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Technical Report 1

Brault Building Renovation

Northern Virginia Community College

Annandale, VA

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Executive Summary

The Brault Building is an administrative office for the Northern Virginia Community College, located in Annandale, VA. This three story, 50,000 square foot building renovation will add additional office space which will allow more employees to occupy the building. This technical report will give a further understanding of the Brault Building's compliance with ANSI/ASHRAE Standard 62.1-2013: Ventilation for Acceptable Indoor Air Quality and ANSI/ASHRAE/IES Standard 90.1-2013: Energy Standard for Buildings Except Low-Rise Residential Buildings.

ANSI/ASHRAE Standard 62.1-2013: Ventilation for Acceptable Indoor Air Quality requires an analysis of a buildings system and equipment as well as the buildings ventilation rate. The Brault building follows Section 5 which has requirements on ventilation air distribution, exhaust duct location, ventilation system controls, airstream surfaces, outdoor air intakes, local capture of contaminants, combustion air, particle matter removal, dehumidification systems, drain pains, finned-tube coils and heat exchangers, humidifiers and water-spray systems, access for inspection, cleaning, and maintenance, building envelope and interior surfaces, buildings with attached parking garages, air classification and recirculation, and requirements for buildings containing ETS areas and ETS-Free areas. Section 6 requires a building to have a certain ventilation rate with a mandatory percentage of outdoor air mixed within. The Brault Building requires 44,550 CFM of ventilated air throughout the building, where 37% of that air must be outdoor air.

ANSI/ASHRAE/IES Standard 90.1-2013: Energy Standard for Buildings Except Low-Rise Residential Buildings requires a building to maintain a certain efficiency. As the Brault Building is try to reach LEED Silver rating, the building must meet stricter regulations than that in Standard 90.1. Standard 90.1 – 2013 requires an analysis of a buildings building envelope, heating, ventilating, and air conditioning, service water heating, power, lighting, and other equipment. These section require that the building must be properly insulated and sealed to prevent heat loss and infiltration, must have a properly sized and equipped HVAC system that will yield a high efficiency, and properly meeting the amount of domestic water, power density, efficient lighting, and ensure that all other equipment are regulated and will work safely.

The Brault Building successful complies with all of the regulations that are required by ANSI/ASHRAE Standard 62.1-2013: Ventilation for Acceptable Indoor Air Quality and ANSI/ASHRAE/IES Standard 90.1-2013: Energy Standard for Buildings Except Low-Rise Residential Buildings.

Mechanical System Overview

The Brault Building is located in Annandale, VA, which is considered to be in cool and humid climate. This requires that the building must be able to supply sufficient amount of cooling as well as heating to maintain occupant comfort.

The Brault Building renovation will incorporate fives air handling units, three located on the roof and two in the mechanical room, with a capability of supplying 45,900 CFM. The building requires a minimum of 44,550 CFM to be able to properly ventilate the building according to ASHRAE Standard 62.1. The ventilation system supplies 37% of its overall airflow as fresh outdoor air. Areas that may need to be exhausted directly out of the building, including toilets, are done so properly.

The air temperature in the conditioned building is maintained by a hydronic water system. The building contains two 55 GPM gas powered boilers and a 210 GPM air cooled scroll or screw compressor chiller. The boilers are capable of heating water from 110 degrees Fahrenheit to 140 degrees Fahrenheit. The chiller is capable of cooling water from 59 degrees Fahrenheit to 44 degrees Fahrenheit at 95 degrees Fahrenheit outside ambient air temperature. The buildings cooling system uses a 210 GPM pump with 70 feet of head, and the heating system has a 55 GPM primary pump with 60 feet of head as well as have secondary pumps located at each of the air handling units. The Brault Building also makes use of fan-powered parallel flow terminals and variable air volume boxes. This allows the occupants to have more control of the building temperature to increase the occupancy comfort.

Passively, the Brault Building is capable of regulating loads and help increased mechanical system efficiency. The building utilizes a curtain wall system facing the south, which can help decrease the heating load needed for the building needed during the heating season. The building also has horizontal metal sun louvers which will help shade the building from solar heat gain during the cooling season to reduce the cooling load needed.

ANSI/ASHRAE Standard 62.1 – 2013

Section 5 Systems and Equipment

5.1 Ventilation Air Distribution

The Brault Building has been designed to supply the minimum amount of outdoor air needed to ventilate a building under maximum load conditions. This project uses direct connections from ventilation air ducts to terminal units. There is proper documentation of the ventilation air distribution calculations and assumptions approved by professional engineers.

5.2 Exhaust Duct Location

The Brault Building has proper air exhaust from restrooms throughout the building. In compliance with this standard, the exhaust ductwork does not circulate through any conditioned space where improper air contamination may occur. The exhaust ductwork runs directly from the buildings restrooms to the exterior of the building.

5.3 Ventilation System Controls

The Brault Building includes a Building Automation System (BAS) with CO_2 controls to modulate ventilation systems in response to occupancy are included in this system. This system included a direct digital control (DDC) to switch the system between occupied and und occupied situations. Also, the supply fan and outside air dampers have a hardwire interlock as well as the relief damper and return fan.

5.4 Airstream Surfaces

Galvanized sheet-metal with exterior fiberglass duct insulation is used for all ductwork within the Brault Building. This will ensure mold shall not grow and circulate throughout the ventilation system, as well as being composed of a material which will not erode.

5.5 Outdoor Air Intakes

With three air handling units on the roof of the building and one air handling unit in the mechanical room with direct ductwork to the building exterior, the air intakes of these units are properly located away from possible contaminants specified on Table 5.5.1, also located in Appendix A. And are protected from rain and snow with a bird screen to protect the air intake from bird nesting.

5.6 Local Capture of Contaminants

This section of the standard does not apply to the Brault Building.

5.7 Combustion Air

Combustion air intake and exhaust are directly ducted to the exterior of the building via 6 inch round ductwork. This section also complies with the requirements from Section 5.5: Outdoor Air Intakes.

5.8 Particulate Matter Removal

The Brault Building's filtration system complies with ASHRAE 52.2 with a MERV rating of 8. The disposable panel filter is 1 inch thick with interlaced glass fivers sprayed with nonflammable adhesive and antimicrobial agent.

5.9 Dehumidification Systems

This section of the standard does not apply to the Brault Building.

5.10 Drain Pans

Comprised of galvanized or Type 304 stainless steel sheet metal, the pan extends at minimum 12 inches past the coil. The pans are sloped at minimum in tow planes to collect condensate

5.11 Finned-Tube Coils and Heat Exchangers

All cooling coil assemblies and condensate-producing heat exchangers are scheduled, with a drain pan with a minimum depth of 2 inches, in accordance with Section 5.10. There are no finned-tube coils in this building.

