

TECHNICAL REPORT I

ASHRAE STANDARD 62.1: Ventilation Compliance



TEMPLE UNIVERSITY – TYLER SCHOOL OF ART

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October 5, 2007

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Executive Summary

The 234,000 square foot Temple University Tyler School of Art ventilation systems were evaluated for compliance with ASHRAE Standard 62.1 *Ventilation for Acceptable Indoor Air Quality*. The evaluation procedure for ASHRAE Standard 62.1 is based on floor areas, space type, occupancy, and the ventilation system.

The Temple University Tyler School of Art is a 3-story art education building located in Philadelphia, PA. The Tyler School of Art is moving from its current location of Elkins Park, PA to create a complete Arts campus at the Temple main campus. The three floors and basement consist 234,000 square feet of administration, art education, and auditorium space.

The supply air system consists of four (4) air handling units (AHU) and one (1) makeup air unit located in the basement mechanical room. In addition, there are three (3) roof top units (RTU). AHU-1, AHU-2, RTU-1, and RTU-2 are all variable air volume (VAV) systems. RTU-3, AHU-3, and AHU-4 are all constant air volume (CAV) systems that run at 100% OA, because these AHUs serve most of the studio spaces. The MAU is a 5,000 cfm unit that only serves the furnace room located on the 1st floor. The air handling units range from 35,000 to 62,000 cfm.

The basement floor is separated into two sections connected by a large mechanical space. The south section is connected to the main lobby by a two-story basement lobby and houses the auditorium and photo studios. The lower level shops are located on the north end of the basement. The 1st floor is broken into the zones representing the ceramics, sculpture, and glass departments as well as the school’s exhibition space and a 1st floor core which features the main lobby and two-floor promenade which stretches between the two branches of the building. The 2nd floor is broken down into administration and the departments of metals, printmaking, foundations, gaid, and fibers. The painting studios are located on the top floor at north end of the building.

Only five (5) of the units met the ventilation requirements of ASHRAE 62.1. The other two (2) units failed because of occupancy and space discrepancies between the calculated OA and the given AHU OA. The breakdown of which zones correspond to which air handling unit or roof top unit is as follows:

	LOCATION	AREAS SERVED	MAX CFM	COMPLIES w/62.1
AHU-1	BASEMENT	PHOTO, EXHIBIT	50,000	Yes
AHU-2	BASEMENT	LOWER LEVEL/1ST FLOOR CORE	50,000	No
AHU-3	BASEMENT	CERAMICS, SCULPTURE, GLASS	62,000	Yes
AHU-4	BASEMENT	PRINTMAKING, METALS, LL SHOPS	62,000	Yes
RTU-1	ROOF	2ND FLOOR ADMIN/CORE, FOUNDATIONS	42,000	Yes
RTU-2	ROOF	GAID, FIBERS, 2ND FLOOR CORE	51,000	No
RTU-3	ROOF	PAINTING	35,000	Yes

Assumptions

Ventilation Rates in Breathing Zone

Table 6-1 of ASHRAE 62.1 requires assumptions to be made regarding designed spaces that do not appear in the table. These assumed functions of the designed spaces correspond to the zone ventilation rates as follows:

- All studio spaces were treated as “art classrooms”
- All lounges were designed as “multi-use assembly” spaces
- The promenade was designed as a “corridor”
- Critique spaces were designed as “classrooms (age 9 plus)”

Spaces Not Included

Areas such as men’s/women’s bathrooms, electrical rooms, telecom rooms, elevator machine rooms, and janitor closets were not included in the report. Elevator shafts, stairways and areas not supplied by the AHUs were also not included in the evaluation.

Occupancy

The occupancy for all the design spaces were calculated using the occupant density in Table 6-1 or were taken from the floor plans.

Supply Airflow

The supply airflow rates are taken from the mechanical plans.

Diversity

The diversity accounts for variations in occupancy for the different spaces. Assume the *occupant diversity* (D) = 1.

Exhaust Ventilation

The exhaust ventilation was not considered for the entire report. These exhausted spaces include but are not limited to bathrooms, studios, and electrical spaces.

Indoor Air Quality

The Tyler School of Art and the areas near outdoor air intakes are entirely environmental tobacco smoke free (ETS-Free). The requirements involving transfer air, recirculation, exhaust systems, and signage of section 5 of ASHRAE 62.1 at satisfied by the building being ETS-Free.

Makeup Air Unit (MAU)

The 5,000 cfm MAU that serves the 1st floor furnace room was not considered in this evaluation.

Procedure from ASHRAE 62.1

1. Determine the *breathing zone outdoor airflow* (V_{bz}):

$$V_{bz} = R_p \cdot P_z + R_a \cdot A_z \quad (6-1)$$

Where:

R_p = Outdoor airflow rate per person (Table 6-1)

P_z = Zone population

R_a = Outdoor airflow rate per area (Table 6-1)

A_z = Zone floor area

2. Determine *zone air distribution effectiveness* (E_z):

$$E_z = 1.0 \text{ for a ceiling supply of cool air} \quad (\text{Table 6-2})$$

3. Determine *zone outdoor airflow* (V_{oz}):

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

4. For the 100% OA AHU-3 and AHU-4:

$$V_{ot} = \sum_{\text{all zones}} V_{oz} \quad (6-4)$$

5. For AHU-1, AHU-2, RTU-1, RTU-2, and RTU-3, determine the *uncorrected outdoor air intake* (V_{ou}):

$$V_{ou} = D \sum_{\text{all zones}} (R_p \cdot P_z) + \sum_{\text{all zones}} (R_a \cdot A_z) \quad (6-6)$$

6. Determine the *zone primary outdoor air fraction* (Z_p):

$$Z_p = V_{oz} / V_{pz} \quad (6-5)$$

Where:

V_{pz} = Primary airflow to the zone

7. Determine E_v by using Table 6-3:

TABLE 6-3 System Ventilation Efficiency

Max (Z_p)	E_v
≤0.15	1.0
≤0.25	0.9
≤0.35	0.8
≤0.45	0.7
≤0.55	0.6
>0.55	Use Appendix A

