

The Ed Roberts Campus

Technical Report 1

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Mechanical Option

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Executive Summary

This technical report is designed to evaluate compliance with the 2013 editions of ASHRAE 62.1 and ASHRAE 90.1. ASHRAE 62.1 is a standard for ventilation and indoor air quality (IAQ), while ASHRAE 90.1 is a standard for energy use in buildings. The building being evaluated in this report is the Ed Roberts Campus, an education and community center in Berkeley, CA with a focus on supporting Americans with disabilities.

The ERC was evaluated against ASHRAE 62.1 Ventilation for Acceptable Indoor Air Quality and found to be in compliance. All systems and equipment was compared to the requirements in Section 5 and, where appropriate information was available, were found to meet the standard. The ventilation loads were calculated per procedures in Section 6 and compared to the capacities of the Outdoor Air system and found to be well above requirements.

The ERC was then compared to ASHRAE 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings and found to be in general compliance. The building envelope was compared to the requirements in Section 5 of the standard and was compliant in most areas as information was available. Section 6, on HVAC equipment and efficiency, was also evaluated and the building was compliant in all applicable areas of the standard.

Note: Due to issues with AutoCAD files sent by the architect, specific information on many construction details and materials is not available. Several sections in the ASHRAE standards 62.1 and 90.1 require material details that are unavailable at this time. Assumptions were made throughout the report as necessary and when appropriate.

Building Overview

The Ed Roberts Campus is a 2-story, 80,000 sq. ft., transit-oriented community center located in downtown Berkeley, California. The campus is connected to a BART Station (Bay Area Rapid Transit) and is designed with a focus on accessibility for people with disabilities. Completed in 2011, the ERC is home to exhibition spaces, meeting spaces, a child development center, a fitness center, vocational training facilities, and offices.

Every square foot of the building is designed far and above the requirements of the Americans with Disabilities Act through a design concept called “Universal Design”. Universal Design aims to create environments that are useful for people of all ages and abilities without additional cost. Extra-wide corridors, automatic doors, two-sided elevators are examples of this design ideal. In addition, the ERC’s fully accessible connection to the BART station works to connect people directly to airports and bus stations around the city.



Leddy Maytum Stacy Architects

Mechanical Systems Overview

The Ed Roberts Campus combines several system types to heat and cool the building. The building is served by five rooftop air handling units (AHUs):

AHU-1: East Wing – South

AHU-2: B.O.R.P.

AHU-3: West Wing – South

AHU-4: West Wing – North

AHU-5: Covered Court

AHUs 1, 3, and 4 are constant volume units with 100% outdoor air. AHU 2 is a VAV unit with 100% outdoor air that operates in tandem with AHU 1. AHU 5 is a Variable Air Volume (VAV), packaged air cooled DX cooling unit. Each AHU is equipped with a supply fan only. There are also water-source heat pumps for additional heating and cooling to meet the needs of each individual zone within the building.

The building has four roof-mounted fans that serve general exhaust needs (EF-3, EF-4, EF-5, and EF-7) with 1,200 cfm, 1,000 cfm, 800 cfm, and 1,600 cfm respectively. In addition, there are four more roof-mounted fans that serve specific areas. EF-1 serves the BORP with 5,500 cfm of exhaust, EF-2 serves the restrooms with 2,600 cfm, EF-6 serves the garage with 72,000 cfm, and EF-9 serves the BART elevator room with 1,200 cfm. The garbage room has a smaller wall mounted fan that exhausts 350 cfm for that space.

In addition to these air systems, the ERC utilizes a radiant floor system which serves three zones: the entrance lobby, art exhibition space, and covered court area. Altogether, the system provides 115 MBH of cooling (9.6 tons) and 68 MBH of heating (5.6 tons).

ASHRAE 62.1 Evaluation

Section 5: Systems and Equipment

5.1 Ventilation Air Distribution

The Ed Roberts Campus is designed to meet the criteria set out in section 5.1. The system is designed for air balancing, and the specifications describe plans for testing and verification of balancing throughout the entire air system. The building directly connects ventilation air to terminal units in the space, and so complies with the plenum system sub-section. The drawings specify all minimum ventilation rates.

5.2 Exhaust Duct Location

Exhaust air ducts are located throughout the building to funnel air directly from the space out about the roof. Negative pressurization ensures that contaminants do not re-enter the space. The building has four roof-mounted fans that serve general exhaust needs (EF-3, EF-4, EF-5, and EF-7) with 1,200 cfm, 1,000 cfm, 800 cfm, and 1,600 cfm respectively. In addition, there are four more roof-mounted fans that serve specific areas. EF-1 serves the BORP with 5,500 cfm of exhaust, EF-2 serves the restrooms with 2,600 cfm, EF-6 serves the garage with 72,000 cfm, and EF-9 serves the BART elevator room with 1,200 cfm. The garbage room has a smaller wall mounted fan that exhausts 350 cfm for that space.

5.3 Ventilation System Controls

The entire HVAC system is interfaces with a real-time, 12-bit, digital control system to ensure proper operation of all related systems.