5.12 Humidifiers and Water-Spray Systems

This section of the standard does not apply to the Brault Building.

5.13 Access for Inspection, Cleaning, and Maintenance

The Brault Building currently maintains acceptable clearances for all mechanical equipment and appropriate ventilation equipment and air distribution system access.

5.14 Building Envelope and Interior Surfaces

The Brault Building is properly sealed with a moisture and vapor barrier as well as providing weep holes where water may accumulate. All doorways, joints, and windows are sealed to prevent moisture damage. The interior walls are made from Gypsum Shaftliner Board, Moisture- and Mold-Resistant Type X.

5.15 Buildings with Attached Parking Garages

This section of the standard does not apply to the Brault Building.

5.16 Air Classification and Recirculation

The air in the Brault Building is classified as Type 1 except for restrooms. Air from restrooms are pressurized and exhausted directly to the exterior of the building without contaminating other areas of the building.

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

The Brault Building is being built to become a LEED Silver certified building. No smoking will be allowed in this building. This section of the standard does not apply to the Brault Building.

Section 6 Ventilation Rate Calculation Procedure

Section 6: Ventilation Rate Calculation Procedure of the ANSI/ASHRAE Standard 62.1-2013 explains how much air needs the system needs to intake in order to provide the proper amount of outdoor air based on space type, application, occupancy level, and floor zone. The first step in calculating the ventilation rate, the outdoor airflow required in the breathing zone must be acquired. The breathing zone outdoor airflow was calculated using the following equation:

$$V_{bz} = R_p * P_z + R_a * A_z$$

Where:

V_{bz} is the breathing zone outdoor airflow

R_p is the outdoor airflow rate required per person as determined from Table A-1

P_z is the zone population or the number of people in the ventilation zone during typical usage

R_a is the outdoor airflow rate required per unit area as determined from Table A-1

A_z is the zone floor area or the net occupiable floor area of the ventilation zone, ft^2 or m^2

Once the required amount of outdoor air airflow is determined, the primary outdoor air fraction must be determined. The primary outdoor air fraction is calculated using the following equation:

$$Z_{pz} = V_{oz} / V_{pz}$$

Where:

Z_{pz} is the primary outdoor air fraction

V_{oz} is the zone outdoor airflow

V_{pz} is the primary airflow

The Brault Building has an estimated 406 occupants at full load, which requires 44,550 CFM to provide enough airflow for the occupancy load. To meet ASHRAE standards, 16,662 CFM, or 37% of the overall airflow, of outdoor air must be provided to the entire building. The Brault Building ventilation calculations can be found in Appendix A, Table A-2.

ANSI/ASHRAE Standard 62.1 – 2013

Conclusion

The Brault Building being a low rise non-residential building, must comply with ANSI/ASHRAE Standard 62.1 – 2013. After an in depth analysis of Standard 62.1 Section 5 and Section 6, it is determined that the Brault Building does comply with all the requirements that it must meet.

ANSI/ASHRAE Standard 62.1 – 2013 Section 5 requires an analysis of a buildings systems and equipment. There are some areas in this section that are inapplicable to the Brault Building, including Sections 5.6, 5.9 5.12, and 5.15, thus may be ignored in this analysis. The rest of Section 5 requirements are meet by the Brault Building design.

ANSI/ASHRAE Standard 62.1 – 2013 Section 6 requires an analysis of a buildings ventilation rates. The Brault Building design follows Section 6, and a table showing the calculations for each individual room and overall ventilation rate may be found in Appendix A as Table A-2.

ANSI/ASHRAE/IES Standard 90.1 – 2013

Section 5 Building Envelope

5.1 General

The Brault Building is located in Annandale, Virginia, which is considered to be in Climate Zone 4A. This zone is to be considered cool and humid. Please refer to Appendix B Figure B-1 for full map.

5.2 Compliance Paths

The Brault Building must comply with Section 5.1, Section 5.4, Section 5.7, and Section 5.8, as well as comply with either Section 5.5 or Section 5.6

5.3 Simplified Building

The section of the standard is not used for the Brault Building.

5.4 Mandatory Provisions

Being located in Climate Zone 4A, the Brault building must be properly sealed, especially at exterior doors and fenestrations. In Appendix B, Figures B-2, B-3, and B-4 illustrate that the buildings windows and doors are properly sealed for the outdoor environment. The building's exterior wall materials are also very import for to maintain proper insulation. The Brault Building meets these requirements of acceptable materials allowable in its climate zone. The main entrance of the Brault Building is separated from the interior of the building by a vestibule that will protect the conditioned space from the unconditioned outdoor environment.

5.5 Prescriptive Building Envelope Option

According to Table 5.5-4, also located in Appendix B, declares that vertical fenestration is limited to 40% of the wall and 3% of the roof for skylights. The Brault Buildings total exterior surface area is approximately 16,650 square feet with only approximately 6,250 square feet of vertical fenestration. This yields a 38% vertical fenestration limit, which is less than the maximum limit for the building. Since the Brault Building has no skylights, it meets the requirements for under 3% of the roof may be a skylight. Table 5.5-4 also requires that the walls, roof, and windows must meet a certain U-Value. Figures B-2 and B-3 in Appendix B illustrate the buildings compliance with Table 5.5-4. Have a large percentage of the building with vertical fenestration, solar heat gain must be regulated. As seen in Figures B-2 and B-3 in Appendix B, the Brault Building has horizontal metal sun louvers that is operable and may determine how much sunlight enters through the vertical fenestrations.

Section 6 Heating, Ventilating, and Air Conditioning

6.1 General

All mechanical equipment for the new addition of the Brault Building must comply with Section 6.2. All existing cooling systems serving previously unconditioned spaces must comply with Section 6.2.

6.2 Compliance Paths

The Brault Building must comply with Section 6.1, Section 6.7, and Section 6.8 as well as complying with either Section 6.3, Section 6.4, or Sections 6.4 and 6.6.

6.3 Simplified Approach Option

The Brault Building does not meet the qualifications to use Section 6.3.

6.4 Mandatory Provisions

This section requires that all equipment in Tables 6.8.1-1 through 6.8.1-13 will reach the minimum specified rating conditions for its performance.