8. Determine the design the *outdoor air intake flow* (V_{ot}):

$$V_{ot} = V_{ou} / E_v \quad (6-8)$$

Procedure from ASHRAE 62.1

9. For $Z_p > 0.55$ refer to Appendix A:

Use the single supply system:

$$E_{vz} = 1 + X_s - Z_d \quad (\text{A-1})$$

$$E_v = \text{minimum}(E_{vz}) \text{ is critical space} \quad (\text{A-3})$$

Where:

E_{vz} = Zone ventilation efficiency

X_s = Average outdoor air fraction

$$X_s = V_{ou} / V_{ps}$$

$$V_{ps} = \Sigma V_{pz}$$

Z_d = Discharge outdoor air fraction

$$Z_d = V_{oz} / V_{dv}$$

$$V_{dv} = V_{pz}$$

Plug E_v into equation (6-8)

Results

RTU-1

Room #	Use	Az	Pz	Ra	Rp	(Rp)(Pz)	(Ra)(Az)	Vbz	Vpz	ZONE	Zp	Evz
2001	2nd Floor South Lobby	3000	450	0.06	5	2250	180	2430	6300	2nd Core/Admin	0.3857	0.8804
2002	Bridge	360		0.06			22	22	2000	2nd Core/Admin	0.0108	1.2553
2003	Comp. Teaching Classrm	660	16	0.12	10	160	79	239	815	2nd Core/Admin	0.2935	0.9726
2004	Comp. Storage	125		0.12			15	15	210	2nd Core/Admin	0.0714	1.1947
2006	CS Manager	175	2	0.06	5	10	11	21	215	2nd Core/Admin	0.0953	1.1708
2007	Staff Room	150	2	0.06	5	10	9	19	305	2nd Core/Admin	0.0623	1.2038
2008	Media Output Center	900	23	0.12	10	230	108	338	1140	2nd Core/Admin	0.2965	0.9696
2009	All School Comp. Classrm	790	20	0.12	10	200	95	295	1125	2nd Core/Admin	0.2620	1.0041
2015	Student Lounge	1460	146	0.06	7.5	1095	88	1183	1495	2nd Core/Admin	0.7910	0.4751
2016	Deans Reception	450	14	0.06	5	70	27	97	380	2nd Core/Admin	0.2553	1.0108
2017	Deans Asst	140	1	0.06	5	5	8	13	170	2nd Core/Admin	0.0788	1.1873
2018	Deans Office	315	3	0.06	5	15	19	34	470	2nd Core/Admin	0.0721	1.1940
2020	Deans Smart Conf Room	330	8	0.06	5	40	20	60	1045	2nd Core/Admin	0.0572	1.2089
2021	Corridor	325		0.06			20	20	180	2nd Core/Admin	0.1083	1.1578
2022	Assoc. Dean	130	3	0.06	5	15	8	23	305	2nd Core/Admin	0.0748	1.1913
2023	Assoc. Dean	130	3	0.06	5	15	8	23	305	2nd Core/Admin	0.0748	1.1913
2024	Develop. Director	130	3	0.06	5	15	8	23	305	2nd Core/Admin	0.0748	1.1913
2025	Develop. Asst.	130	3	0.06	5	15	8	23	305	2nd Core/Admin	0.0748	1.1913
2026	Asst. Dean	130	3	0.06	5	15	8	23	305	2nd Core/Admin	0.0748	1.1913
2027	Publication Director	130	3	0.06	5	15	8	23	305	2nd Core/Admin	0.0748	1.1913
2028	Conference	130	6	0.06	5	30	8	38	430	2nd Core/Admin	0.0879	1.1782
2029	Reception	250	8	0.06	5	40	15	55	390	2nd Core/Admin	0.1410	1.1251
2030	Student Reception	100	3	0.06	5	15	6	21	90	2nd Core/Admin	0.2333	1.0328
2032	Files	75		0.12			9	9	80	2nd Core/Admin	0.1125	1.1536
2034	Corridor	110		0.06			7	7	90	2nd Core/Admin	0.0733	1.1928
2035	Clerical	300	4	0.06	5	20	18	38	570	2nd Core/Admin	0.0667	1.1994
2036	Workroom	155	1	0.06	5	5	9	14	150	2nd Core/Admin	0.0953	1.1708
2038	Asst.Deans Office Mgr	130	2	0.06	5	10	8	18	125	2nd Core/Admin	0.1424	1.1237
2039	Advisor	130	2	0.06	5	10	8	18	125	2nd Core/Admin	0.1424	1.1237
2040	Registration & Records	130	2	0.06	5	10	8	18	115	2nd Core/Admin	0.1548	1.1113
2041	Chairs Admin	325	3	0.06	5	15	20	35	330	2nd Core/Admin	0.1045	1.1616
2042	Advising & Registration	110	2	0.06	5	10	7	17	115	2nd Core/Admin	0.1443	1.1218
2044	Chair	150	3	0.06	5	15	9	24	125	2nd Core/Admin	0.1920	1.0741
2045	Chair	150	3	0.06	5	15	9	24	125	2nd Core/Admin	0.1920	1.0741
2046	Chair	150	3	0.06	5	15	9	24	125	2nd Core/Admin	0.1920	1.0741

Results

RTU-1 (cont.)