5.4 Air Stream Surfaces

All ductwork is specified as sheet metal and connected with metal fasteners, and complies with section 5.4.

5.5 Outdoor Air Intakes

The drawings indicate that outdoor air intakes are located such that they meet the separation requirements set out in Table 5.5.1 in ASHRAE 62.1. The table requires at least 10 feet separation from any Class 2 exhaust outlet, and each air intake exceeds this requirement. Additionally, each outdoor air intake is equipped with a weatherproof hood to meet the requirements of sections 5.5.2 – 5.5.4 for rain and snow. Each AHU is equipped with a bird screen to meet the requirements in section 5.5.5.

5.6 Local Capture of Contaminants

The building captures discharge from contaminant generating equipment and vents it directly outdoors, in compliance with section 5.6.

5.7 Combustion Air

The ERC does not utilize any combustion equipment for its heating requirements, and therefore the requirements in section 5.7 are not applicable. Refer to the Mechanical System Overview.

5.8 Particulate Matter Removal

The building is outfitted with a combination filter that meets the requirement in section 5.8. The filters specified are a 2-inch MERV 6 pre-filter followed by a 12-inch MERV 14 final stage filter, thus exceeding the requirement of a MERV 8 filter.

5.9 Dehumidification Systems

The ERC does not utilize and air washers or water-spray systems, and thus section 5.9 is not applicable.

5.10 Drain Pans

All drain pans are installed to meet the requirements set out in sections 5.10.1-5.10.4 and so comply with 5.10.

5.11 Finned-Tube Coils and Heat Exchangers

All equipment is installed with drain pans and adequate maintenance/cleaning access, and thus complies with section 5.11.

5.12 Humidifiers and Water-Spray Systems

The ERC does not utilize any water-spray or air washing equipment, and thus section 5.12 is not applicable.

5.13 Access for Inspection, Cleaning, and Maintenance

All ventilation equipment has sufficient clearance and access for maintenance, per sections 5.13.1 and 5.13.2, and these areas are clearly marked on plan. All air distribution systems also have sufficient access for maintenance. The ERC is compliant with section 5.13.

5.14 Building Envelope and Interior Surfaces

Without architectural details available, the exact specifications of vapor barriers and other envelope elements cannot be found. However, this mechanical detail shows some detail of the roof construction and refers to flashing used to prevent water penetration. It can be assumed that these types of water barriers would be in place throughout the building envelope. For compliance with 5.14.2 Condensation on Interior Surfaces, the mechanical specifications, require that all ductwork be installed with Kraft paper reinforced with glass fiber to serve as a vapor barrier jacket and prevent condensation.

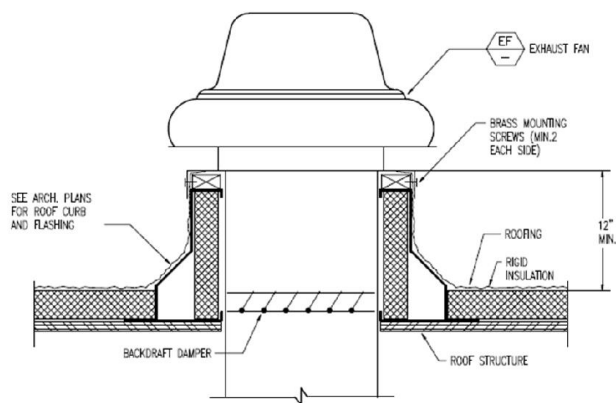


Figure 1 - Mechanical Roof Detail

5.15 Buildings with Attached Parking Garage

The garage space in the basement is isolated from the occupied space by a floor, and the air is directly exhausted to the roof via Exhaust Fan 6. This meets requirements set out in section 5.15.

5.16 Air Classification and Recirculation

All air within the building is classified as Class 2 or Class 1, and thus is approved for recirculation. However, the 100% OA system does not recirculate any air, so all air is immediately exhausted to the outside of the building. The ERC is compliant with section 5.16.

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

The ERC has been designed with the intention of maintaining high IAQ for occupants with chemical sensitivities, and is entire ETS-free. Therefore section 5.17 does not apply.

Section 6: Procedures

6.1 General

The ERC is able to use outdoor air for ventilation purposes and thus the Ventilation Rate Procedure in section 6.2 and the Exhaust Rate Procedure in section 6.5 can be used to evaluate compliance with this section of ASHRAE 62.1. The Natural Ventilation Procedure in section 6.4 is not applicable to this building.

6.2 Ventilation Rate Procedure

The first step in the procedure is to determine the outdoor airflow required in the breathing zone, as outlined in section 6.2.2.1. Breathing zone outdoor airflow (V_{bz}) should be greater than the value obtained by the following equation:

$$V_{bz} = R_p \times P_z + R_a \times A_z$$

A_z = zone floor area, the net occupiable floor area of the ventilation zone [sq. ft.]