6.5 Prescriptive Path

Being located in Climate Zone 4A, the Brault Building is not required have an economizer for its cooling system, but the building does take advantage of this energy efficient method. The control sensor for outside air will modulate the outdoor air damper when the outside air temperature falls below 69 degrees Fahrenheit. The building has reheating/recooling opportunities at each VAV box that may be individually controlled at each location by the use of a hydronic heat pump system. The Brault Building also complies with the fan power limitations and does not exceed the motor nameplate horsepower. All heating and cooling air flow and temperature is regulated using DDC Controllers and sensors that control the systems.

Section 7 Service Water Heating

The Brault Building utilizes boilers for hot water supply to the air handling units, the unit heaters, the variable air volume boxes, and the fan-powered parallel flow terminals. Each 55 gallon gas fueled condensing boiler is set to supply the water at 140 degrees Fahrenheit from 110 degrees Fahrenheit. A 100 gallon domestic water heater set at 140 degrees Fahrenheit is used to supply all the heated potable water in the building. All piping meets the minimum insulation requirements.

Section 8 Power

The Brault Building is required to have a maximum voltage drop of 2% of the design load for the feeders and a maximum of 3% of the design load at branch circuits. With the largest branch circuit voltage drop of 1.89%, the building is within the regulation of the standard. Table B-1 in Appendix B gives more detail for the voltage drop calculations.

Section 9 Lighting

The Brault Building lighting design uses many features to save energy. Having a curtain wall facing the south with operable sun louvers, the building is capable of maximizing its use of natural daylight while being able to regulate the amount of solar heat gain entering the building. The Brault Building also utilizes combination dual technology occupancy sensor and light switch, which will greatly reduce the energy used in a room when unoccupied. From the NEC Table 220-12, electrical loads for office buildings are required to be 3.5 VA/SqFt for lighting and 1 VA/SqFt for Power, which gives an overall power density of 4.5 VA/SqFt.

Section 10 Other Equipment

Under Section 230514 – Common Motor Requirements for HVAC Equipment in the Brault Building Project Manual, all electric motors are in conformance with National Electrical Manufactures Association (NEMA) MG 1 standard, the Energy Independence and Security Act of 2007, and must comply with NFPA 70. The Brault Building complies with all of these regulations which makes the building compliant with ANSI/ASHRAE 90.1 – 2013 Section 10.

ANSI/ASHRAE/IES Standard 90.1 – 2013

Conclusion

The Brault Building being a low rise non-residential building, must comply with ANSI/ASHRAE/IES Standard 90.1 – 2013. As the design team has designed the building to reach LEED Silver rating, LEED requires that Section 90.1 needs to be meet and surpassed. After an in depth analysis of Standard 90.1 Section 5, Section 6, Section 7, Section 8, Section 9, and Section 10, it is determined that the Brault Building does comply with all the requirements that it must meet.

ANSI/ASHRAE/IES Standard 90.1 – 2013 Section 5 requires an analysis of the building envelope. Being in Climate Zone 4A, the Brault Building must meet certain requirements for insulation and infiltration prevention. The Brault Building is properly insulated and sealed to meet and surpass ASHRAE standards.

ANSI/ASHRAE/IES Standard 90.1 – 2013 Section 6 requires an analysis of the heating, ventilation, and air conditioning systems. Being hydronically heated and cooled at both the air handling units as well as being able to be reheated or recooled at individual variable air volume boxes, the Brault Building is able to maintain proper temperature regulation within the conditioned area. The addition of being able to use an economizer in the building greatly increases the energy efficiency of the system.

ANSI/ASHRAE/IES Standard 90.1 – 2013 Section 7, Section 8, Section 9, and Section 10 require an analysis of the service water heating, power, lighting and other equipment. The domestic water is supplied from a single 100 gallon hot water heater at 140 degrees Fahrenheit, and the service water for heating systems is supplied from two 55 gallon boilers at 140 degrees Fahrenheit. The power for the building has a branch circuit voltage loss of only 1.89% and having a combined power and lighting density load of 4.5 VA/SqFt. The curtain wall system allows for optimal amount of daylighting in the building while having the capability of being shaded to prevent solar heat gain. All electric motors must fit regulations that have more complies and is stricter than the ASHRAE Standard.

References

ANSI/ASHRAE Standard 60.1-2013, Ventilation for Acceptable Indoor Air Quality. Atlanta, GA. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

ANSI/ASHRAE/IES Standard 90.1-2013, Ventilation for Acceptable Indoor Air Quality. Atlanta, GA. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

Cole & Denny Incorporated. "Architectural Construction Documents". Alexandria, VA.

Summer Consultants, Inc. "Electrical Construction Documents". McLean, VA.

Summer Consultants, Inc. "Mechanical Construction Documents". McLean, VA.

Appendix A

TABLE 5.5.1 Air Intake Minimum Separation Distance

Object	Minimum Distance, ft (m)
Class 2 air exhaust/relief outlet (Note 1)	10 (3)
Class 3 air exhaust/relief outlet (Note 1)	15 (5)
Class 4 air exhaust/relief outlet (Note 2)	30 (10)
Plumbing vents terminating less than 3 ft (1 m) above the level of the outdoor air intake	10 (3)
Plumbing vents terminating at least 3 ft (1 m) above the level of the outdoor air intake	3 (1)
Vents, chimneys, and flues from combustion appliances and equipment (Note 3)	15 (5)
Garage entry, automobile loading area, or drive-in queue (Note 4)	15 (5)
Truck loading area or dock, bus parking/idling area (Note 4)	25 (7.5)
Driveway, street, or parking place (Note 4)	5 (1.5)
Thoroughfare with high traffic volume	25 (7.5)
Roof, landscaped grade, or other surface directly below intake (Notes 5 and 6)	1 (0.30)
Garbage storage/pick-up area, dumpsters	15 (5)
Cooling tower intake or basin	15 (5)
Cooling tower exhaust	25 (7.5)

Note 1: This requirement applies to the distance from the outdoor air intakes for one ventilation system to the exhaust/relief outlets for any other ventilation system.
Note 2: Minimum distance listed does not apply to laboratory fume hood exhaust air outlets. Separation criteria for fume hood exhaust shall be in compliance with NFPA 45[5] and ANSI/AIHA Z9.5.[6] Information on separation criteria for industrial environments can be found in the *ACGIH Industrial Ventilation Manual*[7] and in *ASHRAE Handbook—HVAC Applications*.[8]
Note 3: Shorter separation distances shall be permitted when determined in accordance with (a) ANSI Z223.1/NFPA 54[9] for fuel gas burning appliances and equipment, (b) NFPA 31[10] for oil burning appliances and equipment, or (c) NFPA 211[11] for other combustion appliances and equipment.
Note 4: Distance measured to closest place that vehicle exhaust is likely to be located
Note 5: Shorter separation distance shall be permitted where outdoor surfaces are sloped more than 45 degrees from horizontal or that are less than 1 in. (30 mm) wide.
Note 6: Where snow accumulation is expected, the surface of the snow at the expected average snow depth constitutes the "other surface directly below intake."

