8 (AHU C-3)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
D108	Band Room	<i>music/theater/dance</i>	2851	0.06	90	10	1071

Table B.9 (AHU C-4)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
C177	Cafeteria	<i>cafeterias</i>	4200	0.18	310	7.5	3081

Table B.10 (AHU C-5)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
C185	Cafeteria	<i>cafeterias</i>	4200	0.18	298	7.5	2991

Table B.11 (AHU B-1)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
C160	Office	<i>office space</i>	152	0.06	3	5	24
C161	Waiting Room	<i>reception area</i>	422	0.06	6	5	55
C156	Office	<i>office space</i>	133	0.06	3	5	23
C157	Office	<i>office space</i>	130	0.06	3	5	23
C158	Office	<i>office space</i>	133	0.06	3	5	23
C151	Mailroom	<i>storage rooms</i>	125	0.12	-	-	15
C152	Work Room	<i>office space</i>	223	0.06	1	5	18
C153	Waiting Room	<i>reception area</i>	437	0.06	10	5	76
C145	Conference Room	<i>conference/meeting</i>	188	0.06	-	5	11
C143	Vice Principal	<i>office space</i>	174	0.06	5	5	35
C144	Principal	<i>office space</i>	178	0.06	5	5	36
C146	Corridor	<i>corridors</i>	320	0.06	-	-	19
C147	Receptionist	<i>reception area</i>	70	0.06	1	5	9
C148	I.T. Office	<i>office space</i>	67	0.06	1	5	9
C149	I.T. Office	<i>office space</i>	76	0.06	1	5	10
C130	Maintenance	<i>wood/metal shop</i>	384	0.18	8	10	149
C136	Cots	<i>sick room</i>	162	0.18	4	10	69
C131	Incl. Tech	<i>electrical equipment</i>	131	0.06	-	-	8
C132	Waiting Area	<i>reception area</i>	453	0.06	7	5	62
C134	Office	<i>office space</i>	80	0.06	1	5	10
C135	Office	<i>office space</i>	80	0.06	1	5	10
C139	Exam. Room	<i>sick room</i>	134	0.18	2	10	44
Total:							738

Table B.12 (AHU D-1)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
D111	Auditorium	<i>auditorium seating area</i>	5387	0.06	650	5	3573

Table B.13 (AHU D-2)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
C126	Library Classroom	<i>classrooms (age 9 plus)</i>	856	0.12	30	10	403

Table B.14 (UNIT VENTILATOR UV-109)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
C110	Uniform Storage	<i>storage rooms</i>	473	0.12			57
C111	Music Library	<i>storage rooms</i>	303	0.12			36
C112	Office	<i>office space</i>	186	0.06	3	5	26
Total:							119

Table B.15 (Unit Ventilator Examples)							
Room	Description	Category	A _z (sf)	R _a (cfm/sf)	P _z (occ)	R _p (cfm/occ)	V _{bz} (cfm)
C103	Tech. Ed.	<i>wood/metal shop</i>	1405	0.18	36	10	613
C251	Foreign Language	<i>classrooms (age 9 plus)</i>	943	0.12	26	10	373
C204	Business Ed.	<i>computer lab</i>	877	0.12	26	10	365
C324	Special Ed.	<i>classrooms (age 9 plus)</i>	869	0.12	34	10	444
C433	Soc. Studies	<i>classrooms (age 9 plus)</i>	910	0.12	28	10	389
C212	FCS Classroom	<i>classrooms (age 9 plus)</i>	973	0.12	30	10	417
C301	Math	<i>classrooms (age 9 plus)</i>	873	0.12	30	10	405
C373	English	<i>classrooms (age 9 plus)</i>	871	0.12	26	10	365
C305	Reading	<i>classrooms (age 9 plus)</i>	797	0.12	30	10	396
C238	Faculty Lounge	<i>break rooms</i>	1015	0.06	30	5	211
C108	Music Classroom	<i>classrooms (age 9 plus)</i>	750	0.12	33	10	420
C451	Science	<i>science labs</i>	958	0.18	25	10	422

Appendix C

Primary Outdoor Air Fraction (Z_p) Summary

Table C.1 (AHU A-1)		
V_{oz}	V_{pz}	Z_p
4333	7400	0.586

Table C.2 (AHU A-2)		
V_{oz}	V_{pz}	Z_p
4333	7400	0.586

Table C.3 (AHU A-3)		
V_{oz}	V_{pz}	Z_p
1524	3200	0.476

Table C.4 (AHU A-4)		
V_{oz}	V_{pz}	Z_p
1524	3200	0.476

Table C.5 (AHU A-7)		
V_{oz}	V_{pz}	Z_p
1288	3650	0.353

Table C.6 (AHU C-1)		
V_{oz}	V_{pz}	Z_p
954	3400	0.281

Table C.7 (AHU C-2)		
V_{oz}	V_{pz}	Z_p
1389	2500	0.556

Table C.8 (AHU C-3)		
V_{oz}	V_{pz}	Z_p
1071	4410	0.243

Table C.9 (AHU C-4)		
V_{oz}	V_{pz}	Z_p
3081	3780	0.815

Table C.10 (AHU C-5)		
V_{oz}	V_{pz}	Z_p
2991	3780	0.791

Table C.11 (AHU B-1)		
V_{oz}	V_{pz}	Z_p
738	3160	0.234

Table C.12 (D-1)		
V_{oz}	V_{pz}	Z_p
738	3160	0.234

Table C.13 (AHU D-2)		
V_{oz}	V_{pz}	Z_p
738	3160	0.234

Table C.14 (UV-109)		
V_{oz}	V_{pz}	Z_p
119	750	0.159

Table C.15 (Unit Ventilator Examples)			
	V_{oz}	V_{pz}	Z_p
UV-102	613	1250	0.49
UV-232	373	1000	0.373
UV-218	365	1500	0.243
UV-313	444	1250	0.355
UV-408	389	1000	0.389
UV-214	417	1000	0.417
UV-301	405	1000	0.405
UV-324	365	1000	0.365
UV-320	396	750	0.528
UV-233	211	1500	0.141
UV-104	420	750	0.56
UV-434	422	1000	0.422

Appendix D

Comparison of Results

Table D.1 - Actual and Calculated OA Requirement Comparison			
System	Min. OA Actual	Min. OA Calculated	Difference
AHU A-1	3875	4333	458
AHU A-2	3875	4333	458
AHU A-3	1440	1524	84
AHU A-4	1440	1524	84
AHU A-7	1040	1288	248
AHU C-1	1300	954	-346
AHU C-2	200	1389	1189
AHU C-3	2305	1071	-1234
AHU C-4	2700	3081	381
AHU C-5	2700	2991	291
AHU B-1	1400	738	-662
AHU D-1	4875	3573	-1302
AHU D-2	375	403	28
UV-109	100	119	19
UV-102	375	613	238
UV-232	375	373	-2
UV-218	375	365	-10
UV-313	375	444	69
UV-408	375	389	14
UV-214	375	417	42
UV-301	375	405	30
UV-324	375	365	-10
UV-320	375	396	21
UV-233	240	211	-29
UV-104	375	420	45
UV-434	375	422	47