P_z = zone population, the number of people in the ventilation zone during typical usage [people]

R_p = outdoor airflow rate required per person as determined from Table 6.2.2.1 [cfm/person]

R_a = outdoor airflow rate required per unit area as determined from Table 6.2.2.1 [cfm/sq ft]

To determine the required zone outdoor air flow (V_{Oz}) to be provided by the supply air system, use the equation in section 6.2.2.3.

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

E_z is the Zone Air Distribution effectiveness and can be determined in Table 6.2.2.2, which is available in the appendices. The outdoor air intake flow (V_{ot}) can be determined with the following equation from section 6.2.4 for 100% Outdoor Air Systems.

$$V_{ot} = \sum_{all\ zones} V_{Oz}$$

The resulting air flows for each zone within the ERC are tabulated in an Excel spreadsheet in Appendix A.

A summary of the results for each AHU can be found in the table below (Table 1).

Note: The current mechanical system does not service the unleased areas of the building, but dedicates airflow for future expansion. A total of 2,270 cfm of future expansion airflow is included in the Total Outside Air of AHU-3.

Table 1- AHU Supplied Ventilation Air Rates

AHU	Design CFM	Outside Air %	Total Outside Air	62.1 Required Outdoor Air	Compliance
AHU-1	7,800	100	7,800	3388.94	Yes
AHU-2	5,500	100	5,500	513.18	Yes
AHU-3	3,500	100	3,500	999.67	Yes
AHU-4	6,000	100	6,000	1780.92	Yes
AHU-5	5,000	100	5,000	1178	Yes

Note: AHU-2 and AHU-5 are Variable Air Volume AHUs, but were calculated as 100% outdoor air units, with the assumption that they would never be allowed to drop below the required ventilation air flow.

ASHRAE 62.1 Conclusion

This section of the report analyzed the existing mechanical components and their ventilation performance per ASHRAE 62.1. The entire building was evaluated against section 5 of the standard, System and Equipment, and all five AHUs were evaluated against the prescriptive ventilation rate procedures of section 6.

In summary, the Ed Roberts Campus meets the criteria laid out by ASHRAE 62.1 Ventilation for Acceptable Indoor Air Quality and, in some cases, exceeds the standard significantly. All criteria in section 5 were met with the proper measures being taken to prevent contamination, mold growth, and rain entrainment, as well as many others. Due to the use of a 100% Outdoor Air system, the building easily met the ventilation outdoor requirements laid out in Section 6.

ASHRAE 90.1 Evaluation

Section 5: Building Envelope

5.1.4 Climate

The Ed Roberts Campus is located in Berkeley, California, in the San Francisco Bay Area, and is classified as Climate Zone 3C.

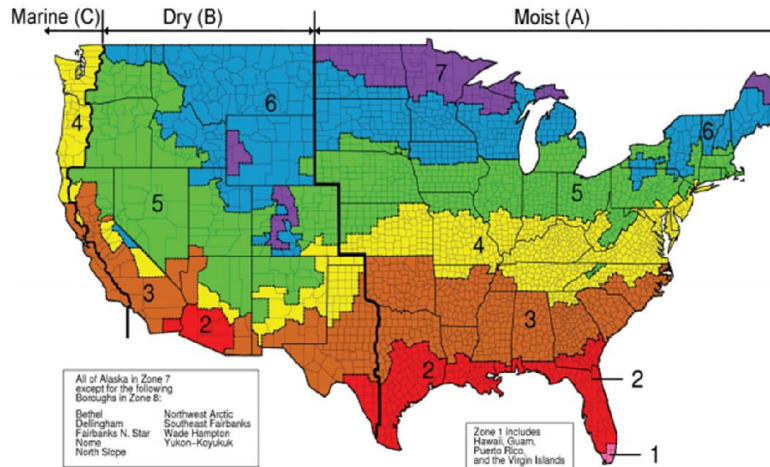


Figure 2 - ASHRAE 90.1 Climate Zones

5.2 Compliance Paths

The ERC will be evaluated against the mandatory provisions laid out by ASHRAE 90.1 in sections 5.1, 5.4, 5.7, and 5.8. The building will also be evaluated against the “Prescriptive Building Envelope Option” in section 5.5 of the standard.

5.4 Mandatory Provisions

Note: Due to issues with AutoCAD files sent by the architect, specific information on wall and roof details and materials. Some basic information on materials and construction is given in the mechanical details and those details will be used to make assumptions about walls throughout the building. Referenced mechanical details can be found in Appendix B.

Section 5.4.3.1 specifies allowed wall constructions in order to meet air leakage criteria. It can be assumed that proper construction techniques were used to seal joints. Wall assemblies, according to mechanical section drawings, are generally made up of one to two layers of Nom. 5/8” Gypsum board, rigid insulation, Nom. 4” wood or metal studs, and exterior cladding. These constructions will most likely be compliant with section 5.4.3.1. Section 5.4.3.4 specifies allowed leakage and construction of doorways. The main entrance of the building does not use a vestibule, as recommended, but opens directly into the conditioned lobby space. In Climate Zone 3C the door is not allowed to open to a conditioned space of more than 10,000 sq. ft. (exception 5), but the sliding door opens into a two-level lobby and courtyard area totaling roughly 18,000 sq. ft. Therefore, the building does not meet this criteria.