Room #	Use	Az	Pz	Ra	Rp	(Rp)(Pz)	(Ra)(Az)	Vbz	Vpz	ZONE	Zp	Evz
2062	Chair/Admin Office	240	5	0.06	5	25	14	39	110	foundation	0.3582	0.9079
2063	Faculty Workroom	200	1	0.06	5	5	12	17	130	foundation	0.1308	1.1353
2064	Studio	800	16	0.18	10	160	144	304	910	foundation	0.3341	0.9320
2065	Studio	800	16	0.18	10	160	144	304	1120	foundation	0.2714	0.9947
2066	Corridor	800		0.06			48	48	210	foundation	0.2286	1.0375
2067	Studio	840	17	0.18	10	170	151	321	775	foundation	0.4145	0.8516
2068	Studio	840	17	0.18	10	170	151	321	775	foundation	0.4145	0.8516
2069	Studio	800	16	0.18	10	160	144	304	1120	foundation	0.2714	0.9947
2070	Studio	800	16	0.18	10	160	144	304	1120	foundation	0.2714	0.9947
2071	Studio	800	16	0.18	10	160	144	304	1120	foundation	0.2714	0.9947
2072	Studio	840	17	0.18	10	170	151	321	775	foundation	0.4145	0.8516
2073	Studio	840	17	0.18	10	170	151	321	775	foundation	0.4145	0.8516
2075	Storage	105		0.12			13	13	300	foundation	0.0420	1.2241
2076	Office	125	1	0.06	5	5	8	13	95	foundation	0.1316	1.1345
2077	Office	125	1	0.06	5	5	8	13	95	foundation	0.1316	1.1345
2078	Corridor	260		0.06			16	16	900	foundation	0.0173	1.2488
2114	Studio	800	16	0.18	10	160	144	304	1120	foundation	0.2714	0.9947

Vou	8546
Vps=ΣVpz	32115
Xs=Vou/Vps	0.2661
Ev=min(Evz)	0.47506
Vot=Vou/Ev	17989

RTU-2

Room #	Use	Az	Pz	Ra	Rp	(Rp)(Pz)	(Ra)(Az)	Vbz	Vpz	ZONE	Zp	Evz
2079	Typography	740	15	0.18	10	150	133.2	283.2	450	gaid	0.629333	0.5622
2080	Interactive Studio	805	19	0.12	10	190	96.6	286.6	1050	gaid	0.272952	0.9186
2081	Computer Coordinator	150	2	0.06	5	10	9	19	300	gaid	0.063333	1.1282
2082	BFA Area Head	150	2	0.06	5	10	9	19	300	gaid	0.063333	1.1282
2083	MFA Coordinator	150	2	0.06	5	10	9	19	300	gaid	0.063333	1.1282
2084	Interactive Studio 2	660	18	0.12	10	180	79.2	259.2	965	gaid	0.268601	0.923
2085	Critique Studio	740	15	0.18	10	150	133.2	283.2	510	gaid	0.555294	0.6363
2086	Tele/Comm	60					3.6	3.6	200	gaid	0.018	1.1736
2087	Critique Studio	815	16	0.18	10	160	146.7	306.7	500	gaid	0.6134	0.5782

Results

RTU-2 (cont.)

Room #	Use	Az	Pz	Ra	Rp	(Rp)(Pz)	(Ra)(Az)	Vbz	Vpz	ZONE	Zp	Evz
2088	Illustration Studio	650	13	0.18	10	130	117	247	430	gaid	0.574419	0.6172
2089	Office	100	2	0.06	5	10	6	16	90	gaid	0.177778	1.0138
2090	Office	100	2	0.06	5	10	6	16	90	gaid	0.177778	1.0138
2091	Office	100	2	0.06	5	10	6	16	90	gaid	0.177778	1.0138
2092	Corridor	270		0.06			16.2	16.2	100	gaid	0.162	1.0296
2093	Office	120	2	0.06	5	10	7.2	17.2	100	gaid	0.172	1.0196
2094	Office	120	2	0.06	5	10	7.2	17.2	100	gaid	0.172	1.0196
2095	Storage	65		0.12			7.8	7.8	50	gaid	0.156	1.0356
2096	Office	155	3	0.06	5	15	9.3	24.3	100	gaid	0.243	0.9486
2097	Electrical Room	155		0.06			9.3	9.3	695	gaid	0.013381	1.1782
2098	Portfolio Studio	1125	40	0.06	7.5	300	67.5	367.5	970	gaid	0.378866	0.8127
2098a	Corridor	530		0.06			31.8	31.8	165	gaid	0.192727	0.9989
2099	Work Studio	675	14	0.18	10	140	121.5	261.5	980	gaid	0.266837	0.9247
2100	Computer Studio	430	13	0.12	10	130	51.6	181.6	1080	gaid	0.168148	1.0234
2101	Grad Studio	2025	24	0.18	10	240	364.5	604.5	2250	gaid	0.268667	0.9229
2102	Corridor	350		0.06			21	21	325	fibers	0.064615	1.127
2103	Grad Studio	175	1	0.06	5	5	10.5	15.5	155	fibers	0.1	1.0916
2104	3-D Const Studio	1305	26	0.18	10	260	234.9	494.9	1635	fibers	0.302691	0.8889
2105	Computer Lab	230	5	0.12	10	50	27.6	77.6	280	fibers	0.277143	0.9144
2106	Storage	65		0.12			7.8	7.8	50	fibers	0.156	1.0356
2107	Tech Office	105	1	0.06	5	5	6.3	11.3	75	fibers	0.150667	1.0409
2108	Grad Studio	175	1	0.06	5	5	10.5	15.5	155	fibers	0.1	1.0916
2109	Grad Studio	175	1	0.06	5	5	10.5	15.5	155	fibers	0.1	1.0916
2110	Grad Studio	175	1	0.06	5	5	10.5	15.5	155	fibers	0.1	1.0916
2111	Print Studio	1000	29	0.18	10	290	180	470	525	fibers	0.895238	0.2963
2112	Loom Studio	1820	28	0.18	10	280	327.6	607.6	1345	fibers	0.451747	0.7398
2113	Yarn Storage	96		0.12			11.52	11.52	75	fibers	0.1536	1.038
2115	Washout	140	2	0.18	10	20	25.2	45.2	140	fibers	0.322857	0.8687
2116	Exposure	115	2	0.18	10	20	20.7	40.7	110	fibers	0.37	0.8216
2138	Dye Studio	490	10	0.18	10	100	88.2	188.2	1440	fibers	0.130694	1.0609
2117	2nd Floor N. Lobby	620	93	0.06	5	465	5.58	470.58	500	2nd Core	0.94116	0.2504
2074	Promenade	8660		0.06	0.06		519.6	519.6	14115	2nd Core	0.036812	1.1548

