FINAL THESIS REPORT

Oklahoma University Children's Medical Office Building

Oklahoma City, Oklahoma

Alec T. Canter

Mechanical Option

Bachelor of Architectural Engineering

Faculty Advisor: Laura Miller

4/9/2014

Oklahoma University Children's Medical Office Building

1200 North Phillips Avenue — Oklahoma City, Oklahoma

BUILDING STATISTICS

Occupancy Type:	Office Building
Occupant:	Oklahoma University
Total Size:	337,000 Gross SF
Number of Stories:	12 (180 ft. above grade)
Total Cost:	$ 60,000,000 (approx.)
Project Delivery:	Design-Bid-Build
Construction Dates:	Spring 2006 – Spring 2009

PROJECT TEAM

Building Owner:	University Hospital Trust
Construction Manager:	Flintco, Inc.
Project Architect:	Miles Associates
Design Architect:	Hellmuth, Obata, Kassabaum
Structural Engineer:	Zahl-Ford, Inc.
Civil Engineer:	Smith-Roberts Baldischwiler, Inc.
MEP Engineer:	ZRHD, P.C.

ARCHITECTURAL

- Brick veneer on exterior
- Spans of aluminum and glass curtain walls
- Repetitive interior floor plan
- Continuous corridor separates interior and exterior zones
- Spaces dedicated to offices and medicinal practices

STRUCTURAL

- Entire structure of reinforced concrete down to foundation
- Lateral system is a two way concrete beam and slab grid
- Reinforced concrete columns intersect grid
- Façade is supported by steel framing

ELECTRICAL

- Main power supplied at 480/277 V
- Primary stack for all panel boards and equipment
- Secondary stack for critical, life safety, and emergency loads
- Main distribution panel is 480/277 V
- 500 kW natural gas generator

MECHANICAL

- One 28 ton capacity air handling unit serves each floor
- Variable air volume terminal boxes
- Plenum return air system
- Zone comfort controlled at terminal units
- Separate exhaust system for labs

ALEC CANTER
MECHANICAL

http://www.engr.psu.edu/ae/thesis/portfolios/2014/atc5110/index.html

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Acknowledgements

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Jorge Charneco, AIA; Miles Associates

Rob Gould, PE; AKF Group

Thanks to all my family and friends

Executive Summary

This senior year thesis project is an investigation into Oklahoma University Children's Medical Office Building and a potential new design that would be practical while accomplishing energy savings, reduced emissions, and better controllability for occupant comfort. The Oklahoma University MOB is part of the hospital campus in downtown Oklahoma City, Oklahoma. It is a 12 story mid-rise building that is reserved primarily for offices. The following report contains two parts, the first of which is the study of the existing conditions such as building envelope, designed systems (emphasizing on the mechanical systems), code compliances, and climate and locale amongst others. The second part of this document contains a proposed redesign of the building which is comprised of three sections.

The main mechanical depth is the main section of the redesign proposal. In this section a variable refrigerant volume mechanical system was designed in place of the existing variable air volume system. The variable refrigerant volume system was designed to be paired with floor-by-floor dedicated outdoor air system units to provide the building with 100% outdoor air. The VRF and DOAS couple successfully achieved combined annual electricity and gas savings of 11% as well as reduced the amount of emissions produced. The VRF system also added increased occupant controllability based on the heat recovery option, which allows for simultaneous heating and cooling. Overall, the proposed VRF system outperformed the existing VAV system, except for its high first cost. A life cycle cost analysis discovered the simple payback period of the VRF and DOAS system combination to be approximately fifteen years, even with the annual energy savings, which could discount the system as a viable option.

The next two analyses compared the electrical and acoustical characteristics of the system to that of the variable air volume system. For the acoustical breadth, the sound power levels created by the indoor evaporator units and DOAS system were compared against the VAVs and AHUs in the closest rooms downstream from the main mechanical room. Both systems met the acoustical requirements of rooms and rated similarly in noise criteria values.

Finally, the electrical connections were calculated for both of the systems air handling devices. They were then compared against each of to see if the DOAS units required larger connections than the existing AHUs. It was discovered that the DOAS unit connections were smaller than that of the existing air handling units, which was found to be a good indicator that the existing panel board and power distribution could accommodate the DOAS units. Additional connections were calculated for the outdoor VRF units to get a better understanding of the electrical load they will require.

Part I: Existing Design Analysis

Existing Project Conditions

Building Overview

The Oklahoma University Children's MOB is a 337,000 square foot newly constructed building on the OU hospital grounds. The cost of the project is approximately $60 million, and was set for completion in the spring of 2009. The architecture of the building incorporates a brick veneer façade separated visually by large spans of aluminum panels and glass curtain walls achieving a modern appearance. The interior floors are repetitive and feature exterior and interior offices, which are divided by a continuous corridor. Offices and spaces are designated by their corresponding medical use. The building reaches a total of twelve above ground stories, with a basement floor and ground level parking deck. Although the building is designated as a medical building, approximately half of the space is office space. There are currently 3 ½ floors that are unoccupied.

Systems Overview

The general mechanical layout for the building makes use of an air-handling unit on each of the 11 above-grade floors and 1 basement floor. Each air-handling unit is capable of providing approximately 28 tons of cooling. From the air-handling unit, air is distributed to approximately 40 terminal boxes per floor. All terminal boxes present within the building are intended for variable air volume (VAV). The medical office building uses the plenum space above the rooms for air return and circulation by way of the terminal units and transfer ducts. Additionally, each floor is served by the two mechanical rooms; that which houses the floor's air-handling unit and another at the opposite side of the building were approximately 50% of the distributed air is discharged from the building. All exhaust air travels up to the roof to be relieved.

Chilled and heating water is distributed through the building after transfer in the main mechanical room, which is served by a central steam heating plant and a chiller plant both located offsite, but on the hospital campus. Currently, nine of the twelve floors are set to be occupied, leaving three floors with AHUs not yet in operation. Furthermore, egress spaces on the unoccupied floors, parking deck, and stairwells are served by fan coil units.

The main power is supplied at 480/277 V from the utility transformer. The electrical distribution is divided into two stacks: the north stack supplies all panel boards serving lighting, receptacles, and other equipment and, additionally directly supplies the air handling units; the south stack serves the critical, life safety, and emergency equipment branches. The main 480/277 V distribution panel serves each stack. A 500kW natural gas generator in the event of power failure also serves the south stack.

The structural system uses concrete for the entire height of the building. Each floor features reinforced concrete columns and a grid of reinforced concrete beams. The beams act as column slabs distributing the loads in two directions. Steel framing supports the façade.

Project Team

Owner: Oklahoma University Hospital Trust
Construction Manager: Flintco, Inc.
Design Architect: Hellmuth, Obata, Kassabaum [HOK]
Project Architect: Miles Associates
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MEP Engineer: ZRDH, P.C.
Civil Engineer: Smith-Roberts Baldischwiler, Inc.

ASHRAE Standard 90.1 Energy Standard for Buildings

Chapter 5 Building Envelope

5.1.4 Climate Zones

The climate zones for the continental United States increase from zone one to zone seven (eight is only present in Alaska) as temperature decreases and elevation increases from south to north generally. Additionally each county is defined by its relative humidity progressing from "A" on the east coast and much of the eastern half of the country where climates are considered moist or humid to "C" on the very edge of the west coast where areas are distinguished as cool and marine.

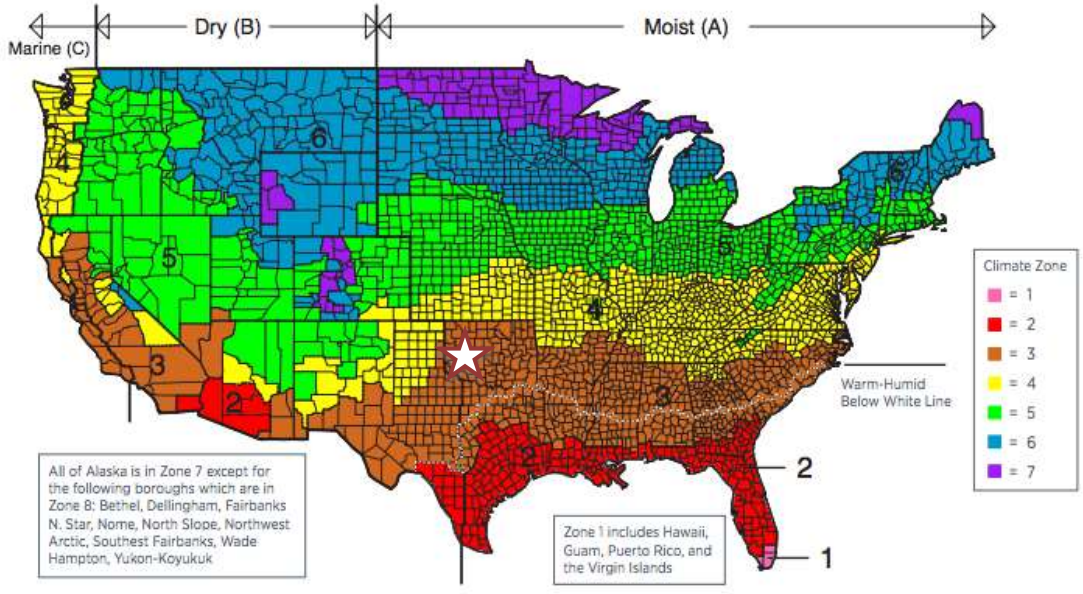


Figure 1. Climate Zones for United States Locations

Oklahoma borders zone four to the north and the dry region (B) to the west. All counties in Oklahoma fall in climate zone 3A except Beaver, Cimarron, and Texas counties, which lie in zone 4A. Therefore, Oklahoma University Children's Medical Office Building in Oklahoma City (Oklahoma County) resides in zone 3A, which is described as being warm-humid.

Section 5.2 Compliance Paths

5.2.1 Compliance: The compliance path of the construction follows Section 5.5, the Prescriptive Building Envelope Option. Refer to Section 5.5 for the full requirements. To comply, the vertical fenestration area of the floors must not exceed 40% of the gross wall area and the skylight fenestration area cannot exceed 5% of the gross roof area. The OU Children's Medical Office Building meets both of these categories in that the ratio of vertical wall fenestration to gross wall area is lower than 40%, and there is no skylight fenestration to factor in. Therefore, the Prescriptive Building Envelope Option can be used.

Section 5.4 Mandatory Provisions

5.4.3 Air Leakage: The entire building envelope is designed to maintain a continuous air barrier.

Section 5.5 Prescriptive Building Envelope Option

5.5.1 Building Envelope Requirements:

OU Children's Medical Office Building is a nonresidential conditioned space; therefore it must comply with the requirements outlined in the table beside for the appropriate climate zone, 3A.

Opaque Elements		Nonresidential Assembly Maximum	Nonresidential Insulation Min. R-Value
Roofs			
	Insulation Entirely above Deck	U-0.048	R-20.0 c.i.
	Metal Building[a]	U-0.055	R-13.0 + R13.0
	Attic and Other	U-0.027	R-38.0
Walls, Above-Grade			
	Mass	U-0.123	R-7.6 c.i.
	Metal Building	U-0.084	R-19.0
	Steel-Framed	U-0.084	R-13.0 + R-3.8 c.i.
	Wood-Framed and Other	U-0.089	R-13.0
Walls, Below-Grade			
	Below-Grade Wall	C-1.140	NR
Floors			
	Mass	U-0.107	R-6.3 c.i.
	Steel-Joist	U-0.052	R-19.0
	Wood-Framed and Other	U-0.051	R-19.0
Slab-On-Grade Floors			
	Unheated	F-0.730	NR
	Heated	F-0.900	R-10 for 24 in.
Opaque Doors			
	Swinging	U-0.700	
	Nonswinging	U-1.450	
Fenestration		**Assembly Max. U**	**Assembly Max. SHGC**
Vertical Glazing, 0%–40% of Wall			
	Nonmetal framing (all)[c]	U-0.65	SHGC-0.25 all
	Metal framing (curtainwall/storefront)[d]	U-0.60	
	Metal framing (entrance door)[d]	U-0.90	
	Metal framing (all other)[d]	U-0.65	

Figure 2. Building Envelope Requirements for Climate Zone 3 (A, B, C) [Skylight Fenestration Excluded from Table]

Chapter 6 Heating, Ventilation, and Air Conditioning

Section 6.2 Compliance Paths

6.2.1 Compliance: Compliance will be achieved by meeting all the requirements for Section 6.4, Mandatory Provisions, and Section 6.5, Prescriptive Path. A discussion follows.

Section 6.4 Mandatory Provisions

6.4.1 Equipment Efficiencies, Verification, and Labeling Requirements: All equipment in the building that is shown on the tables in Appendix D must have a minimum performance that it will meet at the specified rating condition. Only the tables containing pertinent equipment have been included.

Section 6.5 Prescriptive Path

6.5.1 Economizers: Each cooling system that has a fan within the building must include an economizer since all systems are over 54,000 Btuh. All air handling units in the building utilize an air economizer. Computer cooling does not require an economizer as the building resides in climate zone 3A.

Chapter 7 Service Water Heating

The steam and heating water used for the building comes from an offsite location, a steam/heating water plant that is elsewhere on the Oklahoma University Hospital campus. This is also true about the chilled water.

Once on site the water is then distributed to various heat exchangers and pumps to heat domestic and heating water for the Medical Office Building.

Chapter 8 Power

The Children's Medical Office Building uses low-voltage dry-type transformers rated at 600 V and less, with capacities up to 1000 kVA. Under the mandatory provisions section, the feeder conductors cannot impose a voltage drop greater than 2% at design load. Additionally, the branch circuit conductors must not exceed a voltage drop of 3% at design load.