5.5 Prescriptive Building Envelope Option

This section details the required thermal insulation values for different building envelope assemblies, specific for each climate zone. For the ERC, the maximum allowable U-Values for assemblies are listed in the following table.

Table 2 - ASHRAE 90.1 Assembly U-Values

Type	ASHRAE 90.1 U-Value
Wall	0.077 (Steel Frame) 0.089 (Wood Frame)
Below-Grade Wall	1.140
Roof	0.039
Slab	0.074
Window	0.60

Specific information about materials is unavailable, so the precise U-Value of these assemblies cannot be calculated and specific compliance with the rest of section 5.5 is unknown. The lack of architectural elevations means that fenestration area cannot be calculated and evaluated against the 40% wall area standard. One requirement in this section that can be confirmed is the skylight requirement. Section 5.5 requires that less than 6% of the roof area be made up of skylights. The lobby area skylight is roughly 1000 sq. ft., which is far less than 6% of the approx. 40,000 sq. ft. roof.

Section 6: Heating, Ventilating, and Air Conditioning

6.2 Compliance Paths

Compliance with section 6 can be achieved by meeting the requirements in Sections 6.1, 6.7, and 6.8. In addition, the ERC is too large to be evaluated against Section 6.3: Simplified Approach Option, and so will be compared to the requirements in Section 6.4: Mandatory Provisions.

6.4 Mandatory Provisions

This section specifies that the minimum recommended efficiencies in section 6.8 for mechanical equipment in the building must be met for compliance with the mandatory provisions. All mechanical equipment is specified and labeled according to the requirement. The control system capabilities are adequate to meet the off-hour control requirements. The enclosed parking garage in the basement is less than 30,000 sq. ft. and therefore does not require mechanical cooling or heating, but is serviced by a large exhaust air system. The building's HVAC system is controlled by a Direct Digital Control system, as required for a new building of its type, and controls all aspects of temperature, energy, and alarm monitoring. All ductwork is insulated, sealed to prevent leakage, and is tested under high pressure conditions according to specifications. All HVAC piping must be sufficiently insulated per the mechanical specifications. Mechanical details show insulation to indicate compliance with 6.4.4.1.5 Radiant Floor Heating. The building is in compliance with 6.5 Mandatory Provisions.

6.8 Minimum Equipment Efficiency Tables

In Table 6.8.1-2, the minimum efficiencies are specified for water to air, water loop, cooling mode heat pumps. The efficiency data of the water source heat pumps that provide zone cooling and heating is provided in the mechanical schedules. For these heat pumps, which vary in capacity, the minimum efficiency is 12.2 EER for <17,000 Btu/h capacities and 13.0 EER for >17,000 Btu/h and <65,000 Btu/h. According to the schedule, all units operate at efficiencies greater than these listed minimums. Table 6.8.1-2 is located in Appendix B for reference.

ASHRAE 90.1 Conclusion

The ERC was evaluated against ASHRAE 90.1 and found to be in compliance with the Building Envelope and Heating, Ventilating, and Air Conditioning Sections. All elements of the envelope, such as air leakage and envelope assemblies, were found to match the standard or were assumed to match based on the information available at the present. The building was also evaluated against the Prescriptive option for insulation efficiency, but sufficient information was not available to make a definitive conclusion on compliance with the standard. Finally, the HVAC systems were evaluated against the mandatory provisions and minimum efficiencies in Section 6, and found to be in compliance with 90.1.

References

ANSI/ASHRAE. 2013. *Standard 62.1-2013, Ventilation for Acceptable Indoor Air Quality.*

Atlanta, GA. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

ANSI/ASHRAE/IES. 2013. *Standard 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential*

Buildings. Atlanta, GA. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

Appendix A: Calculations

Note: Zone areas and occupancies are based on ventilation rate tables published in the mechanical drawings. These zones are based on heat pump zones, so while the table includes all building area (except unleased spaces) it is not grouped by room. ASHRAE 62.1 Room Types were based on general purpose of each zone.