Vou	6341.4
Vps=ΣVpz	33100
Xs=Vou/Vps	0.191583
Ev=min(Evz)	0.250423
Vot=Vou/Ev	25323

Results

RTU-3

Room #	Use	Az	Pz	Ra	Rp	(Rp)(Pz)	(Ra)(Az)	Vbz	Vpz	Zone	Zp
3001	Senior Studio	2665	21	0.18	10	210	479.7	689.7	4275	painting	0.1613
3002	Advanced Painting Studio	1230	25	0.18	10	250	221.4	471.4	2500	painting	0.1886
3003	Advanced Painting Studio	1230	25	0.18	10	250	221.4	471.4	2500	painting	0.1886
3004	Sophomore Painting Studio	1230	25	0.18	10	250	221.4	471.4	2500	painting	0.1886
3005	Sophomore Painting Studio	1230	25	0.18	10	250	221.4	471.4	2500	painting	0.1886
3006	Intermediate Dwg Studio	1230	25	0.18	10	250	221.4	471.4	2500	painting	0.1886
3007	Advanced Dwg Studio	1230	25	0.18	10	250	221.4	471.4	2500	painting	0.1886
3008	Conference	390	10	0.06	5	50	23.4	73.4	600	painting	0.1223
3009	Critique	1025	36	0.12	10	360	123	483	1050	painting	0.46
3011	Model Changing	60	1	0.06	5	5	3.6	8.6	75	painting	0.1147
3012	Model Changing	60	1	0.06	5	5	3.6	8.6	75	painting	0.1147
3023	Grad Studio	300	6	0.06	10	60	54	114	350	painting	0.3257
3024	Grad Studio	300	6	0.06	10	60	54	114	360	painting	0.3167
3025	Grad Studio	300	6	0.06	10	60	54	114	350	painting	0.3257
3026	Grad Studio	300	6	0.06	10	60	54	114	350	painting	0.3257
3027	Grad Studio	300	6	0.06	10	60	54	114	350	painting	0.3257
3028	Grad Studio	300	6	0.06	10	60	54	114	350	painting	0.3257
3029	Grad Studio	300	6	0.06	10	60	54	114	435	painting	0.2621
3030	Grad Studio	300	6	0.06	10	60	54	114	350	painting	0.3257
3031	Office	125	1	0.06	5	5	7.5	12.5	120	painting	0.1042
3032	Office	125	1	0.06	5	5	7.5	12.5	120	painting	0.1042
3033	Office	125	1	0.06	5	5	7.5	12.5	120	painting	0.1042
3035	Storage	300		0.12			36	36	515	painting	0.0699
3040	Storage	85		0.12			10.2	10.2	75	painting	0.136
3041	Grad Studio	240	5	0.18	10	50	43.2	93.2	225	painting	0.4142
3042	Grad Studio	240	5	0.18	10	50	43.2	93.2	225	painting	0.4142
3043	Grad Studio	240	5	0.18	10	50	43.2	93.2	225	painting	0.4142
3044	Grad Studio	240	5	0.18	10	50	43.2	93.2	225	painting	0.4142
3045	Grad Studio	240	5	0.18	10	50	43.2	93.2	350	painting	0.2663
3045.1	Eyewash	100	1	0.18	10	10	18	28	105	painting	0.2667
3046	Grad Studio	240	5	0.18	10	50	43.2	93.2	350	painting	0.2663
3047	Grad Studio	240	5	0.18	10	50	43.2	93.2	350	painting	0.2663
3048	Grad Studio	240	5	0.18	10	50	43.2	93.2	225	painting	0.4142
3049	Grad Studio	325	6	0.18	10	60	58.5	118.5	415	painting	0.2855
3050	Grad Studio	325	6	0.18	10	60	58.5	118.5	415	painting	0.2855
3051	Corridor	2100		0.06			126	126	1375	painting	0.0916
3052	3rd Floor Lobby	1000	150	0.06	5	750	60	810	1535	painting	0.5277

Vou	7034
Vps=ΣVpz	30940
Ev	0.527687
Vot=Vou/Ev	13330

Results

AHU-1

Room #	Use	Az	Pz	Ra	Rp	(Rp)(Pz)	(Ra)(Az)	Vbz	Vpz	ZONE	Zp	Evz
B014	Lounge	330	33	0.06	7.5	247.5	19.8	267.3	330	photo	0.81	0.3439
B015	Office	75	1	0.06	5	5	4.5	9.5	100	photo	0.095	1.0589
B016	Tool Cage	350		0.12			42	42	315	photo	0.1333	1.0206
B017	LG Format/Scan Studio	600	15	0.12	10	150	72	222	680	photo	0.3265	0.8274
B018	Digital Advanced Studio	1070	16	0.12	10	160	128.4	288.4	1110	photo	0.2598	0.8941
B019	Digital Studio	805	15	0.12	10	150	96.6	246.6	810	photo	0.3044	0.8495
B020	Corridor	200		0.06			12	12	140	photo	0.0857	1.0682
B021	Undergrad Crit	615	20	0.06	5	100	36.9	136.9	600	photo	0.2282	0.9257
B022	Faculty Office	100	2	0.06	5	10	6	16	100	photo	0.16	0.9939
B023	Faculty Office	100	2	0.06	5	10	6	16	100	photo	0.16	0.9939
B024	Faculty Office	100	2	0.06	5	10	6	16	100	photo	0.16	0.9939
B025	Corridor	400		0.06			24	24	100	photo	0.24	0.9139
B026	Corridor	200		0.06			12	12	100	photo	0.12	1.0339
B027	Grad Studio	200	2	0.12	10	20	24	44	200	photo	0.22	0.9339
B028	Grad Studio	200	2	0.12	10	20	24	44	200	photo	0.22	0.9339
B029	Grad Studio	200	2	0.12	10	20	24	44	200	photo	0.22	0.9339
B030	Grad Seminar	425	28	0.06	7.5	210	25.5	235.5	350	photo	0.6729	0.481
B031	Grad Darkroom	200	1	0.12	5	5	24	29	1040	photo	0.0279	1.126
B032	Grad Studio	200	2	0.12	10	20	24	44	200	photo	0.22	0.9339
B040	Darkroom	775	4	0.12	5	20	93	113	2120	photo	0.0533	1.1006
B041	Processing	490	5	0.12	5	25	0.6	25.6	1355	photo	0.0189	1.135
B042	Storage	55		0.12			6.6	6.6	75	photo	0.088	1.0659
B043	Print viewing	210	1	0.12	5	5	25.2	30.2	645	photo	0.0468	1.1071
B044	Darkroom	90	1	0.12	5	5	10.8	15.8	150	photo	0.1053	1.0486
B045	Film Processing	450	5	0.12	5	25	54	79	2160	photo	0.0366	1.1173
B046	Print Mount & Finish	600	12	0.18	10	120	108	228	1000	photo	0.228	0.9259
B047	Corridor	365		0.06			21.9	21.9	645	photo	0.034	1.1199
B048	Lighting Studio	975	20	0.12	10	200	117	317	650	photo	0.4877	0.6662