Chapter 9 Lighting

Only areas such as restrooms, corridors, stairwells, and lobbies will be full automatic-on. The rest of the spaces will be either manual or not more that 50% power when automatically controlled. Based on the occupancy schedule, the lighting will be automatically controlled to shut off when the building is considered unoccupied. In addition to on and off, the space lighting is indicated to have a medium power setting between 30% and 70% of full lighting power.

Mechanical System

Outdoor & Indoor Design Conditions

The design conditions for the building were based on weather data at the nearest weather station, Oklahoma City International Airport, which were taken from the 2009 ASHRAE Handbook of Fundamentals. Additionally these values were based on the 1% and 99% design conditions for cooling and heating, respectively. This data can be seen in Table 1, below.

Table 1. Building Design Conditions

Thermostat Design Settings	
Cooling Dry Bulb [°F]	75
Heating Dry Bulb [°F]	72
Cooling Dry Bulb [%RH]	50
Cooling Drift Point [°F]	81
Heating Drift Point [°F]	64

Essentially, the values in the table mean that during the summer (or cooling season) the temperature exceeds the value in the table only one percent of the hours in a given year while in the winter the temperature exceeds the value 99 percent of the time. It should be noted that the values for the indoor design conditions in building were taken at a relative humidity of 50 percent.

Ventilation

The ventilation rate procedure was computed for the building yielding the results summarized in the table below. A more detailed analysis can be found in Appendix A. Both ASHRAE Standard 62.1 and Standard 170 were used in the analysis as the building is divided into general commercial office building space as well as space intended for healthcare.

Table 2. Ventilation Rate Results Summarized

Unit-Floor	Capacity [cfm]	Outdoor Air Supplied [cfm]	Outdoor Air Required [cfm]	ASHRAE 62.1 & 170 Compliance
AHU - F0	15000	5680	2537	Yes
AHU - F2	25000	4000	Not Occupied	Not Occupied
AHU - F3	25000	4625	1115	Yes
AHU - F4	25000	3650	1692	Yes
AHU - F5	25000	4405	2287	Yes
AHU - F6	25000	4550	2096	Yes
AHU - F7	25000	4710	2097	Yes
AHU - F8	25000	5015	2222	Yes
AHU - F9	25000	4310	1256	Yes
AHU - F10	25000	3800	2510	Yes
AHU - F11	25000	4000	Not Occupied	Not Occupied
AHU - F12	25000	4000	Not Occupied	Not Occupied

The fourth column in Table 2 represents the calculated ventilation rate based on space type, area, occupant density, and equipment loads. As can be seen, the current outdoor air rate being supplied by each air-handling unit on each floor meets the minimum value that was computed using ASHRAE 62.1 and ASHRAE 170. Therefore, the current conditions of the ventilation are compliant and will not need to be improved. Floors two, eleven, and twelve were neglected from the ventilation calculations since they have yet to be occupied via the tenant fit-out plan.

Heating & Cooling

The information provided in the table below contains the heating and cooling design flow rates that were taken from the construction documents provided as well as the calculated flow rates from the energy model analyzed through Trane TRACE 700.

Table 3. Heating & Cooling Design vs. Trace Flow Rates

Unit-Floor	Cooling		Heating	
	Designed [CFM]	Calculated [CFM]	Designed [CFM]	Calculated [CFM]
AHU - F0	15000	10929	5680	4031
AHU - F2	25000	-	7500	-
AHU - F3	25000	25854	9200	14735
AHU - F4	25000	25498	10300	14000
AHU - F5	25000	25829	8060	14584
AHU - F6	25000	26242	8600	14883
AHU - F7	25000	25692	7500	14915
AHU - F8	25000	26070	7500	15169
AHU - F9	25000	23254	7500	13506
AHU - F10	25000	23039	7500	13332
AHU - F11	25000	-	7500	-
AHU - F12	25000	-	7500	-

Existing Mechanical Equipment

Air Handling Units

Each floor requires its own air-handling unit to provide air to all the terminal units downstream. Currently, each floor is equipped with an AHU, although not all the floors are occupied. Additionally, it was assumed by the designers that approximately 40 terminal units, which are taken into account and described in greater detail below, would serve the floors currently without tenants in the future.

The role of the twelve air-handling units in the Oklahoma University Children's MOB is to mix the outdoor and return air, condition it, and distribute it throughout each floor. The amount of outside air and return air with respect to total airflow is approximately 20 percent and 80 percent, respectively. The cooling and heating capacities of the air-handling units on each floor are noted in the following table.

Further analysis of the operation of the AHUs with the corresponding mechanical equipment comprising the entire mechanical system will follow.

Table 4. AHU Schedule

Unit-Floor	Capacity [cfm]	Outdoor Air Supplied [cfm]	Return Air [cfm]	Supply Air [cfm]	Exhaust Air [cfm]	Heating [MBH]	Cooling [Tons]
AHU - F0	15000	5680	9320	6000	4930	450	48.3
AHU - F2	25000	4000	21000	10000	2000	330	71.1
AHU - F3	25000	4625	20375	9200	2165	380	70.5
AHU - F4	25000	3650	21350	10300	7940	330	67.8
AHU - F5	25000	4405	20595	8060	1920	330	72.8
AHU - F6	25000	4550	20450	8600	2285	330	71.1
AHU - F7	25000	4710	20290	7500	4210	330	71.1
AHU - F8	25000	5015	19985	7500	4665	330	71.1
AHU - F9	25000	4310	20690	7500	1640	330	71.1
AHU - F10	25000	3800	21200	7500	3090	330	71.1
AHU - F11	25000	4000	21000	7500	2000	330	71.1
AHU - F12	25000	4000	21000	7500	2000	330	71.1
Total	**290000**	**52745**	**237255**	**97160**	**38845**	**4130**	**828.2**

Air Terminal Units

The air terminal units present within the medical office building are all single duct variable air volume boxes. There are a total of 454 terminal units used by the air-handling units to deliver air to each space. The units are based off two different series fan powered boxes manufactured by Price. Additionally, each box is equipped with a reheat coil that has ranges between 0.33 GPM all the way up to 7 GPM. The coils are supplied by the main mechanical room, which is in turn supplied with steam and chilled water from the nearby plant.

Hydronic Unit Heaters

The hydronic unit heaters are located in the mechanical and fan rooms on each floor. Each provides heat at approximately 18000 to 34000 Btu's per hour with varying flow rates of 1 to 5 GPM. The mechanical rooms tend to have the greater capacity heaters for the purposes of mitigating mold growth in the space while the fan rooms (which are exhausting air) do not need as great of a thermal offset. The unit heaters require 120 V power.

Packaged Terminal Heat Pumps

Similar to the hydronic unit heaters previously described, the packaged terminal heat pumps are used to provide heat to small spaces not requiring ventilation air. The heat pumps, which are located exclusively in the elevator equipment rooms, however, also provide cooling during the summer months. The heat pumps are fitted with an electric motor requiring 208 V to power to the fans. The larger of the two types of packaged heat pumps used, provide cooling at 14,500 Btuh and heating at 11,600 Btuh.

Fan Coil Units

There are four different types of fan coil units in design of the building. They are located in the stairwells, the elevator machine room, and on the ground floor egress areas to and from the parking deck. The FCUs utilize hydronic piping to provide both heat and cooling when needed. The largest of the FCUs is the one located on the parking deck floor that supplies the corridor and elevator lobby. This fan coil unit is ducted and provides approximately 42000 Btuh for heating and 22000 Btuh for cooling.

System Operation

Airside

The air-handling unit on each floor mixes outdoor air and return air (which is ducted back to the air handling unit from the plenums above each space). A variable speed fan pulls the return air back to air handling unit through normally open dampers. At a minimum, 30 percent of the mixture will be outdoor air; the outdoor and return air dampers control the mixture. After leaving the mixing chamber, the air passes through the mixed air filter. If the differential pressure sensor across the filter senses a drop below the set point, maintenance must be performed.

The mixed air then passes through the variable volume preheat coil, which will be modulated in all modes to maintain a temperature of 52°F. The supply fan, which is controlled by a variable speed drive, carriers the air along based on an occupied-unoccupied basis. Essentially this means that the fan is either on or off depending on whether the building is occupied or unoccupied respectively. However, when in occupied mode, the variable speed drive of the fan modulates to maintain duct static pressure.

Finally, the mixed air passes through the variable volume cooling coils, which are operated to maintain discharge air temperature at 54°F. From here the air travels to the space devices where the air will get delivered. The pressure sensor at the supply outlet determines the AHU supply fan speed in order to maintain duct static pressure.

Waterside

Multiple boilers contained in the heating plant off site feed the mechanical heating water and steam system. The high-pressure steam from the plant passes through a large heat exchanger in the building's main mechanical room and transfers its heat to a mixture of 65% water and 35% propylene glycol. The steam condensate returns to the plant to be reheated. After passing through an air separator, the water mixture is distributed by two 980 GPM hot water pumps to hydronic heating equipment throughout the building, such as the air handlers and VAV terminal boxes.

The high-pressure steam from the plants also heats the domestic hot water. Again in the main mechanical room, steam passes through a double-wall, instantaneous, domestic hot water heater, where heat is exchanged to the domestic water and pumped out the various plumbing systems. Chilled water and domestic cold water come directly from plant to the main mechanical room where the water is pumped to the floors for hydronic cooling or domestic use.

Mechanical System Space

The Oklahoma University Children's Medical Office Building features two mechanical rooms on each floor: one for the air handling unit and equipment and the other for exhausting air. Very little equipment is placed on the roof except for several exhaust fans. The basement floor contains the main mechanical room, which is served by the central plant. Overall, the mechanical spaces only account for roughly five percent of the floor area.

As can be seen in the figure below the cost of the mechanical systems designed for the Children's MOB is a majority leader at approximately $12.7 million or 19% of the total construction cost.

ASHRAE Standard 62.1 Ventilation for Acceptable Indoor Air Quality

Chapter 5. Systems & Equipment

Ventilation Air Distribution (Section 5.1)

Every zone on the system is supplied by at least one terminal box. The system is only part plenum, where the primary air is delivered from the air handling units directly by duct, while the air is returned to the plenum spaces above the zones. Here some of this air will be mixed with the primary air in the terminal units for recirculation. Otherwise the return air in the plenum is pulled through the spaces via plenums and transfer ducts back to floor air handling unit to be re-circulated or exhausted.

The terminal units used by every space are variable air volume. Majority of the variable air volume boxes deliver only supply air from the air handling unit and do not directly re-circulate return air from the plenum. These terminal units vary the volume of primary air through the use of a damper. The remaining variable air volume boxes make use of a fan and mix return and primary air. In order to maintain minimum ventilation air the fans are variable speed. In addition, every supply branch downstream of all the terminal units is equipped with a manual air damper.

Exhaust Duct Location (Section 5.2)

All necessary rooms such as toilet rooms, janitor closets, equipment rooms, as well as all required medical rooms and laboratories are provided with exhaust ductwork that is negatively pressurized by roof top fans (located outside the system). All exhaust ducts are additionally sealed per SMACNA Seal Class A. Most of the return air is also exhausted due to the buildings medical implications. However, the return air is exhausted through exterior walls with a fan provided just within the exterior wall.

Ventilation System Controls (Section 5.3)

The supply fans for the AHUs run only on an occupied/unoccupied basis; there is no consideration of part load occupancy. In the occupied mode the control panel will enable the fan and modulate speed to maintain duct pressure. When the spaces are unoccupied the fan will be off unless any space temperature falls below the night setback temperature set-point of 62°F or rises above a set-point of 85°F.

An airflow measuring station serves the air handling units on each floor where the outdoor air intake is. The system also includes outdoor air economizers, in which case minimum outdoor air dampers have been included at the inlet to provide accurate airflow measurements in economizer mode.

Airstream Surfaces (Section 5.4)

According to the specifications for obvious equipment, surfaces that are in contact with the airstream will have to comply with the 2004 requirements of ASHRAE 62.1. Therefore, it can be assumed to meet the standards under such tests as UL 181 or ASTM C 1338 for resistance to mold growth and erosion. Further investigation into the construction of certain mechanical devices will yield the use galvanized metals as well as specific cleaning and installation for the prevention of debris and particulates.

Outdoor Air Intakes (Section 5.5)

Each floor features two mechanical rooms: one that houses the floor's air handling unit and the other who's main airside function is for exhausting the return and exhaust air therefore separating the outdoor air intake from the return/exhaust relief by the entire length of the building. Lab air as well as the basement floor air is ducted up to the roof and exhausted by rooftop fans where there is no intake equipment.

All outdoor air intakes are equipped with louvers in which air-performance, water-penetration, and wind-driven rain ratings are compliant with the equivalent tested manufacturer equipment per AMCA 500-L. Louvers are also manufactured with a gutter in the frame as well as on each blade and the sill is steeply sloped preventing water accumulation. For extra protection access doors and slopes to drainage are included in all outdoor air intake equipment that adjoins to these louvers. All outdoor air intakes are equipped with ½"x½" bird screens to prevent nesting.

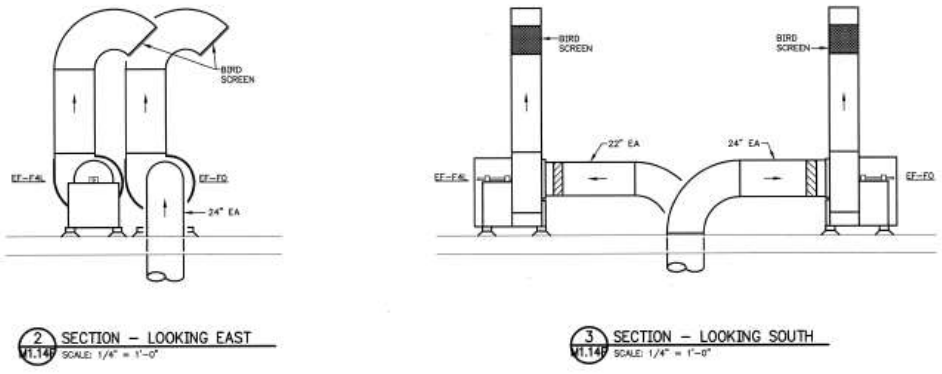


Figure 3. Bird Screens and Goosenecks

Local Capture of Contaminants (Section 5.6)

This section is not applicable. See Section 5.8 *Particulate Matter Removal* for related material.