Table 3 – ASHRAE 62.1 Ventilation Rate Calculations

Figure 3 - 62.1 Ventilation Rate Calculations

Zone Information			ASHRAE 62.1 Requirements			Calculated Ventilation Rates		
Zone Number	Zone Area (Az)	Zone Occupancy (Pz)	Room Type	OA Flow Rate/Sq. Ft. (Ra)	OA Flow/Person (Rp)	Breathing Zone OA Flow (Vbz)	Zone Air Distribution Effectiveness (Ez)	Zone OA Flow (Voz)
AHU-1 - East Wing South								
120-1	583	5.8	Office Space	0.06	5	63.98	1	63.98
120-2	942	9.4	Office Space	0.06	5	103.52	1	103.52
120-3	780	7.8	Office Space	0.06	5	85.8	1	85.8
125-1 E	1800	36	Classroom (5-8,9+)	0.12	10	576	1	576
125-2 E	1800	36	Classroom (5-8,9+)	0.12	10	576	1	576
126 Meeting	1533	51	Meeting Room	0.06	5	346.98	1	346.98
215-1 E	650	6.5	Office Space	0.06	5	71.5	1	71.5
215-2	2234	22.3	Lecture Classroom	0.06	7.5	301.29	1	301.29
215-4E	690	6.9	Office Space	0.06	5	75.9	1	75.9
214A-1	754	7.6	Office Space	0.06	5	83.24	1	83.24
214A-2	2520	25.2	Office Space	0.06	5	277.2	1	277.2
214A-3 E	1178	11.8	Office Space	0.06	5	129.68	1	129.68
TOILETS	378	3.7	Restroom	0.18	7.5	95.79	1	95.79
220 Boardroom	751	25	Meeting Room	0.06	5	170.06	1	170.06
218-1	1625	16.2	Meeting Room	0.06	5	178.5	1	178.5
218-2 E	1310	13.2	Office Space	0.06	5	144.6	1	144.6
E229 Telecom	37	0.4	Telephone Closet	0	0	0	1	0
B-Electrical	379	3.8	Electrical Closet	0	0	0	1	0
215-3 E	990	9.9	Office Space	0.06	5	108.9	1	108.9
Total Outdoor Air Intake (Vot)								3388.94
AHU-2 - BORP								
BORP	3803	38	Multiuse Assembly	0.06	7.5	513.18	1	513.18
Total Outdoor Air Intake (Vot)								513.18

Figure 4 - 62.1 Ventilation Rate Calculations (contintued)

Zone Information			ASHRAE 62.1 Requirements			Calculated Ventilation Rates		
Zone Number	Zone Area (Az)	Zone Occupancy (Pz)	Room Type	OA Flow Rate/Sq. Ft. (Ra)	OA Flow/Person (Rp)	Breathing Zone OA Flow (Vbz)	Zone Air Distribution Effectiveness (Ez)	Zone OA Flow (Voz)
AHU-3 - West Wing South								
BMPOE	250	2.5		0	0	0	1	0
E138 Telecom	92	0.9	Telephone Closet	0	0	0	1	0
127 Kitchen	207	2.1	Kitchen	0.12	7.5	40.59	1	40.59
111-1	256	1	Office Space	0.06	5	20.36	1	20.36
111-2	665	2	Meeting Room	0.06	5	49.9	1	49.9
111-3	386	1	Office Space	0.06	5	28.16	1	28.16
110-1E	1270	12.7	Office Space	0.06	5	139.7	1	139.7
110-2	3886	38.8	Multiuse Assembly	0.06	7.5	524.16	1	524.16
110-3 E	1200	12	Office Space	0.06	5	132	1	132
110-4 E	480	4.8	Multiuse Assembly	0.06	7.5	64.8	1	64.8
Total Outdoor Air Intake (Vot)								999.67
AHU-4 - West Wing North								
B-Elev	112	1.2		0	0	0	1	0
ART	1259	63	Museum/Gallery	0.06	7.5	548.04	1	548.04
LOBBY	2037	101.8	Lobbies	0.06	5	631.22	1	631.22
RECEPTION	473	23.6	Reception	0.06	5	146.38	1	146.38
BUILDING OFFICE	377	3.8	Office Space	0.06	5	41.62	1	41.62
213-1	467	4.7	Meeting Room	0.06	5	51.52	1	51.52
213-2	1720	17.2	Office Space	0.06	5	189.2	1	189.2
213-3 E	405	4.1	Office Space	0.06	5	44.8	1	44.8
213-4 E	844	8.4	Office Space	0.06	5	92.64	1	92.64
225	325	3.2	Office Space	0.06	5	35.5	1	35.5
E124 Telecom	40	0.4	Telephone Closet	0	0	0	1	0
E224 Telecom	27	0.4	0	0	0	0	1	0
Total Outdoor Air Intake (Vot)								1780.92
AHU-5 - Covered Court								
COVERED COURT	3800	190	Lobbies	0.06	5	1178	1	1178
Total Outdoor Air Intake (Vot)								1178