Table A-1 - Standard 62.1 Outdoor Air Rates (Not Full List)

	IP		SI		Default Occupant Density
Occupancy Category	*Rp* (cfm/per)	*Ra* (cfm/ft2)	*Rp* (L/s-per)	*Ra* (L/s-m2)	#/1000 ft^2 (#/100 m$^{2)}$
Conference/meeting	5	0.06	2.5	0.3	50
Corridors	0	0.06	0	0.3	0
Electrical equipment rooms	0	0.06	0	0.3	0
Elevator machine rooms	0	0.12	0	0.6	0
Office space	5	0.06	2.5	0.3	5
Storage rooms	0	0.12	0	0.6	0
Telephone closets	0	0	0	0	0
Telephone/data entry	5	0.06	2.5	0.3	60

Tabel A-2 - Outdoor Air Ventilation Rate Calculation

							ASHRAE 62.1-2007								
System	Floor	Room		Usage	Floor Area	Load CFM	People / 1000 SqFt	People	CFM / Person	CFM / SqFt	Uncorrected OA Req(CFM)	Calc'd OA	30% more OA	OA % of Load	Minimum Exhaust (CFM)
AHU-1	1	100		Vestibule	60	50	0	0	0	0	0	17	22	0.44	
AHU-1	1	101,124,125,126,140		corridor	1847	300	0	0	0	0.06	111	102	132	0.44	
Vent	1	102		sprinkler	135		0	0	0	0	0				
AHU-1	1	103		office	131	150	5	1	5	0.06	11	51	66	0.44	
AHU-1	1	104		office	130	200	5	1	5	0.06	11	68	88	0.44	
AHU-1	1	105		office	130	200	5	1	5	0.06	11	68	88	0.44	
AHU-1	1	106		office	130	200	5	1	5	0.06	11	68	88	0.44	
AHU-1	1	107		office	124	125	5	1	5	0.06	11	42	55	0.44	
AHU-1	1	108		office	131	125	5	1	5	0.06	11	42	55	0.44	
AHU-1	1	109		office	124	125	5	1	5	0.06	11	42	55	0.44	
AHU-1	1	110		office	143	125	5	1	5	0.06	12	42	55	0.44	
vent	1	111		elec closet	130										
vent	1	112		elev. mach rm	60										
AHU-1	1	113		office	120	100	5	1	5	0.06	10	34	44	0.44	
AHU-1	1	114		office	126	125	5	1	5	0.06	11	42	55	0.44	
AHU-1	1	115		office	120	125	5	1	5	0.06	10	42	55	0.44	
AHU-1	1	116a		open office	440	150	5	2	5	0.06	37	51	66	0.44	
AHU-1	1	116b		office	152	250	5	1	5	0.06	13	85	110	0.44	
AHU-1	1	118		office	114	100	5	1	5	0.06	10	34	44	0.44	
AHU-1	1	119		office	134	200	5	1	5	0.06	11	68	88	0.44	
AHU-1	1	120		office	128	200	5	1	5	0.06	11	68	88	0.44	
AHU-1	1	121		office	110	100	5	1	5	0.06	9	34	44	0.44	
AHU-1	1	122		staff lounge	620	650	25	16	5	0.06	115	220	287	0.44	200
AHU-1	1	123		office	110	100	5	1	5	0.06	9	34	44	0.44	
AHU-1	1	126	125	office	180	150	5	1	5	0.06	15	51	66	0.44	
AHU-1	1	127	126	office	116	100	5	1	5	0.06	10	34	44	0.44	
AHU-1	1	128	127	office	110	100	5	1	5	0.06	9	34	44	0.44	
AHU-1	1	129	128	office	134	125	5	1	5	0.06	11	42	55	0.44	
AHU-1	1	130	129	office	135	125	5	1	5	0.06	11	42	55	0.44	
RTU-5	1	131	130	conference	475	450	50	24	5	0.06	147	78	101	0.23	
RTU-5	1	132	131	a/v room	470	125	0	0	0	0.12	56			0.00	
AHU-1	1	133	134	storage	150	75	0	0	0	0.06	9	25	33	0.44	
AHU-1	1	134	133	open office	300	275	5	2	5	0.06	26	93	121	0.44	
AHU-1	1	136		office	276	250	5	1	5	0.06	23	85	110	0.44	
split	1	137		lt server	182	300								0.00	
vent	1	138,139		toilet	305	50								0.00	
vent	1	143		elev mach rm	65										
vent	1	144		mech rm	2307										
AHU-1 TOTAL					10,654										
AHU-2	2	200		entry	216	225	0	0	0	0.06	13	74	96	0.43	
AHU-2	2	201		lobby	710	500	10	7	5	0.06	78	164	213	0.43	
AHU-2	2	207a		office	175	300	5	1	5	0.06	15	98	128	0.43	
AHU-2	2	207b		open office	350	300	5	2	0	0.12	42	98	128	0.43	
AHU-2	2	208		file room	175	50	0	0	5	0.06	11	16	21	0.43	
AHU-2	2	209		conference	242	600	50	12	5	0.12	90	196	255	0.43	
AHU-2	2	210		office	241	575	5	1	5	0.06	20	188	245	0.43	
AHU-2	2	211		office	120	225	5	1	5	0.06	10	74	96	0.43	
AHU-2	2	212		office	144	275	5	1	5	0.06	12	90	117	0.43	
AHU-2	2	213a		office	250	450	5	1	5	0.06	21	147	191	0.43	
AHU-2	2	213b		open office	375	325	5	2	5	0.06	32	106	138	0.43	
AHU-2	2	213c		corridor	480	75	0	0	2.5	0.06	29	25	32	0.43	
AHU-2	2	214		office	115	225	5	1	5	0.06	10	74	96	0.43	
AHU-2	2	215		office	122	125	5	1	5	0.06	10	41	53	0.43	
AHU-2	2	216a		office	430	650	5	2	5	0.06	37	213	276	0.43	
AHU-2	2	216b		office	612	1050	5	3	5	0.06	52	343	446	0.43	
AHU-2	2	216c		office	2,041	1700	5	10	5	0.06	173	556	723	0.43	
AHU-2	2	216d		office	250	225	5	1	5	0.06	21	74	96	0.43	
AHU-2	2	216e		office	855	800	5	4	5	0.06	73	262	340	0.43	
AHU-2	2	216f		office	550	700	5	3	5	0.06	47	229	298	0.43	
AHU-2	2	216g		office	511	525	5	3	5	0.06	43	172	223	0.43	
AHU-2	2	218		office	130	150	5	1	5	0.06	11	49	64	0.43	
AHU-2	2	219		office	113	100	5	1	5	0.06	10	33	43	0.43	
AHU-2	2	220		pantry	52	100	25	1	5	0.06	10	33	43	0.43	
AHU-2	2	221		storage	50	50	0	0	0	0.12	6	16	21	0.43	
AHU-2	2	224,225,242		corridor	720	100	0	0	0	0.06	43	33	43	0.43	
AHU-2	2	227		IT stack	85	50	0	0	0	0	0	16	21	0.43	
vent	2	228,229		TOILET	315	50	0	0	0	0	0	16	21	0.43	
AHU-2	2	231		office	1285	1250	5	6	5	0.06	109	409	532	0.43	
AHU-2	2	232		office	130	125	5	1	5	0.06	11	41	53	0.43	
AHU-2	2	233		office	152	125	5	1	5	0.06	13	41	53	0.43	
AHU-2	2	234		office	120	100	5	1	5	0.06	10	33	43	0.43	
AHU-2	2	235		office	120	150	5	1	5	0.06	10	49	64	0.43	
AHU-2	2	237		office	150	225	5	1	5	0.06	13	74	96	0.43	
AHU-2	2	238		office	380	350	5	2	5	0.06	32	114	149	0.43	
AHU-2	2	239		office	230	400	5	1	5	0.06	20	131	170	0.43	
AHU-2	2	241		office	110	100	5	1	5	0.06	9	33	43	0.43	
AHU-2	2	243		storage	70	50	0	0	0	0.12	8	16	21	0.43	
AHU-2	2	244		storage	70	50	0	0	0	0.12	8	16	21	0.43	
AHU-2	2	246		office	1,195	1150	5	6	5	0.06	102	376	489	0.43	
AHU-2	2	247		office	135	125	5	1	5	0.06	11	41	53	0.43	
AHU-2	2	248		office	135	125	5	1	5	0.06	11	41	53	0.43	
AHU-2	2	249		office	140	275	5	1	5	0.06	12	90	117	0.43	
AHU-2	2	250		office	130	225	5	1	5	0.06	11	74	96	0.43	
AHU-2	2	251		office	152	350	5	1	5	0.06	13	114	149	0.43	
AHU-2	2	252		office	185	400	5	1	5	0.06	16	131	170	0.43	
AHU-2 TOTAL					15,318										