Combustion Air (Section 5.7)

There is no combustion or fuel burning equipment within the building. The power system requires a natural gas generator. However, the generator and equipment are located outside the building and thus are exhausted outside the confines of the building.

Particulate Matter Removal (Section 5.8)

The main air handling units contain 4" thick filters that have a MERV rating of 11. These are the pre-filters within the system. All other air distribution devices such as the terminal units are supplied with 2" filters, which are downstream from the cooling coils, which have the potential to harbor microbial growth. These filters have a MERV rating of 7 and achieve an arrestance of 90%. The downstream filter rating meets the minimums established in ASHRAE standard 52.1 and 52.2.

Dehumidification Systems (Section 5.9)

The standard requires that upper limit of relative humidity (RH) be set at 65% for the space air. The air handling units in this building have a heating coil preceding the cooling coil in-order for the cooling coil to extract the moisture out of the air as it conditions the air to the correct supply temperature. The temperature drop through the cooling coils effectively accommodates a relative humidity that is less than 65%.

Drain Pans (Section 5.10)

The requirements laid out in this section apply only to the building air handling units and fan coil units which contain cooling coils; terminal units contain only heating coils. The air handling and fan coil units that contain cooling and/or dehumidification coils are compliant with the specific requirements for drain pan slope and size as well as drain outlet size. In addition, the selected air handling units contain the drain pans within a double-wall construction with foam insulation in-between to seal the moisture tight, further preventing the spread of microbial contaminants in the event there is standing water or a blockage in the drain.

Finned-Tube Coils and Heat Exchangers (Section 5.11)

In addition to the above mentioned equipment for dehumidification coil drain pans; all condensate producing heat exchangers are equipped with drainage for consequent water within the shell of the exchanger. The drainage is compliant with the requirements in this section and is connected with by a hose for removal.

No finned-tube coils are used in the heat exchangers; heat exchangers are shell and tube construction with seamless copper tubes.

Humidifiers and Water-Spray Systems (Section 5.12)

There are no humidifiers and/or water-spray systems present in either of the two types of air handling units used, nor is there any system that makes use of these components anywhere else in the building.

Access for Inspection, Cleaning, and Maintenance (Section 5.13)

Access to all equipment is provided by the appropriate clearances for service and maintenance. It is implied in each device's installation section of their specification to be compliant with manufacturer clearances. The equipment which includes all air handling units, fan coil units, and terminal units

are manufactured with access doors or removable panels for access to parts requiring service, adjustment, cleaning, or maintenance. It is additionally important to note that all equipment requiring drain pans have access to these areas.

As demonstrated in the air handling unit below there is an access door for the following: air intake/mixing plenum section, filter access, downstream section of heating coil, fan section, and one for the discharge plenum which is downstream of the cooling coil. This is compliant with the standard and also denoted by the manufacturer in the specifications for periodic maintenance and inspections.

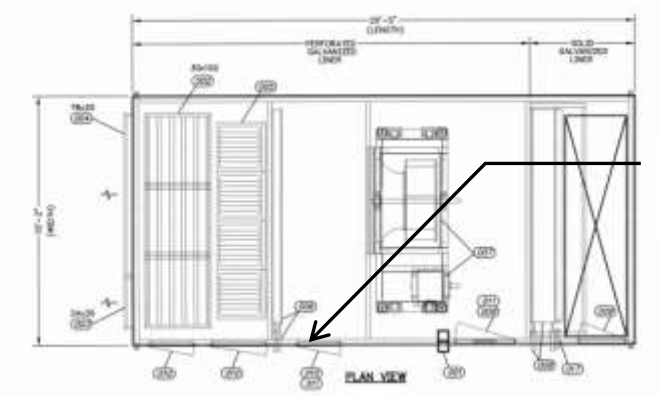


Figure 4. Plan View of Air Handling Unit with Access Doors

Building Envelope and Interior Surfaces (Section 5.14)

Air and vapor barrier systems within the building envelope establish a continuous barrier to air infiltration/exfiltration and water vapor transmission while also acting as a liquid water drainage plane flashed to discharge any incidental condensation or water penetration. Since a large part of the exterior façade is brick veneer, weeps are included in the exterior wall construction to allow water to pass through into the air space via wicks. Joint sealants and caulking provide continuous weather tight construction along with flashing, transition tape, drainage mats and the membrane roofing, which is aided by roof drains.

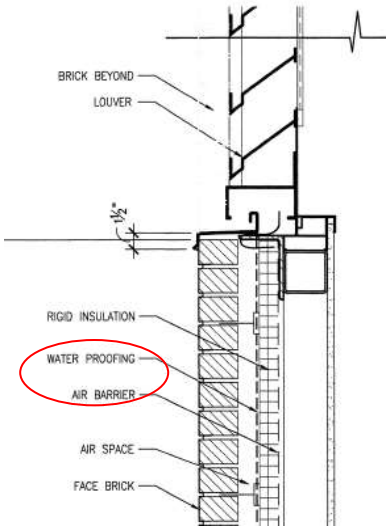


Figure 5. Exterior Wall Section indicating Weather-Proofing

Interior equipment that has the potential to generate condensation such as supply ducts, various piping, and other mechanical equipment are fitted with thermal insulation and vapor retarders as necessary. Similar to barrier/water prevention connections being made for all walls, foundation, windows, doors, roof, etc. with retarders and sealants, all joints, seams, and penetrations in ducts and piping are ensured to be sealed.

No measures are taken for radon infiltration from the ground or other soil gas contaminants. There is also no indication of the authority having jurisdiction requiring extra measures be taken.

Buildings with Attached Parking Garages (Section 5.15)

The building has a parking garage on the ground floor that is accessed by several stairwells and elevators. Entry to the elevators and one stairwell is provided through a lobby, which is positively pressurized while a vestibule serves the other stairwell. Each of these egress spaces is designed to limit the entry of vehicular exhaust.

Air Classification and Recirculation (Section 5.16)

All floors are served only by the air handling unit on that floor. Toilet rooms, janitor closets, and equipment rooms are the only rooms, which are exhausted. The remainder of spaces on each floor is designated as either Class 1 or Class 2 and each air class is only re-circulated with its own class. Lab fume hoods are also exhausted from the spaces containing them.

Requirements for ETS Areas and ETS-Free Areas (Section 5.17)

Not applicable. Smoking is prohibited throughout the building.

Chapter 6. Ventilation Rate Calculations Procedure

The section provides the ventilation rate procedure used to design each ventilation system within the building. The approach is based on the minimum outdoor air that will be required based on the

space area, occupancy, and room design. The section also includes the minimum ventilation rates in the breathing zone which will be utilized for the analysis. However, OU Children's Medical Office Building has been considered to be a healthcare facility, so ASHRAE Standard 170, Ventilation of Health Care Facilities, is also used.

Oklahoma University Children's Medical Office Building is a tenant fit out construction. Therefore, as floors and spaces are leased the floor plans are developed and designed base on the ventilation needed for those particular spaces. Currently, floors two, eleven, and twelve have yet to be occupied by tenants. However, each of the three floors is sized with an air handling unit that will provide 4000 CFM of outside air for the entire floor area. Once occupied, the air handling units with be adjusted to provide the correct amount of outdoor air required based on the ventilation calculations in this section.

Already included above (under the Mechanical Section, Ventilation) was a summary of the floor by floor outdoor air currently being supplied, the amount of outdoor air that will be required, and whether or not these rates are compliant with the corresponding ASHRAE standard. Further analysis of room by room outdoor air ventilation rates can be found in Appendix A.

Load Calculations

The loads presented and energy consumed by Oklahoma University Children's MOB was obtained through Trane's load calculation and energy simulation software, TRACE 700. The software makes calculations based on the user input and guideline criteria established by the American Society of Heating, Refrigeration, and Air Condition Engineers (ASHRAE).

Design Conditions

Based upon the weather data and the design documents a general thermostat setting is used, shown in Table 1. This was created as the default for all of the spaces in the building; however, thermostat settings could be changed on a room by room basis if a specific space has required so. For the purposes of this analysis all of the spaces use the thermostat design settings in the following table.

Table 5. Thermostat Setting

Thermostat Design Settings	
Cooling Dry Bulb [°F]	75
Heating Dry Bulb [°F]	72
Cooling Dry Bulb [%RH]	50
Cooling Drift Point [°F]	81
Heating Drift Point [°F]	64

Model Design

The medical office building is a tenant fit-out construction project and thus requires the use of 12 air handling units (AHU). A single air handling unit is used to serve each of floors; one basement floor below the parking garage and 11 floors above the parking deck. Therefore as a building floor is leased out, the air handling unit that serves the floor becomes operable. Currently only three and half floors have not become occupied.

The model for the building defines zones room by room. Since there are a wide variety of rooms, each room was inputted into the software individually as opposed to using block loading. For example, an interior block along the east face of the building envelope may contain everything from an exam room to library to laboratory, thus the need to evaluate each room individually.

Load Assumptions

The loads for the building were based upon the supposed occupancy due to the space types established in the construction documents. Rooms were selected based upon a sufficient amount of space templates created from the design documents, which will be described in more detail later. For rooms where sufficient information could not be gathered from the construction documents, comparable room properties provided by the software (set forth by ASHRAE) were used. The general space characteristics used follow.

Occupancy Assumptions

Occupancy numbers and densities are given for the sixteen general room templates in Table 2. The number and density for each room has been acquired from the interior architectural drawings provide by Miles Associates and from general densities provided by TRACE from ASHRAE literature. Upon creating the individual rooms if a single room varied from a given template then the occupancy was independently input. There are a total of 738 rooms in the building created from the templates displayed below.

Table 6. Common Room Occupancy

Space Templates	Occupancy	
	No. of Persons	Persons per Square Foot
Office	1	-
Conference	-	20
Patient Room	2	-
Basic Storage	0	0
Special Storage	0	0
Equipment Room	2	-
Laboratory	-	33
Work	-	143
Break Room	3	-
Copy/Printing	0	0
Reception	-	17
Waiting	3	-
Corridor	0	0
toilet	0	0
Changing/Locker Room	0	0
Library	-	50

Lighting and Equipment Electrical Load Assumptions

The lighting equipment described in the MEP design documents was used for each of the room templates. Generally, the lighting equipment used on each floor for each space was the same and was approximately two watts per square foot. Additionally for rooms where lighting would typically be off for the majority of the day a lower wattage per square foot was used for the individual room, such as janitor closets.

The building in examination is a medical building, which means that the equipment load is generally more than a basic commercial office building. This plays a significant factor in the load analysis. The majority of the spaces in the building are patient, procedure, and exam rooms which are typically considered to have sufficient densities of mechanical equipment which use electrical power. Laboratories and other special equipment rooms such as X-Ray rooms are also present within the medical office building. General lighting and miscellaneous equipment power densities for the room templates are given in Table 3, below.

Table 7. Space Lighting and Equipment Loads

Space Templates	Lighting Loads [W/ft^2]	Miscellaneous Equipment Loads [W/ft^2]
Office	1	1
Conference	1	1
Patient Room	1	2
Basic Storage	1	0
Special Storage	1	2
Equipment Room	1	2
Laboratory	1	1
Work	1	1
Break Room	1	2
Copy/Printing	1	2
Reception	1	1
Waiting	1	0
Corridor	1	0
Toilet	1	0
Changing/Locker Room	1	0
Library	1	2

Construction

The basic construction elements for the building were acquired from the construction documents and entered into the room templates as they applied to each one. Then as each specific room was created, the building envelope materials were applied at the correct angle from North. Much of the office and exam rooms are located at the exterior walls facing north and east. Each of the spaces contained at least one window that was correctly applied to the exterior wall. On the west face of the building, corridors and waiting areas are situated and contain a continuous glass curtain wall along the entire face.

The typical construction assemblies are laid out in the table below. The elements used in the design were as closely matched to those provided by TRACE.

Table 8. Typical Construction Assemblies

Glass	Type	U-Factor, Btu/hr-ft^2-^{o}F	Shading Coefficient

Window	6mm Double Pane Low-E, Clear, 13mm Air Space	0.293	0.48
Door	Standard Door	0.20	0.00

Construction	Type	U-Factor, Btu/hr-ft^2-^{o}F
Slab	4" Light Weight Concrete	0.213
Roof	8" Heavy Weight Concrete, 4" Insulation	0.065
Wall	Metal, 2" Insulation	0.130
Partition	3/4" Gypsum Wall Board Framed	0.388

Schedules

Occupancy schedules for people, lights, and miscellaneous loads were utilized during normal work hours because Oklahoma University Children's Medical Office Building is mostly an office building. Loads during the day are much higher than at night with off peak hours of 11:00pm to 7:00am used during the weekday.

Calculated Load vs. Design Load Analysis

The calculated loads using Trane's software proved to be accurate with what was previously designed for, as can be seen in Table 9. The majority of the error that exist can be pin-pointed to the basement floor. First and foremost, bathrooms, corridors, and waiting areas were all accounted for in the TRACE model. Typically these rooms would not be set to receive a significant amount of design airflow. However, between the exterior spaces and the interior space there is ample corridor and waiting space which makes up a sufficient amount of the total floor area. In the model, the waiting areas were design to have an occupant density. Additionally, majority of the floors have areas designated for future construction or what is denoted as available or open office space. These spaces were applied as offices in the model. The total error in the calculated airflow versus the designed airflow only amounts to 1.21 percent.