Appendix B: Reference Tables

TABLE 6.2.2.1 Minimum Ventilation Rates in Breathing Zone
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values			Air Class	
	cfm/person	L/s-person	cfm/ft ²	L/s-m ²		Occupant Density (see Note 4)		Combined Outdoor Air Rate (see Note 5)		
						#/1000 ft ² or #/100 m ²		cfm/person		L/s-person
Correctional Facilities										
Cell	5	2.5	0.12	0.6		25		10	4.9	2
Dayroom	5	2.5	0.06	0.3		30		7	3.5	1
Guard stations	5	2.5	0.06	0.3		15		9	4.5	1
Booking/waiting	7.5	3.8	0.06	0.3		50		9	4.4	2
Educational Facilities										
Daycare (through age 4)	10	5	0.18	0.9		25		17	8.6	2
Daycare sickroom	10	5	0.18	0.9		25		17	8.6	3
Classrooms (ages 5–8)	10	5	0.12	0.6		25		15	7.4	1
Classrooms (age 9 plus)	10	5	0.12	0.6		35		13	6.7	1
Lecture classroom	7.5	3.8	0.06	0.3		65		8	4.3	1
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3		150		8	4.0	1
Art classroom	10	5	0.18	0.9		20		19	9.5	2
Science laboratories	10	5	0.18	0.9		25		17	8.6	2
University/college laboratories	10	5	0.18	0.9		25		17	8.6	2
Wood/metal shop	10	5	0.18	0.9		20		19	9.5	2
Computer lab	10	5	0.12	0.6		25		15	7.4	1
Media center	10	5	0.12	0.6	A	25		15	7.4	1
Music/theater/dance	10	5	0.06	0.3		35		12	5.9	1
Multiuse assembly	7.5	3.8	0.06	0.3		100		8	4.1	1
Food and Beverage Service										
Restaurant dining rooms	7.5	3.8	0.18	0.9		70		10	5.1	2
Cafeteria/fast-food dining	7.5	3.8	0.18	0.9		100		9	4.7	2
Bars, cocktail lounges	7.5	3.8	0.18	0.9		100		9	4.7	2
Kitchen (cooking)	7.5	3.8	0.12	0.6		20		14	7.0	2
General										
Break rooms	5	2.5	0.06	0.3		25		7	3.5	1

GENERAL NOTES FOR TABLE 6.2.2.1

- 1 Related requirements:** The rates in this table are based on all other applicable requirements of this standard being met.
- 2 Environmental Tobacco Smoke:** This table applies to ETS-free areas. Refer to Section 5.17 for requirements for buildings containing ETS areas and ETS-free areas.
- 3 Air density:** Volumetric airflow rates are based on an air density of 0.075 lb_{air}/ft³ (1.2 kg_{air}/m³), which corresponds to dry air at a barometric pressure of 1 atm (101.3 kPa) and an air temperature of 70°F (21°C). Rates may be adjusted for actual density but such adjustment is not required for compliance with this standard.
- 4 Default occupant density:** The default occupant density shall be used when actual occupant density is not known.
- 5 Default combined outdoor air rate (per person):** This rate is based on the default occupant density.
- 6 Unlisted occupancies:** If the occupancy category for a proposed space or zone is not listed, the requirements for the listed occupancy category that is most similar in terms of occupant density, activities, and building construction shall be used.

ITEM-SPECIFIC NOTES FOR TABLE 6.2.2.1

- A** For high-school and college libraries, use values shown for Public Assembly Spaces—Libraries.
- B** Rate may not be sufficient when stored materials include those having potentially harmful emissions.
- C** Rate does not allow for humidity control. Additional ventilation or dehumidification may be required to remove moisture. “Deck area” refers to the area surrounding the pool that would be expected to be wetted during normal pool use, i.e., when the pool is occupied. Deck area that is not expected to be wetted shall be designated as a space type (for example, “spectator area”).
- D** Rate does not include special exhaust for stage effects, e.g., dry ice vapors, smoke.
- E** When combustion equipment is intended to be used on the playing surface or in the space, additional dilution ventilation and/or source control shall be provided.
- F** Default occupancy for dwelling units shall be two persons for studio and one-bedroom units, with one additional person for each additional bedroom.
- G** Air from one residential dwelling shall not be recirculated or transferred to any other space outside of that dwelling.

TABLE 6.2.2.1 Minimum Ventilation Rates in Breathing Zone (Continued)
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values			Air Class
	cfm/person	L/s-person	cfm/ft ²	L/s-m ²		Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
						#/1000 ft ² or #/100 m ²	cfm/person	L/s-person	
Coffee stations	5	2.5	0.06	0.3		20	8	4	1
Conference/meeting	5	2.5	0.06	0.3		50	6	3.1	1
Corridors	—	—	0.06	0.3		—			1
Occupiable storage rooms for liquids or gels	5	2.5	0.12	0.6	B	2	65	32.5	2
Hotels, Motels, Resorts, Dormitories									
Bedroom/living room	5	2.5	0.06	0.3		10	11	5.5	1
Barracks sleeping areas	5	2.5	0.06	0.3		20	8	4.0	1
Laundry rooms, central	5	2.5	0.12	0.6		10	17	8.5	2
Laundry rooms within dwelling units	5	2.5	0.12	0.6		10	17	8.5	1
Lobbies/prefunction	7.5	3.8	0.06	0.3		30	10	4.8	1
Multipurpose assembly	5	2.5	0.06	0.3		120	6	2.8	1
Office Buildings									
Breakrooms	5	2.5	0.12	0.6		50	7	3.5	1
Main entry lobbies	5	2.5	0.06	0.3		10	11	5.5	1
Occupiable storage rooms for dry materials	5	2.5	0.06	0.3		2	35	17.5	1
Office space	5	2.5	0.06	0.3		5	17	8.5	1
Reception areas	5	2.5	0.06	0.3		30	7	3.5	1
Telephone/data entry	5	2.5	0.06	0.3		60	6	3.0	1
Miscellaneous Spaces									
Bank vaults/safe deposit	5	2.5	0.06	0.3		5	17	8.5	2
Banks or bank lobbies	7.5	3.8	0.06	0.3		15	12	6.0	1
Computer (not printing)	5	2.5	0.06	0.3		4	20	10.0	1