Tabel A-2 - Outdoor Air Ventilation Rate Calculation Continued

							ASHRAE 62.1-2007							
System	Floor	Room		Usage	Floor Area	Load CFM	People / 1000 SqFt	People	CFM / Person	CFM / SqFt	Uncorrected OA Req(CFM)	Calc'd OA	30% more OA	OA % of Load	Minimum Exhaust (CFM)
AHU-3	3	300		Lobby	200	75	0	0	0	0.06	12	23	30	0.41	
AHU-3	3	300a,320,331,339,340		corridor	1380	250	0	0	0	0.12	166	78	102	0.41	
AHU-3	3	301		open office	430	375	5	2	5	0.06	37	117	152	0.41	
AHU-3	3	302		file room	50	50	0	0	0	0.12	6	16	20	0.41	
AHU-3	3	303		conference	370	700	50	19	5	0.06	115	219	285	0.41	
AHU-3	3	304		office	115	175	5	1	5	0.06	10	55	71	0.41	
AHU-3	3	308		file room	120	50	0	0	0	0.12	14	16	20	0.41	
AHU-3	3	309		office	352	700	5	2	5	0.06	30	219	285	0.41	
AHU-3	3	310		bathroom	70	50	0	0	0	0	0	16	20	0.41	
AHU-3	3	311		office	125	225	5	1	5	0.06	11	70	91	0.41	
AHU-3	3	312		office	121	225	5	1	5	0.06	10	70	91	0.41	
AHU-3	3	313a		office	145	225	5	1	5	0.06	12	70	91	0.41	
AHU-3	3	313b		corridor	130	50	0	0	0	0.06	8	16	20	0.41	
AHU-3	3	314		conference	206	400	50	10	5	0.12	76	125	163	0.41	
AHU-3	3	315		office	123	225	5	1	5	0.06	10	70	91	0.41	
AHU-3	3	316		office	250	400	5	1	5	0.06	21	125	163	0.41	
AHU-3	3	317		bathroom	77	50								0.00	
AHU-3	3	318		office	190	175	5	1	5	0.06	16	55	71	0.41	
AHU-3	3	319		pantry	125	100	25	3	5	0.06	23	31	41	0.41	
AHU-3	3	325		office	208	350	5	1	5	0.06	18	109	142	0.41	
AHU-3	3	326		conference	246	300	50	12	5	0.06	76	94	122	0.41	
AHU-3	3	328		office	152	250	5	1	5	0.06	13	78	102	0.41	
AHU-3	3	329		office	470	600	5	2	5	0.06	40	188	244	0.41	
AHU-3	3	331		office	152	350	5	1	5	0.06	13	109	142	0.41	
AHU-3	3	333		office	320	500	5	2	5	0.06	27	156	203	0.41	
AHU-3	3	335		office	115	100	5	1	5	0.06	10	31	41	0.41	
AHU-3	3	336		office	125	225	5	1	5	0.06	11	70	91	0.41	
AHU-3	3	338		office	145	125	5	1	5	0.06	12	39	51	0.41	
AHU-3	3	339		office	125	175	5	1	5	0.06	11	55	71	0.41	
AHU-3	3	342		pantry	278	200	25	7	5	0.06	51	63	81	0.41	200
AHU-3	3	344,345		toilet	430	75	0	0	0	0	0	23	30	0.41	
AHU-3	3	347a		office	185	200	5	1	5	0.06	16	63	81	0.41	
AHU-3	3	347b		open office	340	350	5	2	5	0.06	29	109	142	0.41	
AHU-3	3	347c		corridor	120	50	0	0	0	0.06	7	16	20	0.41	
AHU-3	3	348		conference	242	275	50	12	5	0.06	75	86	112	0.41	
AHU-3	3	349		file room	127	50	0	0	0	0.06	8	16	20	0.41	
AHU-3	3	350		storage	45	50	0	0	0	0.12	5	16	20	0.41	
AHU-3	3	351		office	120	100	5	1	5	0.06	10	31	41	0.41	
AHU-3	3	352		office	130	200	5	1	5	0.06	11	63	81	0.41	
AHU-3	3	353		office	175	250	5	1	5	0.06	15	78	102	0.41	
AHU-3	3	354a		office	167	175	5	1	5	0.06	14	55	71	0.41	