Results

AHU-1 (cont.)

Room #	Use	Az	Pz	Ra	Rp	(Rp)(Pz)	(Ra)(Az)	Vbz	Vpz	ZONE	Zp	Evz
1005	Reception/Waiting	315	9	0.06	5	45	18.9	63.9	285	exhibit	0.2242	0.9297
1006	Admin. Couns. 1	130	1	0.06	5	5	7.8	12.8	100	exhibit	0.128	1.0259
1007	Admin. Couns. 2	130	1	0.06	5	5	7.8	12.8	100	exhibit	0.128	1.0259
1008	Work Room	510	3	0.06	5	15	30.6	45.6	400	exhibit	0.114	1.0399
1009	Conference Room	260	13	0.06	5	65	15.6	80.6	500	exhibit	0.1612	0.9927
1010	Storage	100		0.12			12	12	75	exhibit	0.16	0.9939
1011	Asst. Dean	180	1	0.06	5	5	10.8	15.8	825	exhibit	0.0192	1.1347
1012	Webmaster/Mistress	122	1	0.06	5	5	7.32	12.32	300	exhibit	0.0411	1.1128
1013	Exhibitions Coordinator	140	1	0.06	5	5	8.4	13.4	935	exhibit	0.0143	1.1396
1014	Exhibitions Director	163	1	0.06	5	5	9.78	14.78	740	exhibit	0.02	1.1339
1015	Seminar/Work Room	440	2	0.06	5	10	26.4	36.4	2400	exhibit	0.0152	1.1387
1016	Associate	130	1	0.06	5	5	7.8	12.8	100	exhibit	0.128	1.0259
1017	Break Room/Food Prep	120	3	0.06	5	15	7.2	22.2	100	exhibit	0.222	0.9319
1018	Continuing Education	145	1	0.06	5	5	8.7	13.7	160	exhibit	0.0856	1.0683
1019	Gallery 3	1715	69	0.06	7.5	517.5	102.9	620.4	2180	exhibit	0.2846	0.8693
1020	Gallery 2	840	34	0.06	7.5	255	50.4	305.4	1000	exhibit	0.3054	0.8485
1021	Gallery 1	840	34	0.06	7.5	255	50.4	305.4	1040	exhibit	0.2937	0.8602
1027	Work/Prep Area	1150	6	0.06	5	30	69	99	1000	exhibit	0.099	1.0549
1028	Prep Office	165	1	0.06	5	5	9.9	14.9	160	exhibit	0.0931	1.0608
1029	Clean Storage	465		0.12			55.8	55.8	330	exhibit	0.1691	0.9848

Vou	4356.3
Vps=ΣVpz	28305
Xs=Vou/Vps	0.1539
Ev=min(Evz)	0.3439
Vot=Vou/Ev	12667

Results

AHU-2

Room #	Use	Az	Pz	Ra	Rp	(Rp)(Pz)	(Ra)(Az)	Vbz	Vpz	ZONE*	Zp	Evz
B001	Elevator Lobby	1050	158	0.06	5	790	63	853	1500	LL Core	0.5687	0.6603
B002	Auditorium	1740	189	0.06	5	945	104.4	1049.4	4385	LL Core	0.2393	0.9897
B003	AV	540	14	0.12	10	140	64.8	204.8	420	LL Core	0.4876	0.7414
B004	Office	110	1	0.06	5	5	6.6	11.6	100	LL Core	0.116	1.113
B005	Computer Storage	85		0.12			10.2	10.2	75	LL Core	0.136	1.093
B006	Slide Storage	150		0.12			18	18	100	LL Core	0.18	1.049
B007	Slide Library	420	4	0.06	5	20	25.2	45.2	365	LL Core	0.1238	1.1052
B008	Copy Workroom	80	1	0.06	5	5	4.8	9.8	155	LL Core	0.0632	1.1658
B009	Office	170	2	0.06	5	10	10.2	20.2	155	LL Core	0.1303	1.0987
B010	Student Installation	1540	31	0.12	10	310	184.8	494.8	1660	LL Core	0.2981	0.9309
B013	Basement Lobby	2375	350	0.06	5	1750	142.5	1892.5	4400	LL Core	0.4301	0.7989
1002	Lobby	1865	19	0.06	5	95	111.9	206.9	3200	1st core	0.0647	1.1643
1003	Lounge	2940	294	0.06	7.5	2205	176.4	2381.4	2135	1st core	1.1154	0.1136
1004	Reception/Mailboxes	2870	86	0.06	5	430	172.2	602.2	7000	1st core	0.086	1.143
1026	Promenade	5630		0.06			337.8	337.8	10750	1st core	0.0314	1.1976
1079	Sculpture Workroom	740	15	0.18	10	150	133.2	283.2	350	1st core	0.8091	0.4199
1080	Corridor	500		0.06			30	30	75	1st core	0.4	0.829