GENERAL NOTES FOR TABLE 6.2.2.1

- 1 Related requirements:** The rates in this table are based on all other applicable requirements of this standard being met.
- 2 Environmental Tobacco Smoke:** This table applies to ETS-free areas. Refer to Section 5.17 for requirements for buildings containing ETS areas and ETS-free areas.
- 3 Air density:** Volumetric airflow rates are based on an air density of 0.075 lb_m/ft³ (1.2 kg_m/m³), which corresponds to dry air at a barometric pressure of 1 atm (101.3 kPa) and an air temperature of 70°F (21°C). Rates may be adjusted for actual density but such adjustment is not required for compliance with this standard.
- 4 Default occupant density:** The default occupant density shall be used when actual occupant density is not known.
- 5 Default combined outdoor air rate (per person):** This rate is based on the default occupant density.
- 6 Unlisted occupancies:** If the occupancy category for a proposed space or zone is not listed, the requirements for the listed occupancy category that is most similar in terms of occupant density, activities, and building construction shall be used.

ITEM-SPECIFIC NOTES FOR TABLE 6.2.2.1

- For high-school and college libraries, use values shown for Public Assembly Spaces—Libraries.
- Rate may not be sufficient when stored materials include those having potentially harmful emissions.
- Rate does not allow for humidity control. Additional ventilation or dehumidification may be required to remove moisture. "Deck area" refers to the area surrounding the pool that would be expected to be wetted during normal pool use, i.e., when the pool is occupied. Deck area that is not expected to be wetted shall be designated as a space type (for example, "spectator area").
- Rate does not include special exhaust for stage effects, e.g., dry ice vapors, smoke.
- When combustion equipment is intended to be used on the playing surface or in the space, additional dilution ventilation and/or source control shall be provided.
- Default occupancy for dwelling units shall be two persons for studio and one-bedroom units, with one additional person for each additional bedroom.
- Air from one residential dwelling shall not be recirculated or transferred to any other space outside of that dwelling.

TABLE 6.2.2.1 Minimum Ventilation Rates in Breathing Zone (Continued)
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values			Air Class
	cfm/person	L/s-person	cfm/ft ²	L/s-m ²		Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
						#/1000 ft ² or #/100 m ²	cfm/person	L/s-person	
Freezer and refrigerated spaces (<50°F)	10	5	0	0	E	0	0	0	2
General manufacturing (excludes heavy industrial and processes using chemicals)	10	5.0	0.18	0.9		7	36	18	3
Pharmacy (prep. area)	5	2.5	0.18	0.9		10	23	11.5	2
Photo studios	5	2.5	0.12	0.6		10	17	8.5	1
Shipping/receiving	10	5	0.12	0.6	B	2	70	35	2
Sorting, packing, light assembly	7.5	3.8	0.12	0.6		7	25	12.5	2
Telephone closets	—	—	0.00	0.0		—			1
Transportation waiting	7.5	3.8	0.06	0.3		100	8	4.1	1
Warehouses	10	5	0.06	0.3	B	—			2
Public Assembly Spaces									
Auditorium seating area	5	2.5	0.06	0.3		150	5	2.7	1
Places of religious worship	5	2.5	0.06	0.3		120	6	2.8	1
Courtrooms	5	2.5	0.06	0.3		70	6	2.9	1
Legislative chambers	5	2.5	0.06	0.3		50	6	3.1	1
Libraries	5	2.5	0.12	0.6		10	17	8.5	1
Lobbies	5	2.5	0.06	0.3		150	5	2.7	1
Museums (children's)	7.5	3.8	0.12	0.6		40	11	5.3	1
Museums/galleries	7.5	3.8	0.06	0.3		40	9	4.6	1
Residential									
Dwelling unit	5	2.5	0.06	0.3	F,G	F			1
Common corridors	—	—	0.06	0.3					1