Table 9. Airflow Comparison

Floor	Design vs. Calculated Airflow		
	Designed [cfm]	Calculated [cfm]	Percent Error
Basement	15000	10929	27.14
Third	25000	25854	3.42
Fourth	25000	25498	1.99
Fifth	25000	25829	3.32
Sixth	25000	26242	4.97
Seventh	25000	25692	2.77
Eighth	25000	26070	4.28
Ninth	25000	23254	6.98
Tenth	25000	23039	7.84
Total	**215000**	**212407**	**1.21**

Part II: Proposed Redesign

Proposed Alternative

The alternative being proposed herein, a variable refrigerant flow system serves only as an alternate to the current system and in no way is to represent a better or more correct design for the medical office building. The system will be studied as a viable option throughout the semester and evaluated as being a plausible or not option for design.

Mechanical Depth

The variable refrigerant flow system (sometimes referred to as variable refrigerant volume, VRV) is a system that was found to be a worthwhile study when evaluating several options for the Oklahoma University Children's MOB. VRF technology is not a cutting edge system; it has been popular in China, Japan, and parts of Europe for several decades, but until recently it was not popular among the HVAC industry within the United States.

The important factors that caused this system to take precedence for the Medical Office Building are as follows:

- system high efficiency,
- increased controllability,
- possibility of simultaneous heating and cooling,
- a comparably small footprint, and
- possible decreases energy consumption and emissions

It is important to note however that the cause for the small footprint is partially due to less ductwork or none at all. Essentially, VRF systems do not need ducting and the only purpose for ducted air would be to supply adequate outdoor air ventilation. Since the building in question is an office building with medical intentions, reducing ductwork must be done carefully and appropriately so as not to induce an unhealthy environment. Additionally ASHRAE has set standards for amounts of refrigerant used in enclosed quarters and within significant rooms, such as patient rooms.

Typically, most hospitals and healthcare designated buildings have spaces, which require one hundred percent outdoor air. This is to mitigate stagnate air, improve patient comfort levels, and most importantly mitigate the spread of airborne illness. Therefore, in designing the VRF system it is of utmost concern to keep rooms, which are deemed sensitive to stale air connected to a supply of air that meets its minimum outdoor air requirement. The VRF system design will be similar to the diagram below with multiple outdoor condensing units each serving a multitude of spaces.

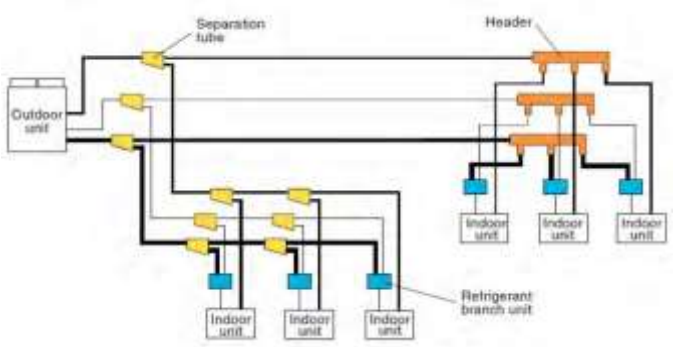


Figure 6: Typical Layout of a VRF System (taken from ASHRAE)

Acoustics Breadth

The changes proposed above to incorporate VRF boxes into each space should reduce the sound created by air handling units in the mechanical spaces and each of the individual occupied spaces. This is mainly due the absence of the originally required VAV boxes, which were designed to serve individual spaces and zones. It is reported that indoor units for VRF systems operate at sound levels as low as 27 dB and 29 dB when they are connected to supply air duct work.

Spaces will be studied to find if the airborne noise generated by the VRF system are comparable to the existing system. If they prove to be significantly higher than the existing sound power levels redesign of the air supply and indoor equipment will need to take place. The sound power level of two systems will be compared through the noise criteria rating and that which is standard for the type of room. Redesign would consist of implement sound reducing equipment such as duct silencers, Z-walls for mechanical rooms, or ever relocation of VRF indoor evaporator units. In this analysis acoustical properties of building materials and mechanical equipment will be evaluated using applicable American National Standards Institute standards, basic architectural acoustics calculations, ASHRAE acoustics guidelines, and Excel.

Electrical Breadth

With the implementation of different mechanical equipment and the exchange of others, it will be important to investigate whether the existing electrical distribution equipment is adequate for the new VRF equipment. Electrical equipment such as conductors, circuit boards, and conduit are going to need to be sized according to their characteristic load amps, horsepower, and voltage. Motor starters will be sized for any mechanical equipment such as pumps and fans applicable to the VRF system design. The National Electric Code will be utilized for all of the sizing and calculations.

Redesign Introduction

The mechanical redesign of Oklahoma University Children's Medical Office Building was based solely on the heating, ventilating, and air-conditioning side of the existing mechanical systems. As analyzed in the Part I of this document, the building heating and cooling was found to be served by the hospital main chilled water and heating water plants, which serve all the buildings on the hospital campus. The first opportunity that presented itself was to isolate the Children's Medical Office Building from the central plants or at least partially.

In order for this to work the MOB would need to be connected to its own plant for heating and chilled water or similar. This needed to happen because the existing air handling units utilize both services from the plant and the floor VAV boxes utilize the heating water for reheat purposes after treatment from the AHUs. Upon analyzing the loads and the climate in the prior investigating, I wanted to try a refrigerant system in some capacity since its seemed optimum under these conditions. Finally research was conducted and a VRF system was chosen to replace the existing heating and cooling loads imposed on the current system.

Redesign System Operation

A VRF System (variable refrigerant flow system) can be thought of as similar to a multi-split system, where a space has an interior fan coil units (the evaporator units) connected to an outdoor condensing unit. A multi-split system supplies a constant amount of refrigerant needed to treat the space based on an "ON" and "OFF" regime. VRF Systems however are able to supply more than one zone with significantly more indoor units connected to a single outdoor unit as well as variable the amount of refrigerant required to treat space loads. This system is more applicable for larger buildings with multiple zones. The fan coil units are different than typical fan coil unit which utilize hydronic heating and cooling. The fan coil units in a VRF system are connected to the outside condensing unit via a series of pipes containing a refrigerant, which is typically R-410A, for both heating and cooling. It is important to remember that it is the refrigeration cycle that cools the space and the reverse process, the heat pump cycle, which heats the space.

The units and connecting refrigerant piping system vary by manufacturer, but each manufacturer usually offers a two pipe system and a three pipe system (excluding Mitsubishi Electric). The two pipe systems are called heat pump systems. These systems utilize a supply line (to the indoor units) and a suction line (back to the condenser), hence the term two pipe. A two pipe system can only do heating or cooling. This can pose a problem in the winter when some zones require heating while others require cooling. This can also be an issue with occupant comfort.

The three pipe systems, also called heat recovery VRF systems, utilize a third pipe, the discharge line. In two pipe systems the refrigerant, supply, line carries the refrigerant in liquid form for cooling and gas for heating to the indoor units from the outdoor unit. In the heat recovery system, on the other hand, the condensing unit supplies the refrigerant as gas in the discharge line and refrigerant as liquid in the supply line to a device called a branch selector, which is also connected to a suction line. The indoor fan coil units are connected to their inherent branch selector via a supply and return line, where the supply line can be used to supply either gas or liquid refrigerant. By using a series of valves and a heat exchanger at the branch selector, the return line can transfer

heat to the hot gas line. In this way, the heat recovery option can provide simultaneous heating and cooling. A simplified diagram, below, is provided to show this process.

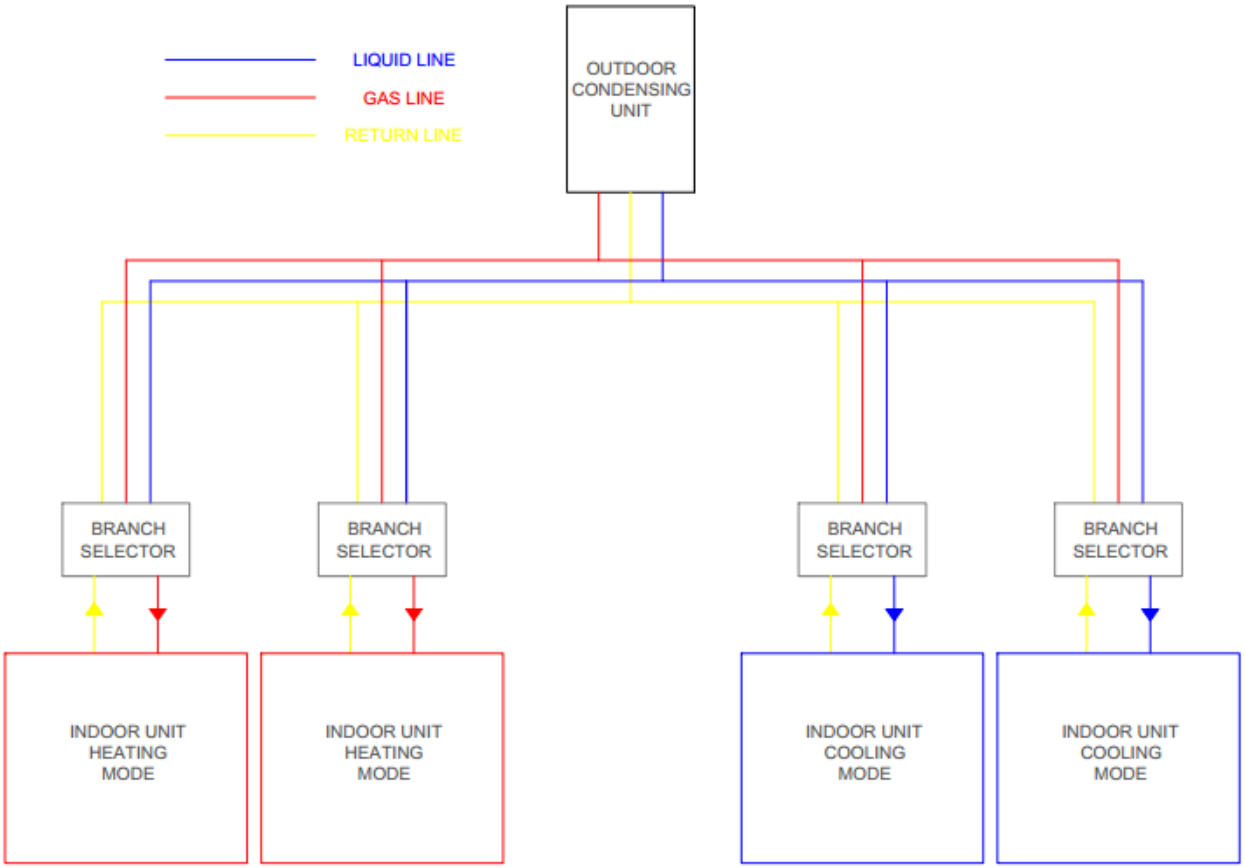


Figure 7. VRF Heat Recovery Diagram

VRF Design & Model

The three-pipe, heat recovery, VRF system was chosen for the redesign of the building based on the layout of the building and the incentive for extra savings. The building construction provided the optimum opportunity for heat recovery due to the interior and perimeter spaces divided by a continuous corridor. It was assumed that throughout the year spaces on the exterior would need heating while those on the interior may require cooling and vice versa. In addition, the majority of the spaces that have higher equipment loads due to medical and laboratory devices are in the interior of the building whereas offices, patient rooms, and waiting rooms are all at the exterior.

Like the existing system, the VRF system was modelled in TRACE which allowed for simple comparison. The VRF model utilized equipment and settings similar to that of Daikin-AC's VRV heat recovery line (VRV being another acronym for VRF coined by Daikin). The analysis found that the loads on each floor were substantially more than any single condensing unit offered by any of the existing VRF system manufacturers in the industry. Therefore each floor had to be divided into zones that would each be served by its own individual condensing unit. The total cooling and heating demand can be found in the table below, Table 10.

Table 10. VRF Cooling and Heating Required

Floor	Cooling [tons]	Heating [MBH]
0	20.8	106.9
3	40.4	59.5
4	39.0	60.4
5	39.6	56.2
6	42.9	61.3
7	41.1	60.7
8	40.3	61.1
9	33.8	51.5
10	35.4	53.4

It was found that the interior spaces account for the majority of the total spaces on each floor, while the perimeter spaces account for the majority of the loads on each floor. The best layout for the refrigerant system was discovered to have the interior spaces on each floor served by a single condensing unit and the exterior/perimeter spaces served by another condensing unit. This is design for each of the eight above ground floors that a currently occupied. The total of the basement loads is significantly less than that of above ground floors so it only needed one condenser unit. Both the exterior and interior spaces for the below ground floor (basement) were considered to be one single interior zone. The zones for each of the floors being redesigned can be seen below. For each of the following floor plans, the interior zone is represented in blue; while the exterior zone is represented in red.