Vou	8451
Vps=ΣVpz	36825
Xs=Vou/Vps	0.22949
Ev=min(Evz)	0.41986
Vot=Vou/Ev	20128.1

Results

AHU-3/4

Room #	Use	Az	Pz	Ra	Rp	(Rp)(Pz)	(Ra)(Az)	Vbz	Vpz	ZONE	Zp
B053	Storage	530		0.12			63.6	64	345	LL SHOPS	0.1843
B054	Plaster/Mouldmaking	1290	26	0.18	10	260	232.2	492	1080	LL SHOPS	0.4557
B055	Central Housekeeping	400		0.12			48	48	285	LL SHOPS	0.1684
B056	Plaster/Clay Studio	975	20	0.18	10	200	175.5	376	1250	LL SHOPS	0.3004
B057	Tech Office Tool Crib	225		0.12			27	27	150	LL SHOPS	0.18
B058	Ceramics- Plaster/Mouldmaking	1175	24	0.18	10	240	211.5	452	960	LL SHOPS	0.4703
B059	Grad Library	475	5	0.12	5	25	57	82	540	LL SHOPS	0.1519
B060	Slide Room	115	1	0.12	5	5	13.8	19	100	LL SHOPS	0.188
B061	Slide Room	115	1	0.12	5	5	13.8	19	100	LL SHOPS	0.188
B062	Storage	115		0.12			13.8	14	100	LL SHOPS	0.138
B063	Storage	115		0.12			13.8	14	100	LL SHOPS	0.138
B068	North Basement Lobby	915	137	0.06	5	685	54.9	740	400	LL SHOPS	1.8498
B075	Corridor	620		0.06			37.2	37	210	LL SHOPS	0.1771
B076	Foundations Woodshop	1905	38	0.18	10	380	342.9	723	3720	LL SHOPS	0.1943
B077	Wood Storage	125		0.12			15	15	200	LL SHOPS	0.075
1084	Office	125	2	0.06	5	10	7.5	18	80	ceramics	0.2188
1085	Office	125	2	0.06	5	10	7.5	18	80	ceramics	0.2188
1086	Bulk Storage	620		0.12			74.4	74	450	ceramics	0.1653
1090	Kiln Room #1	1415	28	0.18	10	280	254.7	535	1000	ceramics	0.5347
1091	Kiln Storage	170		0.12			20.4	20	150	ceramics	0.136
1092	Storage	288		0.12			34.56	35	150	ceramics	0.2304
1093	Clay Machinery	475	10	0.18	10	100	85.5	186	3200	ceramics	0.058
1094	Grad Studio	165	3	0.18	10	30	29.7	60	200	ceramics	0.2985
1095	Grad Studio	165	3	0.18	10	30	29.7	60	200	ceramics	0.2985
1096	Grad Studio	165	3	0.18	10	30	29.7	60	200	ceramics	0.2985
1097	Grad Studio	165	3	0.18	10	30	29.7	60	400	ceramics	0.1493
1098	Corridor	300		0.06			18	18	200	ceramics	0.09
1099	Grad Studio	165	3	0.18	10	30	29.7	60	200	ceramics	0.2985
1100	Grad Studio	165	3	0.18	10	30	29.7	60	200	ceramics	0.2985
1101	Grad Studio	165	3	0.18	10	30	29.7	60	200	ceramics	0.2985
1102	Grad Studio	165	3	0.18	10	30	29.7	60	400	ceramics	0.1493
1103	Undergrad Majors Studio	1410	31	0.18	10	310	253.8	564	2120	ceramics	0.2659
1104	Hand Building	950	24	0.18	10	240	171	411	1360	ceramics	0.3022
1105	Throwing	950	16	0.18	10	160	171	331	1360	ceramics	0.2434
1106	Piazza/Hall	1400	210	0.06	5	1050	84	1134	1140	ceramics	0.9947
1107	Glaze Lab	1180	24	0.18	10	240	212.4	452	4700	ceramics	0.0963
1108	Glaze Storage	525		0.12			63	63	150	ceramics	0.42
1109	Kiln Room #2	170	3	0.18	10	30	30.6	61	1620	ceramics	0.0374

Results

AHU-3/4 (cont.)