AHU-3	3	354b		corridor	111	50	0	0	0	0.12	13	16	20	0.41	
AHU-3	3	355		office	135	150	5	1	5	0.06	11	47	61	0.41	
AHU-3	3	356		office	155	175	5	1	5	0.06	13	55	71	0.41	
AHU-3	3	357		office	125	150	5	1	5	0.06	11	47	61	0.41	
AHU-3	3	358		office	220	275	5	1	5	0.06	19	86	112	0.41	
AHU-3	3	359		storage	50	50	0	0	0	0.12	6	16	20	0.41	
AHU-3	3	360		pantry	50	100	25	1	5	0.06	9	31	41	0.41	150
AHU-3	3	361		file room	130	125	0	0	0	0.12	16	39	51	0.41	
AHU-3	3	362		pantry	65	100	25	2	5	0.06	12	31	41	0.41	150
AHU-3	3	363a		open office	403	500	5	2	5	0.06	34	156	203	0.41	
AHU-3	3	363b		corridor	190	50	0	0	0	0.06	11	16	20	0.41	
AHU-3	3	365		office	125	200	5	1	5	0.06	11	63	81	0.41	
AHU-3	3	366		office	125	200	5	1	5	0.06	11	63	81	0.41	
AHU-3	3	367		office	125	200	5	1	5	0.06	11	63	81	0.41	
AHU-3	3	368		office	128	200	5	1	5	0.06	11	63	81	0.41	
AHU-3	3	369		office	142	200	5	1	5	0.06	12	63	81	0.41	
AHU-3	3	370		office	142	200	5	1	5	0.06	12	63	81	0.41	
AHU-3	3	371		office	112	100	5	1	5	0.06	10	31	41	0.41	
AHU-3	3	372		office	125	225	5	1	5	0.06	11	70	91	0.41	
AHU-3	3	373		office	185	400	5	1	5	0.06	16	125	163	0.41	
AHU-3	3	374		office	112	225	5	1	5	0.06	10	70	91	0.41	
AHU-3	3	375		office	112	250	5	1	5	0.06	10	78	102	0.41	
AHU-3	3	376		open office	310	250	5	2	5	0.06	26	78	102	0.41	
AHU-3	3	377		open office	167	150	5	1	5	0.06	14	47	61	0.41	
AHU-3	3	379		conference	226	275	50	11	5	0.06	70	86	112	0.41	
AHU-3	3	380		office	110	100	5	1	5	0.06	9	31	41	0.41	
AHU-3	3	381		office	110	100	5	1	5	0.06	9	31	41	0.41	
AHU-3	3	382		office	110	100	5	1	5	0.06	9	31	41	0.41	
AHU-3	3	383		office	110	100	5	1	5	0.06	9	31	41	0.41	
AHU-3	3	385		office	125	125	5	1	5	0.06	11	39	51	0.41	
AHU-3	3	386		office	132	125	5	1	5	0.06	11	39	51	0.41	
AHU-3	3	387		IT stack	85	50	0	0	0	0	0	16	20	0.41	
AHU-3	3	388		storage	175	50	0	0	0	0.12	21	16	20	0.41	
AHU-3 TOTAL					13,723										
AHU-4	2	202		conference	850	975	50	43	5	0.06	264	292	379	0.39	
AHU-4	2	245		av room	240	100	0	0	0	0.12	29	30	39	0.39	
AHU-4	3	334		conference	430	500	50	22	5	0.06	133	150	194	0.39	
AHU-3	3	323		a/v room	180	200	0	0	0	0.12	22	60	78	0.39	
AHU-3	3	324		lounge	290	200	25	7	5	0.12	71	60	78	0.39	
AHU-4	3	322		conference	1515	1850	50	76	5	0.06	470	553	720	0.39	
AHU-4 TOTAL					3,505	3825								0.00	
Tot System						44550		406					16662	0.37	

*Calculation courtesy of Sumer Consultants, Inc.

Appendix B

Figure B-1 - ASHRAE Climate Zone Map

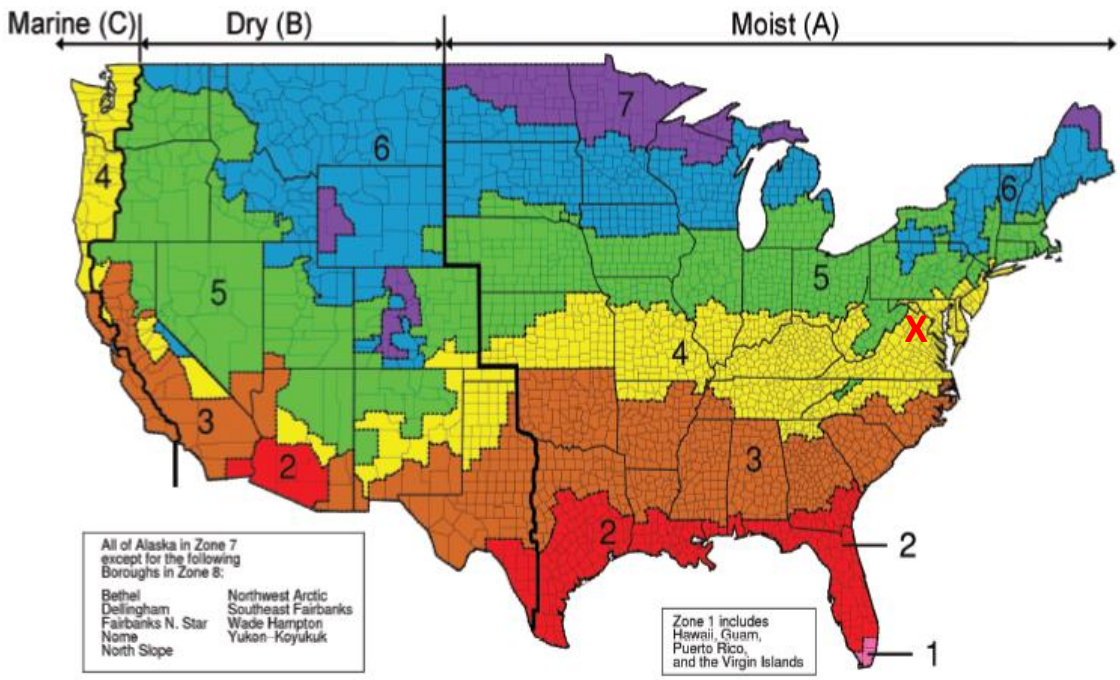

Figure B1-1 U.S. climate zone map (*ASHRAE Transactions*, Briggs et al., 2003).