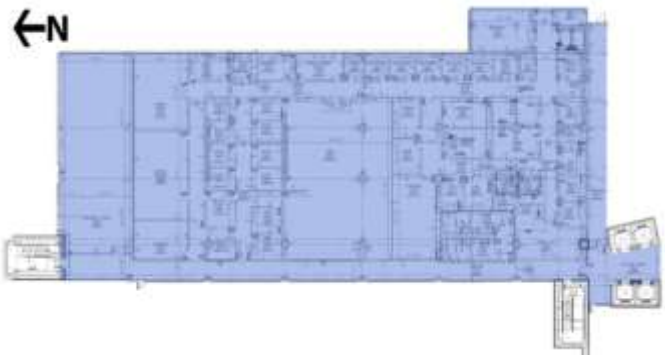


Figure 8. Basement Floor (Floor 0) Zoning

Figure 9. Third Floor Zoning

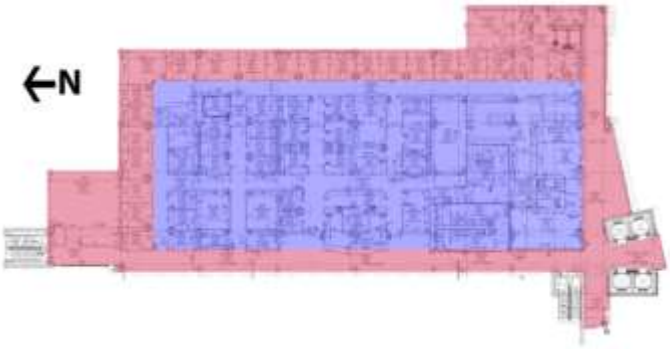


Figure 10. Fourth Floor Zoning

Figure 11. Fifth Floor Zoning

Figure 12. Sixth Floor Zoning

Figure 13. Seventh Floor Zoning

Figure 14. Eighth Floor Zoning

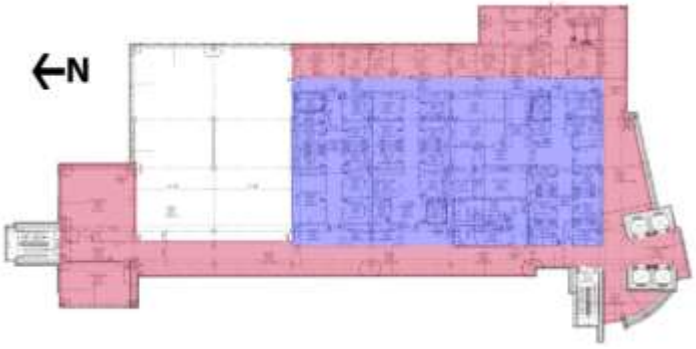


Figure 15. Ninth Floor Zoning

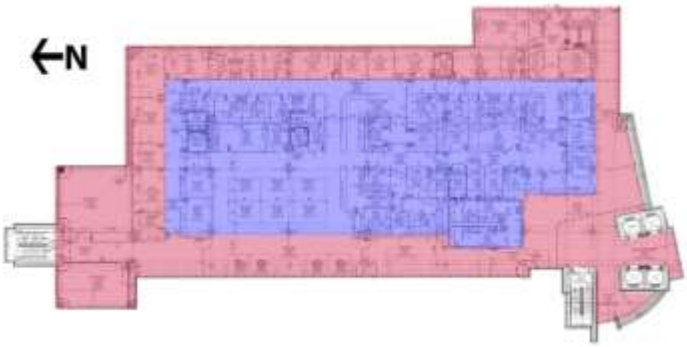


Figure 16. Tenth Floor Zoning

Furthermore, pressure drop had to be considered when creating the zones, and the entire system. Each manufacture gives the distances of allowable total, vertical, and lateral refrigerant piping for their VRF systems. These distances are extremely important as the condenser units are usually located offsite or on the building roof and the refrigerant piping diameter remains small in comparison to hydronic piping. Both of these factors introduce pressure concerns, which are inherent in all VRF systems. The allowable distances given by the manufacture of which this design is based upon are the following:

- 540 linear feet of piping between condensing unit and furthest located fan coil unit or equivalent;
- 3,280 total one-way piping in the complete piping network;
- 164 feet in vertical separation between the condensing unit and the fan coil units;
- and 49 feet in vertical separation between fan coil units.

The assumption has been made that the condensing units will be placed on the roof of the MOB. However, the distance from the basement level to the rooftop (127 ft) exceeds the maximum allowable vertical separation between condensing and evaporator unit. Therefore, the condensing unit which serves the entire basement level will have to be located on grade level or elsewhere. The indoor units were not laid out so it is assumed they meet the requirements by creating two separate systems for each floor: the interior zone and exterior zone.

By designating the rooms to their respective zones, the coil loads were retotaled by zone to find the appropriate sizes for condensing units. Once the new condensing units were selected, the zones were paired with it, which placed each zone on their own system within that model. The coil loads that were used for sizing the zone condenser units were calculated based on the peak loads. This allowed for leeway when selecting the condenser because is it unlikely that all the spaces within on each system will peak at the same time. It was found that the rule of thumb for sizing an outdoor unit is between 70-130% of the combined space loads. The units sized for the Children's Medical Office Building, given below in Table 11, were sized near 100% required cooling load within 0.06 tons.

Table 11. Condenser Schedule

Floor/Units	Condenser Unit Sizes	
	Interior Zone [tons]	Exterior Zone [tons]
F0/CU-1,CU-2	20	-
F3/CU-3,CU-4	10	28
F4/CU-5,CU-6	12	26
F5/CU-7,CU-8	12	26
F6/CU-9,CU-10	12	28
F7/CU-11,CU-12	10	28
F8/CU-13,CU-14	10	28
F9/CU-15,CU-16	8	26
F10/CU-16,CU-17	8	28

Finally, the VRF system was paired with a dedicated outdoor air system (DOAS) for the purposes of ventilation. Each floor was given a single DOAS unit in place of the existing air handling units. The DOAS units will utilize the chilled and heating water (hydronic) piping at far less capacity than the existing AHUs to treat and provide 100 percent outdoor air to the spaces. As the existing VAV system remains ducted supply, the outdoor air will also be ducted to the indoor VRF units. The existing building return and exhaust was converted to be only exhaust at approximately the same flow rates as the incoming outdoor air at each DOAS unit.

VRF Evaluation and Comparison

Overall the VRF system paired with the DOAS outperformed the existing VAV system design. The VRF heat recovery systems reduced to the building gas consumption to almost zero, the annual electrical consumption by 11%, and the annual emissions by approximately 500,000 lbs. of equivalent CO_2. Majority of the savings can be attributed to the use of heat recovery within the VRF system. This significantly reduced the yearly heating costs which accounted for 22% of the entire building energy use in the existing design. The costs due to electricity usage are the largest energy saver for the building when comparing the two designs. The annual energy savings are understood by the following graph.

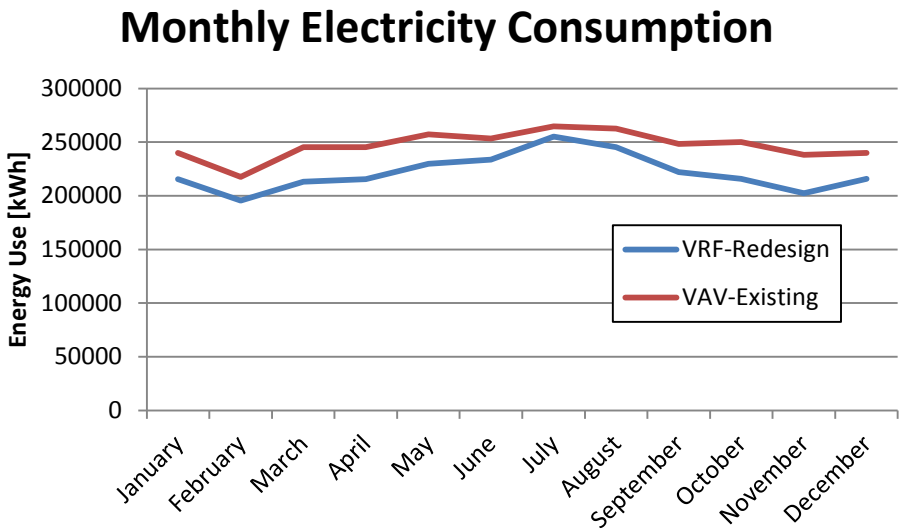


Figure 17. Annual Electricity Comparison

Additionally, the VRF system is ideal for part load conditions. Historically, VRF system efficiency is better than the variable air volume systems when operating at capacities less than 70% because they can control the amount of refrigerant needed to offset loads faster and more accurately; conventional hydronic pumps and HVAC fans cannot. Overall, this leads to VRF systems achieving an excellent coefficient of performance and seasonal energy efficiency rating. The following diagrams document the energy consumption comparisons.

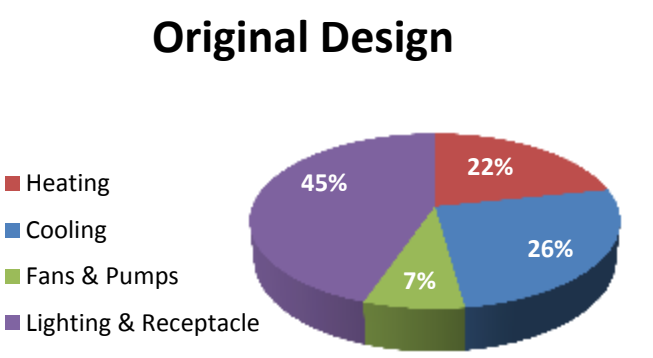


Figure 18. Original Cost Breakdown

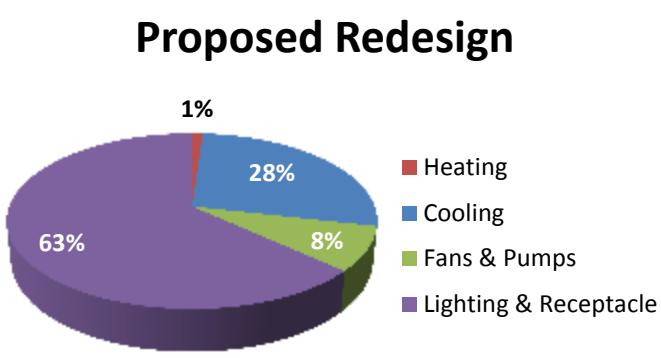


Figure 19. Proposed Design Cost Breakdown

It is easy to see how the lighting and receptacle loads accounted for the majority of the energy costs in both cases, but yields a larger fraction of the consumption for the redesign when the heating is drastically reduced. The proposed design did, however, result in a slightly higher pump and fan cost due to the 17 condensers needed to supply the building refrigerant load.

Although Figures 18 and 19 depict an increase in fan and pump costs, the fans themselves, exclusively the DOAS units, require approximately 200,000 MBtus less than the existing system each year. This data is provided in the following as well as the reduced flow rate required the DOAS system compared to the VAV system.

Table 12. Air Handling Units vs. Dedicated Outdoor Air Units

Fan Energy Savings		
Original Design [kBtu/yr]	Redesign [kBtu/yr]	Energy Saved [kBtu/yr]
969700	741400	**228300**

Table 13. Airflow Comparison

Floor	Required Airflow		
	Original Design [cfm]	Redesign [cfm]	Percent Difference
Basement	10929	8912	18.46
Third	25854	25225	2.43
Fourth	25498	18438	27.69
Fifth	25829	21691	16.02
Sixth	26242	23180	11.67
Seventh	25692	21704	15.52
Eighth	26070	25412	2.52
Ninth	23254	19379	16.66
Tenth	23039	20708	10.12
Total	**212407**	**184648**	**13.07**

Acoustics Breadth

In addition to increased comfort resulting from increased controllability and simultaneous heating and cooling provided by the heat recovery VRF system, sound power levels of VRF indoor units tend to be lower than VAV terminal units. In this analysis, the VAV terminal units supplied by the floor air handling units will be compared to the VRF fan coil units paired with the ducted DOAS units on each floor. The comparisons of the sound power levels resulting for the mechanical equipment are provided in Appendix B. Below, the analysis of one floor is detailed, while each consecutive floor is examined in the same process.

Based on the existing basement floor air handling unit supply and return fan capacities, the following sound power levels were acquired from ASHRAE databases that contain typical sound power data per fan flow rate, ton, and total static pressure.

Table 14. Existing AHU-F0 Sound Power Levels

Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
Supply Fan Power Level, L_w (dB)	94	94	88	87	85	83	78	72
Return Power Level, Lw (dB)	84	86	77	77	76	74	64	60
Combined Sound Power Level, L_w (dB)	94	95	88	87	86	84	78	72

The sound power data for the basement floor DOAS unit were acquired in similar fashion, but based on the flow rate and characteristics given from the TRACE energy and load model. They are as follows:

Table 15. Proposed DOAS Unit and Exhaust Fan Power Levels

Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
Supply Fan Power Level, L_w (dB)	90	91	85	84	84	81	76	71
Exhaust Fan Power Level, L_w (dB)	76	77	76	73	71	68	65	60
Combined Sound Power Level, L_w (dB)	90	91	86	84	84	81	76	71

The existing design incorporates a separate mechanical room where all floor air is exhausted via an exhaust fan. For the proposed design, there is no return fan since it is 100% outdoor air. Therefore, it was decided upon to combine the DOAS supply fan power levels with the exhaust fan sound power levels because by placing both pieces of equipment in the same mechanical room we create a worst case scenario in relation to noise levels. However, another important reason for doing this was to allow for future heat recovery if desired by the building owner. By pairing the exhaust of warm air with the inlet of outdoor air that's needs to be treated in the same mechanical room, a flat plate heat exchanger or similar could be incorporated to transfer reject heat.

Next the sound power data for each terminal unit was obtained from manufacture data based on the existing system design and redesign. This data is provided in the table below. It is clear that the

initial sound power levels of the VRF indoor unit a significantly lower than those of the VAV terminal unit.

Table 16. Terminal Unit sound Power Levels

Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
VAV Sound Power Level, L_w (dB)	60	60	54	44	42	39	34	34
VRF Sound Power Level, L_w (dB)	44	49	40	37	38	34	22	14

Once all of the acoustical data for the equipment was found, the path of the supply air to the terminal units was traced to the nearest room. Each floor system air supply was followed from the air handling device to a nearby room, which happened to be different on each floor providing a more encompassing analysis.

To calculate the sound power level at the room/space diffusers the attenuation due to ducts and other equipment for their respective lengths/dimensions was subtracted from the initial sound power level at the air handling equipment. When the sound level accounted for all attenuation up to the inlet of the terminal device, the VRF indoor unit or VAV box sound power levels were factored in and the attenuation from the terminal unit outlet to the diffuser followed. At this point all attenuation due to mechanical equipment has been accounted for in the space sound power levels. These values are the fully attenuated sound powers levels existing in the space due to the terminal box and air handling device (AHU or DOAS Unit) upstream from the device. All attenuation values were obtained from ASHRAE as well; they include straight duct length for various types of duct, elbows, transitions, split, etc.