Room #	Use	Az	Pz	Ra	Rp	(Rp)(Pz)	(Ra)(Az)	Vbz	Vpz	ZONE	Zp
1030	Grad Studio	200	4	0.18	10	40	36	76	310	glass	0.2452
1031	Grad Studio	200	4	0.18	10	40	36	76	150	glass	0.5067
1032	Critique Room Grad Workshop	700	14	0.18	10	140	126	266	800	glass	0.3325
1033	Majors Studio	1200	24	0.18	10	240	216	456	1200	glass	0.38
1034	Smart Seminar Room	640	42	0.06	7.5	315	38.4	353	1200	glass	0.2945
1037	Grad Studio	200	4	0.18	10	40	36	76	150	glass	0.5067
1038	Grad Studio	200	4	0.18	10	40	36	76	310	glass	0.2452
1039	Kiln Room	760	15	0.18	10	150	136.8	287	2700	glass	0.1062
1040	Vapors Room	160	3	0.18	10	30	28.8	59	75	glass	0.784
1041	Sandblast	100	2	0.18	10	20	18	38	75	glass	0.5067
1042	Cold Shop	1915	38	0.18	10	380	344.7	725	2175	glass	0.3332
1043	Tech Room	100	2	0.18	10	20	18	38	75	glass	0.5067
1046	Office	85	2	0.06	5	10	5.1	15	300	glass	0.0503
1047	Hot Shop	3000	60	0.18	10	600	540	1140	7500	glass	0.152
1048	Office	85	2	0.06	5	10	5.1	15	100	glass	0.151
1047	Undergrad Studio	600	12	0.18	10	120	108	228	875	sculpture	0.2606
1049	Critique	875	18	0.12	10	180	105	285	800	sculpture	0.3563
1050	Smart Classroom	570	25	0.12	10	250	68.4	318	750	sculpture	0.4245
1052	Office	150	2	0.06	5	10	9	19	100	sculpture	0.19
1053	Office	150	2	0.06	5	10	9	19	100	sculpture	0.19
1055	Wood Shop	2705	54	0.18	10	540	486.9	1027	3240	sculpture	0.3169
1056	Classroom #1	800	20	0.12	10	200	96	296	1015	sculpture	0.2916
1057	Undergrad Studio	405	8	0.18	10	80	72.9	153	590	sculpture	0.2592
1058	Grad Studio	300	6	0.18	10	60	54	114	490	sculpture	0.2327
1059	Grad Studio	300	6	0.18	10	60	54	114	490	sculpture	0.2327
1060	Grad Studio	300	6	0.18	10	60	54	114	490	sculpture	0.2327
1064	Metal Shop	4825	97	0.18	10	970	868.5	1839	6480	sculpture	0.2837
1065	Grad Studio	300	6	0.18	10	60	54	114	490	sculpture	0.2327
1066	Tech Room	100	1	0.18	10	10	18	28	100	sculpture	0.28
1066	Undergrad Studio	300	6	0.18	10	60	54	114	590	sculpture	0.1932
1068	Grad Studio	300	6	0.18	10	60	54	114	225	sculpture	0.5067
1069	Grad Studio	250	5	0.18	10	50	45	95	225	sculpture	0.4222
1071	Grad Studio	175	4	0.18	10	40	31.5	72	135	sculpture	0.5296
1072	Grad Studio	300	6	0.18	10	60	54	114	225	sculpture	0.5067
1073	Grad Studio	280	6	0.18	10	60	50.4	110	225	sculpture	0.4907
1074	Grad Studio	280	6	0.18	10	60	50.4	110	225	sculpture	0.4907
1075	Undergrad Studio	280	6	0.18	10	60	50.4	110	225	sculpture	0.4907

Results

AHU-3/4 (cont.)

Room #	Use	Az	Pz	Ra	Rp	(Rp)(Pz)	(Ra)(Az)	Vbz	Vpz	ZONE	Zp
2047	Machine Room	500	10	0.18	10	100	90	190	1890	metals	0.1005
2048	Polishing & Grinding	230	5	0.18	10	50	41.4	91	400	metals	0.2285
2049	Corridor	260		0.06			15.6	16	650	metals	0.024
2050	Smithing/Casting	1280	26	0.18	10	260	230.4	490	2350	metals	0.2087
2051	Tool Room	365	7	0.18	10	70	65.7	136	250	metals	0.5428
2052	Grad Studio	805	18	0.18	10	180	144.9	325	2630	metals	0.1235
2053	Sophomore/Elect Studio	1070	24	0.18	10	240	192.6	433	3960	metals	0.1092
2054	Etching & Anodizing	355	7	0.18	10	70	63.9	134	815	metals	0.1643
2055	Office	160	2	0.06	5	10	9.6	20	125	metals	0.1568
2056	Office	160	2	0.06	5	10	9.6	20	125	metals	0.1568
2057	Junior/Senior Studio	615	11	0.18	10	110	110.7	221	1485	metals	0.1486
2058	Critique/Sem & Exposure	405	20	0.06	5	100	24.3	124	600	metals	0.2072
2059	CAD/CAM Lab	430	17	0.12	10	170	51.6	222	1285	metals	0.1725
2060	SD Printing	340	4	0.12	10	40	40.8	81	605	metals	0.1336
2061	Corridor	260		0.06			15.6	16	75	metals	0.208
2120	Office 2	165	1	0.06	5	5	9.9	15	100	printmaking	0.149
2121	Office 1	165	1	0.06	5	5	9.9	15	100	printmaking	0.149
2122	Grad Studio	400	8	0.18	10	80	72	152	830	printmaking	0.1831
2123	Grad Studio	400	8	0.18	10	80	72	152	830	printmaking	0.1831
2124	Grad Studio	400	8	0.18	10	80	72	152	830	printmaking	0.1831
2125	Grad Print Studio	640	13	0.18	10	130	115.2	245	1115	printmaking	0.2199
2126	Grad Studio	340	7	0.18	10	70	61.2	131	860	printmaking	0.1526
2127	Acid Room	240	5	0.18	10	50	43.2	93	590	printmaking	0.158
2128	Plate Cleaning	240	5	0.18	10	50	43.2	93	885	printmaking	0.1053
2129	Corridor	225		0.06			13.5	14	100	printmaking	0.135
2130	Chem Process Stone Graining	360	7	0.18	10	70	64.8	135	2000	printmaking	0.0674
2131	Tech Room	90		0.12			10.8	11	100	printmaking	0.108
2133	Comp. Lab	500	10	0.18	10	100	90	190	710	printmaking	0.2676
2134	Exposure	310	6	0.18	10	60	55.8	116	1720	printmaking	0.0673
2135	Emulsion Coating	115	2	0.18	10	20	20.7	41	345	printmaking	0.118
2136	Curating/Seminar/Critique	380	10	0.18	10	100	68.4	168	450	printmaking	0.3742
2137	Screenwash	200	4	0.18	10	40	36	76	680	printmaking	0.1118
2139	Screen Printing	1770	35	0.18	10	350	318.6	669	1020	printmaking	0.6555
2140	Corridor	360		0.06			21.6	22	565	printmaking	0.0382
2141	Etching/Relief Studio	1975	40	0.18	10	400	355.5	756	2350	printmaking	0.3215
2142	Lithography	1770	35	0.18	10	350	318.6	669	2655	printmaking	0.2518
2145	Print Corridor	830		0.06			49.8	50	600	printmaking	0.083

*No Critical Zp value because the unit is 100% OA.