Table 5.5-4 Building Envelope Requirements for Climate Zone 4 (A,B,C)*

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-0.032	R-30 c.i.	U-0.032	R-30 c.i.	U-0.093	R-10 c.i.
Metal Building[a]	U-0.037	R-19 + R-11 Ls or R-25 + R-8 Ls	U-0.037	R-19 + R-11 Ls or R-25 + R-8 Ls	U-0.082	R-19
Attic and Other	U-0.021	R-49	U-0.021	R-49	U-0.034	R-30
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-0.060	R-0 + R-15.8 c.i.	U-0.050	R-0 + R-19 c.i.	U-0.162	R-13
Steel Framed	U-0.064	R-13 + R-7.5 c.i.	U-0.064	R-13 + R-7.5 c.i	U-0.124	R-13
Wood Framed and Other	U-0.064	R-13 + R-3.8 c.i. or R-20	U-0.064	R-13 + R-3.8 c.i. or R-20	U-0.089	R-13
Wall, below Grade						
Below Grade Wall	C-0.119	R-7.5 c.i.	C-0.092	R-10 c.i.	C-1.140	NR
Floors						
Mass	U-0.057	R-14.6 c.i.	U-0.051	R-16.7 c.i.	U-0.107	R-6.3 c.i.
Steel Joist	U-0.038	R-30	U-0.038	R-30	U-0.052	R-19
Wood Framed and Other	U-0.033	R-30	U-0.033	R-30	U-0.051	R-19
Slab-on-Grade Floors						
Unheated	F-0.520	R-15 for 24 in.	F-0.520	R-15 for 24 in.	F-0.730	NR
Heated	F-0.843	R-20 for 24 in.	F-0.688	R-20 for 48 in.	F-0.900	R-10 for 24 in.
Opaque Doors						
Swinging	U-0.500		U-0.500		U-0.700	
Nonswinging	U-0.500		U-0.500		U-1.450	

Fenestration	Assembly Max. U	Assembly Max. SHGC	Assembly Min. VT/SHGC	Assembly Max. U	Assembly Max. SHGC	Assembly Min. VT/SHGC	Assembly Max. U	Assembly Max. SHGC	Assembly Min. VT/SHGC
Vertical Fenestration, 0%–40% of Wall		(for all frame types)			(for all frame types)			(for all frame types)	
Nonmetal framing, all	U-0.35			U-0.35			U-0.51		
Metal framing, fixed	U-0.42			U-0.42			U-0.73		
Metal framing, operable	U-0.50	SHGC-0.40	1.10	U-0.50	SHGC-0.40	1.10	U-0.81	NR	NR
Metal framing, entrance door	U-0.77			U-0.68			U-0.77		
Skylight, 0%–3% of Roof									
All types	U-0.50	SHGC-0.40	NR	U-0.50	SHGC-0.40	NR	U-1.15	NR	NR

* The following definitions apply: c.i. = continuous insulation (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), Ls = liner system (see Section A2.3.2.4), NR = no (insulation) requirement.

a. When using the R-value compliance method for metal building roofs, a thermal spacer block is required (see Section A2.3.2).