Finally, the values for each design were converted to sound pressure levels and plotted against room criterion (RC) curves. The results for the mechanical system sound power levels and sound pressure levels that are present in the nearest room, Waiting Room 0300 (for the basement floor), are provided in the following table and plotted on the accompanying RC graph.

Table 17. Room Sound Power and Sound Pressure Levels

Octave Band (Hz)	63	125	250	500	1000	2000	4000	8000
VAV-AHU Sound Power Level at Room	60	63	62	23	6	0	43	44
VAV-AHU Sound Pressure Level	49	52	51	12	0	0	32	33
VRF-DOAS Sound Power Level at Room	55	60	58	13	0	0	7	6
VRF-DOAS Sound Pressure Level	44	49	47	2	0	0	0	0

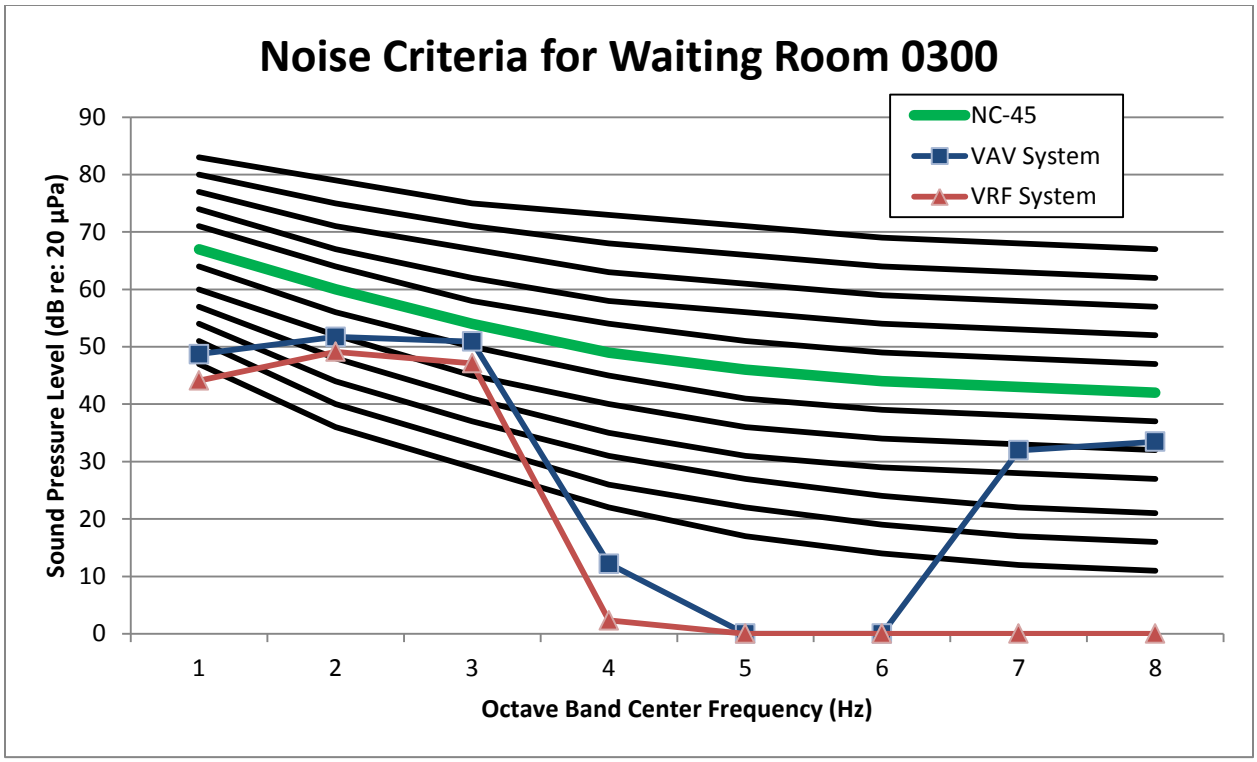


Figure 20. Noise Criteria Curve

The noise criteria value, which is a value based on standard background noise levels generated by certain types of equipment in certain settings, can be obtained by moving the nearest NC curve down to the highest point plotted for each system. For this case, the NC value for the VAV system is approximately 41, whereas the NC value for the VRF system is 36. This means that the VRF indoor unit coupled with the DOAS unit rates lower on the amount of background noise inherent in the waiting, i.e. the VRF system performs better acoustically in this situation as higher NC values equate to more background noise. Research conducted found that a typical NC value for a waiting room should be no higher than 45, which means that both systems are acoustically sound designs not requiring any redesign.

The entire process was carried out in excel spreadsheets which can be viewed in Appendix B. It is important to note the because of the reduced airflow necessary for the VRF system, the duct layout to each of the nearby room was resized based on the proposed airflow rate calculated previously. Overall, each room and system studied resulted in very similar NC values between the two designs, therefore no redesign was necessary. It can be assumed that for all of the rooms at further distances from the AHUs and DOAS units the NC values will be even lower.

Electrical Breadth

The VRF system design determined that 17 outdoor condensing units would be needed to supply the indoor units and loads present within each zone. The system also included the replacement of the existing 12 air handling units with DOAS units. Although only 9 floors are currently occupied the existing AHUs had to be sized and included in the design due to their location within the building on each floor. Likewise, twelve DOAS Units would also need to be placed within the building before the construction commences enclosure. There this analysis was included to size the existing connections of the air handling units (as one was not provided), followed by sizing the electrical equipment for the DOAS units. Finally a simple comparison was made to check whether the electrical distribution system could support the new system.

The process was pretty straightforward by following the National Electrical Code. The connections that would be necessary to support the existing electrical connections were calculated in excel using several equations and rules of thumb found within the NEC. The connections for the existing AHUs are shown below.

Table 18. Connection Schedule for the Air Handling Units

Air Handling Unit Schedule													
Unit	Volt	Phase	Fan HP	FLA	kVA	Wire	Wire amps	Conduit	Starter	Load Amps	CB Size	Gnd Size	Disc. A
AHU-F0	460	3	20	27	12.4	#10	33.8	3/4"	NEMA 2	40.5	45	#10	60
AHU-F2	460	3	30	40	18.4	#8	50.0	1 1/4"	NEMA 3	60	60	#10	60
AHU-F3	460	3	30	40	18.4	#8	50.0	1 1/4"	NEMA 3	60	60	#10	60
AHU-F4	460	3	30	40	18.4	#8	50.0	1 1/4"	NEMA 3	60	60	#10	60
AHU-F5	460	3	30	40	18.4	#8	50.0	1 1/4"	NEMA 3	60	60	#10	60
AHU-F6	460	3	30	40	18.4	#8	50.0	1 1/4"	NEMA 3	60	60	#10	60
AHU-F7	460	3	30	40	18.4	#8	50.0	1 1/4"	NEMA 3	60	60	#10	60
AHU-F8	460	3	30	40	18.4	#8	50.0	1 1/4"	NEMA 3	60	60	#10	60
AHU-F9	460	3	30	40	18.4	#8	50.0	1 1/4"	NEMA 3	60	60	#10	60
AHU-F10	460	3	30	40	18.4	#8	50.0	1 1/4"	NEMA 3	60	60	#10	60
AHU-F11	460	3	30	40	18.4	#8	50.0	1 1/4"	NEMA 3	60	60	#10	60
AHU-F12	460	3	30	40	18.4	#8	50.0	1 1/4"	NEMA 3	60	60	#10	60
TOTALS					214.8								

Notes:
1. Wires are type RHW
2. Conduit material is EMT

The connection schedule for the DOAS units was calculated in a similar based on a 3-phase voltage of 460 V and the calculated fan horsepower need to serve to outdoor air flow rate.

Table 19. Connection Schedule for the DOAS Units

DOAS Unit Schedule

Unit	Volt	Phase	Fan HP	FLA	kVA	Wire	Wire amps	Conduit	Starter	Load Amps	CB Size	Gnd Size	Disc. A
DOAS-F0	460	3	7.5	11	5.1	#14	13.8	3/4"	NEMA 1	16.5	20	#12	25
DOAS-F2	460	3	20	27	12.4	#10	33.8	3/4"	NEMA 2	40.5	45	#10	60
DOAS-F3	460	3	20	27	12.4	#10	33.8	3/4"	NEMA 2	40.5	45	#10	60
DOAS-F4	460	3	20	27	12.4	#10	33.8	3/4"	NEMA 2	40.5	45	#10	60
DOAS-F5	460	3	20	27	12.4	#10	33.8	3/4"	NEMA 2	40.5	45	#10	60
DOAS-F6	460	3	20	27	12.4	#10	33.8	3/4"	NEMA 2	40.5	45	#10	60
DOAS-F7	460	3	20	27	12.4	#10	33.8	3/4"	NEMA 2	40.5	45	#10	60
DOAS-F8	460	3	20	27	12.4	#10	33.8	3/4"	NEMA 2	40.5	45	#10	60
DOAS-F9	460	3	15	21	9.7	#12	26.3	3/4"	NEMA 2	31.5	35	#10	50
DOAS-F10	460	3	20	27	12.4	#10	33.8	3/4"	NEMA 2	40.5	45	#10	60
DOAS-F11	460	3	20	27	12.4	#10	33.8	3/4"	NEMA 2	40.5	45	#10	60
DOAS-F12	460	3	20	27	12.4	#10	33.8	3/4"	NEMA 2	40.5	45	#10	60
TOTALS					138.9								

Notes:
1. Wires are type RHW
2. Conduit material is EMT

From a simple comparison of the schedules, it was determined that the total electrical load demanded by the twelve air handlers was larger than that of the DOAS units. Additionally all connections to the DOAS units are smaller than the existing AHU connections. Therefore, a general assumption was made that the main panel board supplying the system power would be sufficient for the DOAS units provided smaller connections are used. Finally, for completeness a connection schedule was made for the 17 outdoor condenser units, which is provided in Appendix C.

References

ANSI/ASHRAE (2010). Standard 62.1 - 2004, Ventilation for Acceptable Indoor Air Quality. Atlanta, GA: American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc.

ANSI/ASHRAE (2010). Standard 90.1 - 2004, Energy Standard for Buildings Except Low-Rise Residential Buildings. Atlanta, GA: American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc.

ANSI/ASHRAE (2010). Standard 170- 2008, Ventilation of Health Care Facilities. Atlanta, GA: American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc.

ASHRAE (2009). 2005 ASHRAE Handbook - Fundamentals. Atlanta, GA: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

ASHRAE (2007). 2007 ASHRAE Handbook - HVAC Applications. Atlanta, GA: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

ASHRAE (2007). 2007 ASHRAE Handbook - HVAC Syetems and Equipment. Atlanta, GA: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

"DOAS Supply Air Conditions." Mumma, Stanley. ASHRAE Jouranl. 2008.

Trane TRACE 700 v.6.2.6.5. Computer Software. C.D.S. Applications, 2010.

APPENDIX A: Ventilation Schedules

No.	ROOM NAME	AHU	No. of People	ROOM DIMENSIONS			ASHRAE 170 Space Designation	ASHRAE 62.1 Space Designation	MINIMUM CFM REQUIRED		
				Area, SF	Height, FT	Volume, CF			SA	OUTSIDE AIR	
									AIA	AIA	IMC
3108	Mech	AHU F-3	0.0	942	8	7,535		Electrical Equipment Rooms			0
3114	Corridor	AHU F-3	0.0	268	8	2,145	Corridor		71	0	
3115	Conference	AHU F-3	15.0	546	8	4,365		Conference/meeting			95
3412	Shared Conference	AHU F-3	6.0	253	8	2,023		Conference/meeting			50
3410	Echo	AHU F-3	1.0	148	8	1,187	Patient Rooms		119	40	
3408	Exam	AHU F-3	2.0	135	8	1,079	Patient Rooms		108	36	
3406	Exam	AHU F-3	2.0	129	8	1,032	Patient Rooms		103	34	
3404	Nurse Work	AHU F-3	2.0	122	8	980	Patient Rooms		98	33	
3402	Vitals	AHU F-3	1.0	84	8	672	Patient Rooms		67	22	
3400	Reception	AHU F-3	1.0	300	8	2,402		Booking/Waiting			8
3401	Toilet	AHU F-3	0.0	72	8	577	Bathroom		96	0	
3403	Exam	AHU F-3	2.0	122	8	977	Patient Rooms		98	33	
3405	Exam	AHU F-3	2.0	122	8	975	Patient Rooms		98	33	
3407	Exam	AHU F-3	2.0	118	8	945	Patient Rooms		95	32	
3409	Echo	AHU F-3	2.0	148	8	1,183	Patient Rooms		118	39	
3414	Phys. Work	AHU F-3	1.0	153	8	1,227	Patient Rooms		123	41	
3415	Echo Work	AHU F-3	2.0	136	8	1,087	Patient Rooms		109	36	
3322	Heart Storage	AHU F-3	0.0	132	8	1,054	Sterile Storage		70	35	
3324	Office	AHU F-3	1.0	161	8	1,286		Office Spaces			5
3314	Consultation	AHU F-3	3.0	252	8	2,015	Patient Rooms		202	67	
3316	shared Break	AHU F-3	3.0	259	8	2,073		Break Rooms			35
3223	Exam	AHU F-3	2.0	144	8	1,151	Patient Rooms		115	38	
3225	Exam	AHU F-3	2.0	146	8	1,168	Patient Rooms		117	39	
3227	Exam	AHU F-3	2.0	143	8	1,140	Patient Rooms		114	38	
3229	Exam	AHU F-3	2.0	138	8	1,101	Patient Rooms		110	37	
3231	Exam	AHU F-3	2.0	144	8	1,149	Patient Rooms		115	38	