Vps=ΣVpz	101185
Vot=Σvoz	23199

Conclusions

The results in this report show that five (5) of the seven (7) of the units comply with ASHRAE Standard 62.1 for the ventilation requirements.

	Calc. OA (CFM)	AHU		
		OA Min (CFM)	Supply Min	Supply Max
AHU-1	12,670	13,500	26,000	50,000
AHU-2	20,130	13,500	26,000	50,000
AHU-3/4	23,200	124,000	124,000	124,000
RTU-1	17,990	21,000	24,750	42,000
RTU-2	25,325	14,000	28,000	51,000
RTU-3	13,330	35,000	31,150	35,000

The design engineer of the Tyler School of Art used the International Mechanical Code 2003 for ventilation rates. A few of the CFM/Occupants and CFM/Areas differ between this code and the ASHRAE Standard which accounts for some of the variations. However, most of the discrepancies occur because of the localized exhaust in many of the rooms and a few spaces that were overdesigned.

The most critical space for AHU-2 is the sculpture room. The sculpture room is designed for 80% because it is assumed to be an art classroom. This boosts the ventilation requirements and it is possible that the function of the space would not require this high percentage of OA. The E_v for this room is 0.42 but if the next lowest E_v of 0.66 were used, the OA required would be lowered from 20,130 to 12,760 cfm. This would allow the air handlers to meet the OA requirements of ASHRAE Standard 62.1.

This is the same situation for the inconsistencies with the RTU-2 OA. The most critical space for RTU-2 is the 2nd floor north lobby as well as a few design studios. The lobby for RTU-2 is designed for almost 95% OA and the print studio is designed for 90% OA. The other most critical spaces are the 60% OA studios. If the E_v of the 60% OA space was used as opposed to the 90% space, once again the ventilation requirements of ASHRAE 62.1 would be met.

These spaces might be artificially high to account for exhaust that will be transfer ducted to other spaces. However, these few spaces could easily have altered occupancy and space requirements that could cause the difference between the calculated and the actual OA provided by the AHUs. By lowering the outdoor air requirements only slightly to the 2nd most critical space(s), the problem corrects itself. These critical spaces will be reevaluated to determine if the occupancy categories and densities of ASHRAE Standard 62.1 Table 6-1 meet the space needs.

Conclusions

ASHRAE 62.1: Minimum Exhaust Rates

AHU-3, AHU-4, and RTU-3 are all 100% outdoor air units. However, the calculated outdoor air quantity is much less than is indicated by the respective air handling units. This discrepancy occurs because of the large amount of additional air that is brought into the space because of the individual exhaust hoods in all the studios. The minimum exhaust rates required by ASHRAE 62.1 for art classrooms/studios is 0.70 cfm/ft² as indicated by Table 6-4. Using this rate and any that apply to other occupancy categories in these spaces, the minimum exhaust rate summary is as follows:

	Calc. OA	Exhaust CFM	Total CFM
AHU-3/4	23,000	32,945	55,945
RTU-3	13,330	10,515	23,845

This table gives a little better idea of the 100% supply air entering these spaces. This exhaust is only a minimum value and would actually be much higher once areas like bathrooms, electrical rooms, and any other closets and equipment rooms are considered.

ASHRAE 62.1 Sect. 5 – Systems & Equipment Summary

Airstream Surfaces

The ductwork is resistant to both mold growth and erosion because the entire duct is constructed of sheet metal.

Exhaust Duct Location

All the exhaust ducts are located in spaces that could have harmful contaminants are negatively pressurized. This applies to mainly studio areas, bathrooms, electrical rooms, storage rooms, mechanical rooms, and janitors’ closets.

Outdoor Air Intakes

The outdoor air intakes are located on the inner courtyard of the building for the basement air handlers. All the exhaust is on the roof or wall mounted on the street sides of the Tyler School of Art. The outdoor air intakes on the RTUs are an adequate distance away from all the roof-mounted exhaust. The distance requirements for the building’s air intakes from ASHRAE 62.1 Table 5-1 are listed below:

	Min. Dist. (ft)	Complies w/ ASHRAE 62.1
Significantly contaminated exhaust	15	Yes
Noxious or dangerous exhaust	30	Yes
Vents, chimneys, and flues from combustion appliances and equip.	15	Yes
Garage entry, automobile loading area, and drive-in areas	15	Yes
Truck loading area or dock	25	Yes
Driveway, street, or parking place	5	Yes
High traffic volume	25	Yes
Roof, landscaped grade, or surface directly below intake	1	Yes
Garbage storage/pick-up area	15	Yes
Cooling tower intake or basin	15	Yes
Cooling tower exhaust	25	Yes

Access for Inspection, Cleaning, and Maintenance

All the equipment spaces are designed to allow for clearance and access for inspection, cleaning, and maintenance. The custom AHUs in the basement and the RTUs were all designed to with the required access doors and panels.

Building Envelope

The building envelope is adequate to prevent penetration through the walls and into the building. There is a vapor barrier on the inside of the exterior wall air space which prevents this penetration. In reference to interior spaces, the cold water piping is all required to have a 1½” insulation to prevent condensation from leaking.

ASHRAE 62.1 Sect. 5 – Systems & Equipment Summary

Air Classification and Recirculation

The critical spaces in any art education building would be the studios. The air classification of these studios would be categorized as laboratory hoods in air class 4 of Table 5-2 of ASHRAE 62.1. This air class is considered potentially dangerous because of the VOCs that are produced from some of the art chemicals. The Tyler School of Art has direct roof exhaust in all of these studios and none of the air gets transfer ducted to other spaces or recirculated back into the ventilation system.

Environmental Tobacco Smoke

As stated in the assumptions section above, the Tyler School is entirely smoke free. Therefore, no additional exhaust, recirculation, and space pressurization needs to be considered.

References

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