Figure B-2 – Existing Wall Section

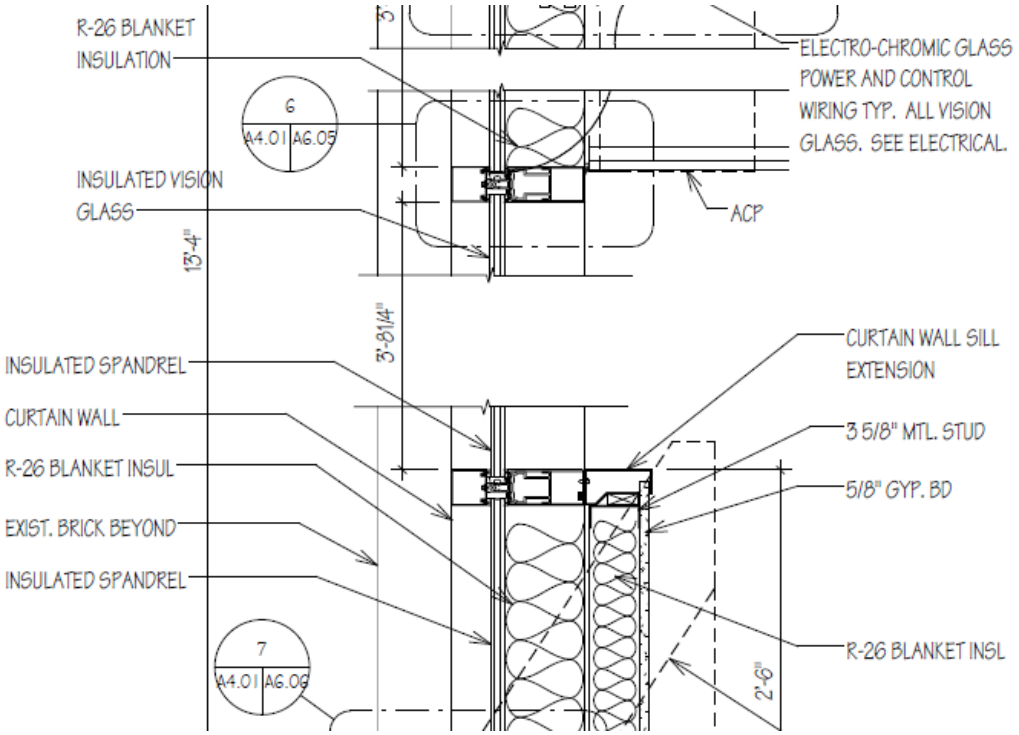

Figure B-3 – New Curtain Wall Section

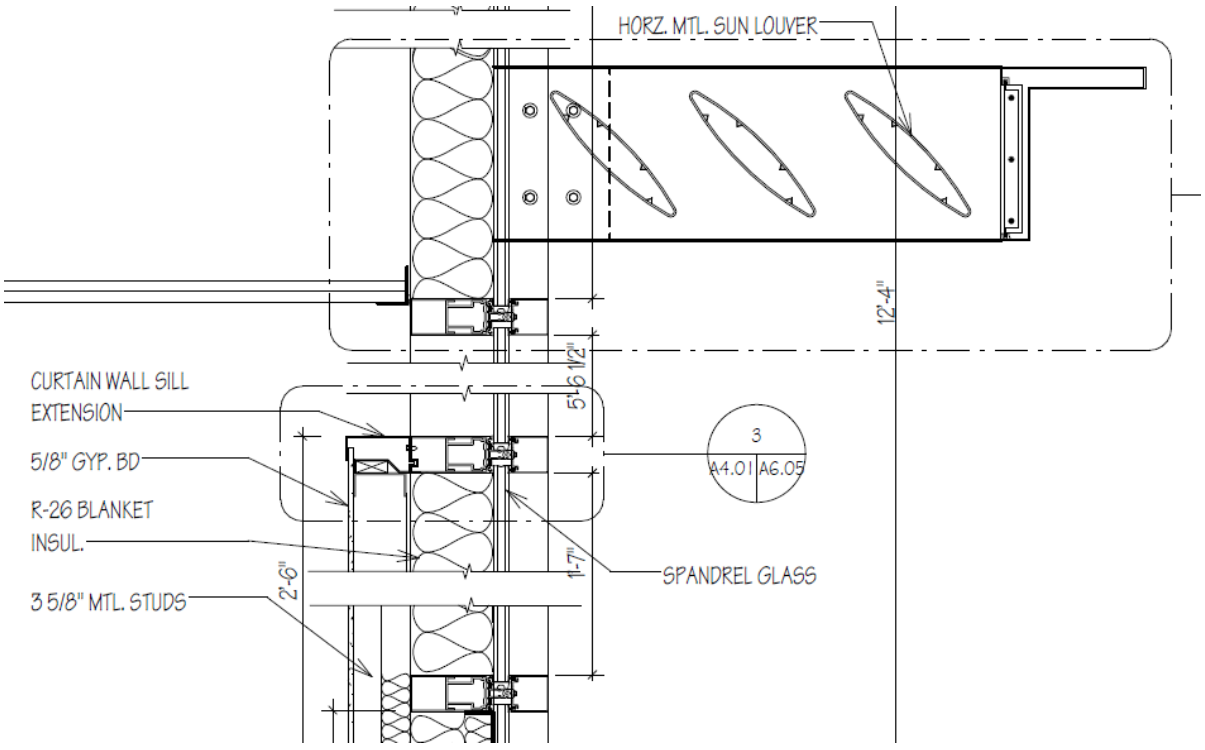

Figure B-4 – Wall Section through Exterior Door

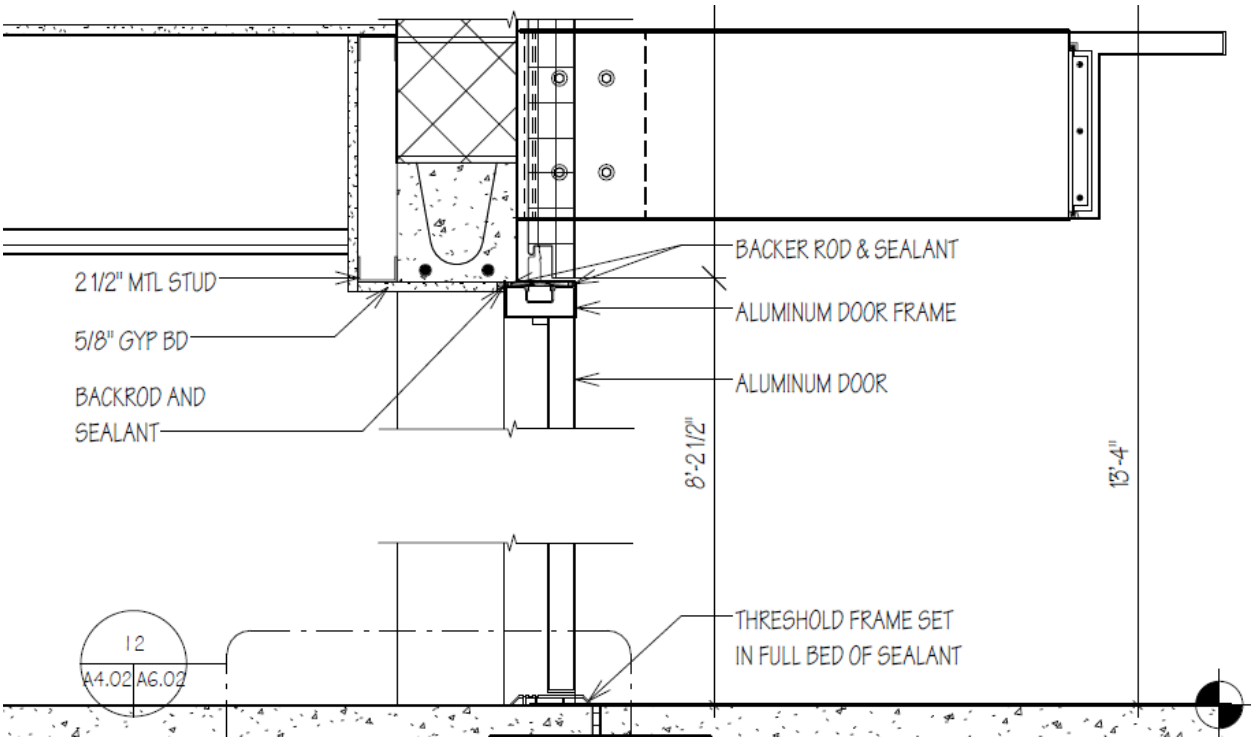

Table B-1 – Equipment Voltage Drop

Branch Curcuit Voltage Drop (NEC Table 9)									
Curcuit	Conductor Size	Resistance	Reactance	Power Factor	Efffective Impedance	Cable Length (Ft)	Number of Sets	Voltage Drop (V)	Voltage Drop %
AHU-1	#10 THHN	1.2	0.063	90%	1.11	250	1	6.71	1.46%
AHU-2	#8 THHN	0.8	0.065	90%	0.73	500	1	5.31	1.15%
AHU-3	#8 THHN	0.8	0.065	90	0.73	200	1	6.82	1.48
AHU-4	#8 THHN	0.8	0.065	90%	0.73	200	1	5.31	1.15%
RF-1	#12 THHN	2.0	0.068	90%	1.83	200	1	2.15	0.47%
RF-2	#12 THHN	2.0	0.068	90%	1.83	250	1	8.70	1.89%
RF-3	#10 THHN	1.2	0.063	90%	1.11	200	1	5.36	1.17%
RF-4	#12 THHN	2	0.068	90%	1.83	200	1	4.81	1.05%
Pump 7.5 HP and Less	#12 THHN	2	0.068	90%	1.83	200	1	6.96	1.51%

*Calculation courtesy of Sumer Consultants, Inc.