3233	Exam	AHU F-3	2.0	146	8	1,168	Patient Rooms		117	39	
3119	Data	AHU F-3	0.0	90	8	721		Telephone/data entry			0
3235	Storage	AHU F-3	0.0	166	8	1,326		Storage Rooms			1
3121	Mechanical	AHU F-3	0.0	461	8	3,692		Electrical Equipment Rooms			0
3118	JC	AHU F-3	0.0	92	8	738		Janitor Closets, Trash Rooms, Recycling			0
3311	Xray/CT	AHU F-3	2.0	485	8	3,879	X-Ray (diagnostic and treatment)		388	129	
3310	Control Room	AHU F-3	1.0	164	8	1,313	Radiology waiting rooms		263	44	
3306	Toilet	AHU F-3	0.0	73	8	586	Bathroom		98	0	
3307	Change	AHU F-3	0.0	40	8	322		Locker/dressing Rooms			0
3309	Change	AHU F-3	0.0	38	8	305		Locker/dressing Rooms			0
3313	Ultra	AHU F-3	2.0	195	8	1,564	Patient Rooms		156	52	
3315	Ultra	AHU F-3	2.0	206	8	1,645	Patient Rooms		164	55	
3313A	Toilet	AHU F-3	0.0	91	8	727	Bathroom		121	0	
3315A	Toilet	AHU F-3	0.0	85	8	677	Bathroom		113	0	
3301	Start Up	AHU F-3	1.0	94	8	755	Patient Rooms		75	25	
3303	Toilet	AHU F-3	0.0	89	8	708	Bathroom		118	0	
3321	Radiology Storage	AHU F-3	0.0	135	8	1,084	Sterile Storage		72	36	
3312	Office	AHU F-3	1.0	120	8	958		Office Spaces			5
3318	Xray	AHU F-3	2.0	249	8	1,993	X-Ray (diagnostic and treatment)		199	66	
3221	Cast 1	AHU F-3	2.0	151	8	1,211	Patient Rooms		121	40	
3219	Cast 2	AHU F-3	2.0	163	8	1,305	Patient Rooms		130	43	
3220	Procedure/Exam	AHU F-3	2.0	186	8	1,484	Patient Rooms		148	49	
3218	Phys. Work	AHU F-3	2.0	173	8	1,387	Patient Rooms		139	46	
3200	Nurse Work	AHU F-3	3.0	261	8	2,091	Patient Rooms		209	70	
3222	Phys. Work	AHU F-3	2.0	134	8	1,076	Patient Rooms		108	36	
3209	Exam	AHU F-3	2.0	146	8	1,169	Patient Rooms		117	39	
3224	Exam	AHU F-3	2.0	142	8	1,133	Patient Rooms		113	38	
3207	Exam	AHU F-3	2	153.9	8	1,231	Patient Rooms		123	41	
3226	Vitals	AHU F-3	1.0	74	8	592	Patient Rooms		59	20	
3201	Toilet	AHU F-3	0.0	63	8	506	Bathroom		84	0	
3203	Toilet	AHU F-3	0.0	70	8	561	Bathroom		93	0	
3205	Vitals	AHU F-3	1.0	73	8	586	Patient Rooms		59	20	

3200	Check-in	AHU F-3	2.0	240	8	1,923		Booking/Waiting			15
3317	Tech Work	AHU F-3	2.0	260	8	2,082	Pharmacy		139	69	
3302	Reception	AHU F-3	1.0	94	8	755		Booking/Waiting			8
3304	Private Reception	AHU F-3	1.0	88	8	705		Booking/Waiting			8
3319	Xray	AHU F-3	2.0	248	8	1,985	X-Ray (diagnostic and treatment)		198	66	
3320	Xray	AHU F-3	2.0	276	8	2,208	X-Ray (diagnostic and treatment)		221	74	
3213	Cast 3	AHU F-3	2.0	193	8	1,541	Patient Rooms		154	51	
3215	RN/CT	AHU F-3	1.0	135	8	1,078	Patient Rooms		108	36	
3217	PA Office	AHU F-3	1.0	114	8	915		Office Spaces			5
3212	Cast 4	AHU F-3	2.0	183	8	1,464	Patient Rooms		146	49	
3214	Toilet	AHU F-3	0.0	69	8	550	Bathroom		92	0	
3216	RN/CT	AHU F-3	1.0	150	8	1,200	Patient Rooms		120	40	
3210	Exam	AHU F-3	2.0	131	8	1,045	Patient Rooms		105	35	
3208	Exam	AHU F-3	2.0	151	8	1,205	Patient Rooms		121	40	
3206	Exam	AHU F-3	2.0	153	8	1,222	Patient Rooms		122	41	
3204	Exam	AHU F-3	2.0	141	8	1,128	Patient Rooms		113	38	
3202	Exam	AHU F-3	2.0	146	8	1,167	Patient Rooms		117	39	
3104	Women	AHU F-3	0.0	229	8	1,835	Bathroom		306	0	
3103	Men	AHU F-3	0.0	202	8	1,619	Bathroom		270	0	
3113	Waiting	AHU F-3	3.0	374	8	2,995		Lobbies/prefunction			23
3111	Waiting	AHU F-3	3.0	391	8	3,128		Lobbies/prefunction			23
3109	Waiting	AHU F-3	3.0	386	8	3,087		Lobbies/prefunction			23
3107	Waiting	AHU F-3	3.0	390	8	3,120		Lobbies/prefunction			23
3105	Waiting	AHU F-3	3.0	412	8	3,293		Lobbies/prefunction			23
3101	Waiting	AHU F-3	3.0	1,158	8	9,264		Lobbies/prefunction			23
3100	Waiting	AHU F-3	3.0	1,065	8	8,520		Lobbies/prefunction			23
3000	Elevator Lobby	AHU F-3	0.0	289	8	2,315		Lobbies/prefunction			0
3001	Alcove	AHU F-3	0.0	216	8	1,727	Corridor		58	0	
3417	Corridor	AHU F-3	0.0	441	8	3,530	Corridor		118	0	
3415	Corridor	AHU F-3	0.0	286	8	2,285	Corridor		76	0	
3305	Corridor	AHU F-3	0.0	367	8	2,933	Corridor		98	0	
3232	Corridor	AHU F-3	0.0	316	8	2,530	Corridor		84	0	
3230	Corridor	AHU F-3	0.0	478	8	3,825	Corridor		127	0	
3228	Corridor	AHU F-3	0.0	317	8	2,538	Corridor		85	0	

3211	Corridor	AHU F-3	0.0	733	8	5,862	Corridor		195	0	
3300	Corridor	AHU F-3	0.0	621	8	4,966	Corridor		166	0	
				21,570					**8871**	**2137**	**400**
0.303	Central Supply	AHU F-0	0.0	700	8	5,603	Sterile Storage		374	187	
0.302B	Medical Records	AHU F-0	0.0	810	8	6,479		Storage Rooms			1
0.301	Receiving	AHU F-0	2.0	365	8	2,924		Booking/Waiting			15
0.401	Mechanical	AHU F-0	0.0	2,359	8	18,870		Electrical Equipment Rooms			0
0.116	Corridor	AHU F-0	0.0	1,760	8	14,080	Corridor		469	0	
0.304	Break Room	AHU F-0	2.0	183	8	1,464		Break Rooms			30
0.322	Toilets	AHU F-0	0.0	93	8	740	Toilet room		123	0	
0.321	Conference	AHU F-0	6.0	197	8	1,573		Conference/meeting			50
0.319	Medical Records Storage	AHU F-0	0.0	215	8	1,718		Storage Rooms			1
0.32	Storage	AHU F-0	0.0	90	8	719		Storage Rooms			1
0.222	Practitioner	AHU F-0	2.0	109	8	868	Patient Rooms		87	29	
0.22	Practitioner	AHU F-0	2.0	114	8	914	Patient Rooms		91	30	
0.218	Practitioner	AHU F-0	2.0	119	8	951	Patient Rooms		95	32	
0.216	Practitioner	AHU F-0	2.0	114	8	916	Patient Rooms		92	31	
0.214	Practitioner	AHU F-0	2.0	114	8	916	Patient Rooms		92	31	
0.212	Break Room	AHU F-0	2.0	114	8	916		Break Rooms			30
0.107	J.C.	AHU F-0	0.0	63	8	504		Janitor Closets, Trash Rooms, Recycling			0
0.21	Resident	AHU F-0	1.0	118	8	941	Patient Rooms		94	31	
0.109	Mechanical	AHU F-0	0.0	461	8	3,688		Electrical Equipment Rooms			0
0.106	Data	AHU F-0	0.0	91	8	728		Electrical Equipment Rooms			0
0.208	Available	AHU F-0	0.0	137	8	1,098		Office Spaces			0
0.206	Special Exam	AHU F-0	2.0	126	8	1,009	Patient Rooms		101	34	
0.204	Exam	AHU F-0	2.0	126	8	1,009	Patient Rooms		101	34	
0.202	Exam	AHU F-0	2.0	132	8	1,056	Patient Rooms		106	35	
0.2	Exam	AHU F-0	2.0	132	8	1,056	Patient Rooms		106	35	
0.305	Office	AHU F-0	1.0	119	8	955		Office Spaces			5
0.306	Office	AHU F-0	1.0	120	8	956		Office Spaces			5
0.307	Office	AHU F-0	1.0	120	8	956		Office Spaces			5
0.308	Office	AHU F-0	1.0	120	8	956		Office Spaces			5
0.309	Med. Rec. Office	AHU F-0	1.0	188	8	1,506		Storage Rooms			1

0.3	Waiting	AHU F-0	3.0	167	8	1,336		Booking/Waiting			23
0.316	Office	AHU F-0	1.0	116	8	927		Office Spaces			5
0.315	Office	AHU F-0	1.0	116	8	929		Office Spaces			5
0.314	Office	AHU F-0	1.0	116	8	929		Office Spaces			5
0.313	Office	AHU F-0	1.0	116	8	929		Office Spaces			5
0.312B	Copy Room	AHU F-0	0.0	127	8	1,019		Copy/Printing Rooms			0
0.311	Admin Assist	AHU F-0	1.0	131	8	1,050		Office Spaces			5
0.317	Work	AHU F-0	3.0	2,921	8	23,371		Office Spaces			15
0.217	Storage	AHU F-0	0.0	198	8	1,582		Storage Rooms			1
0.215	Sewing	AHU F-0	0.0	174	8	1,388		Office Spaces			0
0.213	Equipment	AHU F-0	0.0	608	8	4,866		Electrical Equipment Rooms			0
0.223	Conference	AHU F-0	6.0	225	8	1,801		Conference/meeting			50
0.225	Plaster	AHU F-0	2.0	225	8	1,801	Patient Rooms		180	60	
0.221	Gait	AHU F-0	0.0	273	8	2,182	Patient Rooms		218	73	
0.219	Casting	AHU F-0	2.0	273	8	2,182	Patient Rooms		218	73	
0.211	Oven	AHU F-0	0.0	170	8	1,359	Patient Rooms		136	45	
0.209	LAM	AHU F-0	0.0	170	8	1,359	Patient Rooms		136	45	
0.103	Women	AHU F-0	0.0	239	8	1,915	Toilet room		319	0	
0.102	Men	AHU F-0	0.0	194	8	1,552	Toilet room		259	0	
0.207	Staff Change	AHU F-0	0.0	75	8	602		Locker/dressing Rooms			0
0.205	ADA Toilet	AHU F-0	0.0	75	8	602	Toilet room		100	0	
0.203	File	AHU F-0	0.0	59	8	472		Storage Rooms			1
0.1	Waiting Area	AHU F-0	3.0	575	8	4,598		Booking/Waiting			23
0.201	Reception	AHU F-0	2.0	129	8	1,032		Booking/Waiting			15
1000	Elevator Lobby	AHU F-0	0.0	565	8	4,520		Lobbies/prefunction			0
0.318	Corridor	AHU F-0	0.0	1,072	8	8,576	Corridor		286	0	
0.112	Corridor	AHU F-0	0.0	1,501	8	12,008	Corridor		400	0	
0.117	Corridor	AHU F-0	0.0	641	8	5,128	Corridor		171	0	
				20,760					**4353**	**804**	**311**
4106	Mech	AHU F-4	0.0	877	8	7,016		Electrical Equipment Rooms			0
4070	Director's Office	AHU F-4	1.0	262	8	2,093		Office Spaces			5
4069	Admin Office	AHU F-4	1.0	117	8	939		Office Spaces			5
4068	Faculty Office	AHU F-4	1.0	115	8	920		Office Spaces			5
4067	Faculty Office	AHU F-4	1.0	141	8	1,129		Office Spaces			5