GENERAL NOTES FOR TABLE 6.2.2.1

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- 2 Environmental Tobacco Smoke:** This table applies to ETS-free areas. Refer to Section 5.17 for requirements for buildings containing ETS areas and ETS-free areas.
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TABLE 6.2.2.1 Minimum Ventilation Rates in Breathing Zone (Continued)
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Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values			Air Class
	cfm/person	L/s-person	cfm/ft ²	L/s-m ²		Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
						#/1000 ft ² or #/100 m ²	cfm/person	L/s-person	
Retail									
Sales (except as below)	7.5	3.8	0.12	0.6		15	16	7.8	2
Mall common areas	7.5	3.8	0.06	0.3		40	9	4.6	1
Barbershop	7.5	3.8	0.06	0.3		25	10	5.0	2
Beauty and nail salons	20	10	0.12	0.6		25	25	12.4	2
Pet shops (animal areas)	7.5	3.8	0.18	0.9		10	26	12.8	2
Supermarket	7.5	3.8	0.06	0.3		8	15	7.6	1
Coin-operated laundries	7.5	3.8	0.12	0.6		20	14	7.0	2
Sports and Entertainment									
Gym, sports arena (play area)	20	10	0.18	0.9	E	7	45	23	2
Spectator areas	7.5	3.8	0.06	0.3		150	8	4.0	1
Swimming (pool & deck)	—	—	0.48	2.4	C	—			2
Disco/dance floors	20	10	0.06	0.3		100	21	10.3	2
Health club/aerobics room	20	10	0.06	0.3		40	22	10.8	2
Health club/weight rooms	20	10	0.06	0.3		10	26	13.0	2
Bowling alley (seating)	10	5	0.12	0.6		40	13	6.5	1
Gambling casinos	7.5	3.8	0.18	0.9		120	9	4.6	1
Game arcades	7.5	3.8	0.18	0.9		20	17	8.3	1
Stages, studios	10	5	0.06	0.3	D	70	11	5.4	1

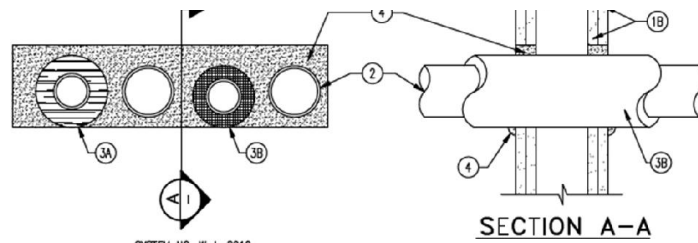
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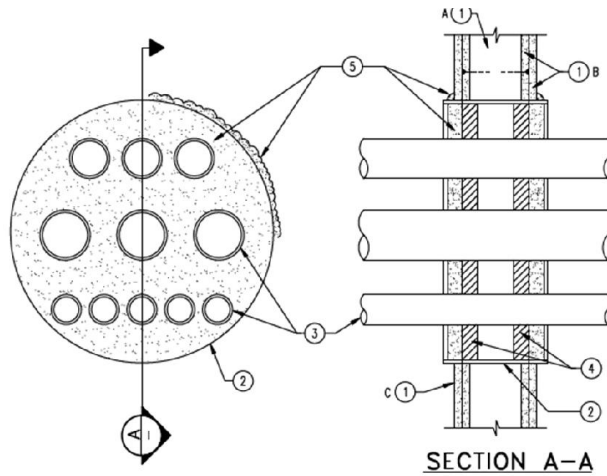
Figure 6 - Mechanical Wall Detail 1



SYSTEM NO. W-L-8010
 F RATINGS - 1 & 2 HR (SEE ITEM 1)
 T RATINGS - 1/4, 3/4, 1, 1-1/2 AND 1-3/4 HR (SEE ITEMS 2 & 3)

1. WALL ASSEMBLY - THE 1 OR 2 HR FIRE-RATED GYPSUM WALLBOARD/STUD WALL ASSEMBLY SHALL BE CONSTRUCTED OF THE MATERIALS AND IN THE MANNER SPECIFIED IN THE INDIVIDUAL U300 OR U400 SERIES WALL AND PARTITION DESIGNS IN THE UL FIRE RESISTANCE DIRECTORY AND SHALL INCLUDE THE FOLLOWING CONSTRUCTION FEATURES:
 - A. STUDS - WALL FRAMING MAY CONSIST OF EITHER WOOD STUDS OR STEEL CHANNEL STUDS. WOOD STUDS TO CONSIST OF NOM 2 BY 4 IN. LUMBER SPACED 16 IN. OC. STEEL STUDS TO BE MIN 3-5/8 IN. WIDE AND SPACED MAX 24 IN. OC.
 - B. WALLBOARD GYPSUM* - NOM 5/8 IN. THICK GYPSUM WALLBOARD, AS SPECIFIED IN THE INDIVIDUAL WALL AND PARTITION DESIGN. MAX AREA OF OPENING IS 65-1/4 SQ IN. WITH MAX DIMENSION OF 14-1/2 IN. THE HOURLY F RATING OF THE FIRESTOP SYSTEM IS EQUAL TO THE HOURLY FIRE RATING OF THE WALL ASSEMBLY.

Figure 5 - Mechanical Wall Detail 2



SYSTEM NO. W-L-1016
 (FORMERLY SYSTEM NO. 322)
 F RATING - 2 HR
 T RATINGS - 1, 1-1/2 AND 2 HR (SEE ITEM 3)
 L RATING AT AMBIENT - 2 CFM/SQ. FT.
 L RATING AT 400 F - 1 CFM/SQ. FT.