4066	Faculty Office	AHU F-4	1.0	159	8	1,274		Office Spaces			5
4065	Faculty Office	AHU F-4	1.0	126	8	1,012		Office Spaces			5
4064	Faculty Office	AHU F-4	1.0	126	8	1,008		Office Spaces			5
4063	Faculty Office	AHU F-4	1.0	123	8	982		Office Spaces			5
4071	Business Manager	AHU F-4	1.0	149	8	1,195		Office Spaces			5
4041	Director's Office	AHU F-4	1.0	201	8	1,606		Office Spaces			5
4040	Admin Office	AHU F-4	1.0	133	8	1,063		Office Spaces			5
4039	Faculty Office	AHU F-4	1.0	154	8	1,230		Office Spaces			5
4038	Nurse's Office	AHU F-4	1.0	152	8	1,212		Office Spaces			5
4037	Faculty Office	AHU F-4	1.0	129	8	1,034		Office Spaces			5
4016	Faculty Office	AHU F-4	1.0	119	8	955		Office Spaces			5
4015	Faculty Office	AHU F-4	1.0	130	8	1,040		Office Spaces			5
4014	Faculty Office	AHU F-4	1.0	130	8	1,039		Office Spaces			5
4013	Faculty Office	AHU F-4	1.0	120	8	964		Office Spaces			5
4012	Faculty Office	AHU F-4	1.0	135	8	1,080		Office Spaces			5
4011	Equipment Room	AHU F-4	0.0	135	8	1,083		Electrical Equipment Rooms			0
4010	Data	AHU F-4	0.0	84	8	674		Electrical Equipment Rooms			0
4009	Lab	AHU F-4	1.0	144	8	1,152	Laboratory, general		115	38	
4113	Mech	AHU F-4	0.0	494	8	3,948		Electrical Equipment Rooms			0
4112	J.C.	AHU F-4	0.0	89	8	715		Janitor Closets, Trash Rooms, Recycling			0
4057	Staff Office Secretary's	AHU F-4	1.0	206	8	1,651		Office Spaces			5
4058	Work Files/Copier	AHU F-4	1.0	136	8	1,089		Copy/Printing Rooms			0
4059	Staff Office	AHU F-4	1.0	98	8	781		Office Spaces			5
4060	Staff Office	AHU F-4	1.0	101	8	809		Office Spaces			5
4061	Staff Office	AHU F-4	1.0	98	8	787		Office Spaces			5
4054	Staff Toilet	AHU F-4	0.0	102	8	813	Toilet room		135	0	
4053	Staff Office	AHU F-4	1.0	85	8	677		Office Spaces			5
4052	Staff Office	AHU F-4	1.0	106	8	851		Office Spaces			5
4051	Staff Office	AHU F-4	1.0	99	8	791		Office Spaces			5
4048	Fellow's Office	AHU F-4	2.0	226	8	1,806		Office Spaces			10
4049	Kitchen	AHU F-4	0.0	117	8	936		Kitchenettes			0
4042	Staff Office	AHU F-4	1.0	137	8	1,093		Office Spaces			5
4043	Staff Office	AHU F-4	1.0	85	8	678		Office Spaces			5

4044	Staff Office	AHU F-4	1.0	90	8	722		Office Spaces			5
4045	Staff Office	AHU F-4	1.0	85	8	683		Office Spaces			5
4046	Small Conference	AHU F-4	2.0	209	8	1,669		Conference/meeting			30
4047	Storage	AHU F-4	0.0	116	8	929		Storage Rooms			1
4036	Physician Workroom	AHU F-4	1.0	137	8	1,094	Patient Rooms		109	36	
4035	Exam Room	AHU F-4	2.0	142	8	1,133	Patient Rooms		113	38	
4034	Exam Room	AHU F-4	2.0	147	8	1,175	Patient Rooms		117	39	
4033	Vital Signs	AHU F-4	2.0	91	8	725	Patient Rooms		72	24	
4032	Vital Signs	AHU F-4	2.0	94	8	753	Patient Rooms		75	25	
4031	Exam Room	AHU F-4	2.0	117	8	935	Patient Rooms		94	31	
4030	Exam Room	AHU F-4	2.0	123	8	986	Patient Rooms		99	33	
4029	Exam Room	AHU F-4	2.0	121	8	971	Patient Rooms		97	32	
4023	IV Infusion Area	AHU F-4	3.0	297	8	2,378	Laboratory, general		238	79	
4024	History/Intake Room	AHU F-4	2.0	152	8	1,215	Patient Rooms		121	40	
4028/26	Nurse Station/Reception/Check-in	AHU F-4	2.0	556	8	4,445	Patient Rooms		445	148	
4025	Nurse's Office	AHU F-4	2.0	110	8	879		Office Spaces			10
4022	Small Conference	AHU F-4	3.0	193	8	1,543		Conference/meeting			35
4019	Medication Room	AHU F-4	2.0	85	8	683	Medication room		46	23	
4020	Procedure Lab	AHU F-4	3.0	201	8	1,606	Laboratory, general		161	54	
4021	Toilet	AHU F-4	0.0	78	8	627	Toilet room		104	0	
4017	Open Office	AHU F-4	0.0	469	8	3,748		Office Spaces			0
4018	Nourishment	AHU F-4	2.0	180	8	1,442	Patient Rooms		144	48	
4104	Women's Toilet	AHU F-4	0.0	222	8	1,774	Toilet room		296	0	
4103	Men's toilet	AHU F-4	0.0	204	8	1,630	Toilet room		272	0	
4007	Lab	AHU F-4	2.0	913	8	7,302	Laboratory, general		730	243	
4004	Calorimetry Room	AHU F-4	1.0	422	8	3,376	Laboratory, general		338	113	
4003	Treadmill Testing	AHU F-4	1.0	106	8	850	Laboratory, general		85	28	
4002	Locker Room	AHU F-4	0.0	110	8	877		Locker/dressing Rooms			0
4001	Exercise Area	AHU F-4	2.0	635	8	5,077	Laboratory, general		508	169	
4006	Metabolic Lab/Body Comp. Lab	AHU F-4	1.0	168	8	1,342	Laboratory, general		134	45	
4005	Vascular Lab	AHU F-4	1.0	284	8	2,275	Laboratory, general		228	76	
4079	Corridor	AHU F-4	0.0	227	8	1,812	Corridor		60	0	
4072	Corridor	AHU F-4	0.0	691	8	5,528	Corridor		184	0	
4073	Waiting	AHU F-4	3.0	1,261	8	10,089		Booking/Waiting			23

4074	Corridor	AHU F-4	0.0	676	8	5,411	Corridor		180	0	
4075	Waiting	AHU F-4	2.0	605	8	4,839		Booking/Waiting			15
4076	Corridor	AHU F-4	0.0	431	8	3,449	Corridor		115	0	
4077	Alcove	AHU F-4	0.0	243	8	1,945	Corridor		65	0	
4000	Elevator Lobby	AHU F-4	0.0	501	8	4,010		Lobbies/prefunction			0
4062	Corridor	AHU F-4	0.0	615	8	4,921	Corridor		164	0	
4056	Corridor	AHU F-4	0.0	456	8	3,645	Corridor		121	0	
4221	Corridor	AHU F-4	0.0	313	8	2,508	Corridor		84	0	
4050	Corridor	AHU F-4	0.0	475	8	3,802	Corridor		127	0	
4055	Corridor	AHU F-4	0.0	528	8	4,228	Corridor		141	0	
4027	Corridor	AHU F-4	0.0	1,006	8	8,051	Corridor		268	0	
4107	Conference	AHU F-4	3.0	523	8	4,185		Conference/meeting			35
				21,549					**6386**	**1364**	**328**
5110	Mechanical	AHU F-5	0.0	985	8	7,883		Electrical Equipment Rooms			0
5109	Conference	AHU F-5	3.0	575	8	4,602		Conference/meeting			35
5108	Corridor	AHU F-5	0.0	254	8	2,030	Corridor		68	0	
5312	Student Break	AHU F-5	2.0	295	8	2,362		Break Rooms			30
5314	Shared Conference	AHU F-5	2.0	278	8	2,224		Conference/meeting			30
5231	Patient/Diab.	AHU F-5	2.0	141	8	1,130	Patient Rooms		113	38	
5233	Patient/Diab.	AHU F-5	2.0	137	8	1,099	Patient Rooms		110	37	
5235	Patient/Diab.	AHU F-5	2.0	154	8	1,235	Patient Rooms		123	41	
5237	Res./Ed. Work	AHU F-5	1.0	270	8	2,161		Office Spaces			5
5239	Office	AHU F-5	1.0	143	8	1,143		Office Spaces			5
5241	Office	AHU F-5	1.0	145	8	1,160		Office Spaces			5
5243	Phys. Work	AHU F-5	1.0	297	8	2,380		Office Spaces			5
5245	Office	AHU F-5	1.0	163	8	1,301		Office Spaces			5
5247	Storage	AHU F-5	0.0	137	8	1,099		Storage Rooms			1
5249	Storage	AHU F-5	0.0	132	8	1,056		Storage Rooms			1
5116	Data	AHU F-5	0.0	93	8	744		Electrical Equipment Rooms			0
5251	Storage	AHU F-5	0.0	188	8	1,501		Storage Rooms			1
5118	Mechanical	AHU F-5	0.0	493	8	3,940		Electrical Equipment Rooms			0
5117	J.C.	AHU F-5	0.0	106	8	846		Janitor Closets, Trash Rooms, Recycling			0
5310	Exam	AHU F-5	2.0	149	8	1,189	Patient Rooms		119	40	

5308	Exam	AHU F-5	2.0	145	8	1,160	Patient Rooms		116	39	
5306	Exam	AHU F-5	2.0	160	8	1,283	Patient Rooms		128	43	
5304	Toilet	AHU F-5	0.0	78	8	626	Toilet room		104	0	
5302	Exam	AHU F-5	2.0	137	8	1,100	Patient Rooms		110	37	
5311	Procedure	AHU F-5	2.0	138	8	1,107	Patient Rooms		111	37	
5309	Exam	AHU F-5	2.0	161	8	1,288	Patient Rooms		129	43	
5307	Exam	AHU F-5	2.0	154	8	1,232	Patient Rooms		123	41	
5305	Nurse Work	AHU F-5	2.0	129	8	1,034	Patient Rooms		103	34	
5303	Vitals	AHU F-5	2.0	78	8	622	Patient Rooms		62	21	
5300	Reception	AHU F-5	1.0	129	8	1,031		Office Spaces			5
5229	Exam	AHU F-5	2.0	131	8	1,050	Patient Rooms		105	35	
5227	Exam	AHU F-5	2.0	124	8	990	Patient Rooms		99	33	
5225	Exam	AHU F-5	2.0	134	8	1,072	Patient Rooms		107	36	
5223	Patient Toilet	AHU F-5	0.0	89	8	712	Toilet room		119	0	
5221	Vitals	AHU F-5	2.0	87	8	695	Patient Rooms		70	23	
5220	Reception	AHU F-5	1.0	124	8	995		Office Spaces			5
5226	Dictation	AHU F-5	1.0	103	8	823		Office Spaces			5
5224	Exam	AHU F-5	2.0	134	8	1,071	Patient Rooms		107	36	
5222	Exam	AHU F-5	2.0	126	8	1,007	Patient Rooms		101	34	
5219	Procedure	AHU F-5	2.0	184	8	1,471	Patient Rooms		147	49	
5217	Exam	AHU F-5	2.0	140	8	1,124	Patient Rooms		112	37	
5215	Exam	AHU F-5	2.0	131	8	1,051	Patient Rooms		105	35	
5213	Nurse Work	AHU F-5	2.0	295	8	2,363	Patient Rooms		236	79	
5211	Consult.	AHU F-5	2.0	295	8	2,360	Patient Rooms		236	79	
5218	Exam	AHU F-5	2.0	135	8	1,080	Patient Rooms		108	36	
5216	Exam	AHU F-5	2.0	134	8	1,071	Patient Rooms		107	36	
5214	Exam	AHU F-5	2.0	132	8	1,054	Patient Rooms		105	35	
5209	Exam	AHU F-5	2.0	146	8	1,170	Patient Rooms		117	39	
5207	Exam	AHU F-5	2.0	143	8	1,142	Patient Rooms		114	38	
5205	Exam	AHU F-5	2.0	142	8	1,138	Patient Rooms		114	38	
5203	Nurse Work	AHU F-5	2.0	296	8	2,369	Patient Rooms		237	79	
5212	Vitals	AHU F-5	2.0	78	8	623	Patient Rooms		62	21	
5201	Vitals	AHU F-5	2.0	87	8	693	Patient Rooms		69	23	
5210	Reception	AHU F-5	1.0	120	8	960		Office Spaces			5
5200	Reception	AHU F-5	1.0	121	8	968		Office Spaces			5

5208	Exam	AHU F-5	2.0	138	8	1,107	Patient Rooms		111	37	
5206	Exam	AHU F-5	2.0	152	8	1,218	Patient Rooms		122	41	
5228	Storage	AHU F-5	0.0	133	8	1,066		Storage Rooms			1
5242	Exam	AHU F-5	2.0	142	8	1,136	Patient Rooms		114	38	
5230	Group Conf./Work	AHU F-5	3.0	548	8	4,384		Conference/meeting			35
5253	Staff Toilet	AHU F-5	0.0	78	8	624	Toilet room		104	0	
5232	PVT. Infusion	AHU F-5	2.0	190	8	1,521	Laboratory, general		152	51	
5255	Control	AHU F-5	2.0	611	8	4,888	Laboratory, general		489	163	
5234	Infusion	AHU F-5	2.0	1,042	8	8,338	Laboratory, general		834	278	
5204	Toilet	AHU F-5	0.0	74	8	589	Toilet room		98	0	
5202	F.C./Consult	AHU F-5	2.0	158	8	1,262	Patient Rooms		126	42	
5238	Lab	AHU F-5	2.0	280	8	2,243	Laboratory, general		224	75	
5236	Meds	AHU F-5	2.0	159	8	1,270	Medication room		85	42	
5104	Women's Toilet	AHU F-5	0.0	238	8	1,903	Toilet room		317	0	
5103	Men's Toilet	AHU F-5	0.0	227	8	1,815	Toilet room		302	0	
5107	Waiting	AHU F-5	3.0	1,170	8	9,357		Booking/Waiting			23
5106	Waiting	AHU F-5	3.0	1,256	8	10,046		Booking/Waiting			23
5105	Waiting	AHU F-5	2.0	246	8	1,968		Booking/Waiting			15
5102	Corridor	AHU F-5	0.0	456	8	3,646	Corridor		122	0	
5000	Elevator Lobby	AHU F-5	0.0	562	8	4,499		Lobbies/prefunction			0
5001	Alcove	AHU F-5	0.0	241	8	1,925	Corridor		64	0	
5002	Corridor	AHU F-5	0.0	638	8	5,104	Corridor		170	0	
5003	Corridor	AHU F-5	0.0	458	8	3,661	Corridor		122	0	
5301	Corridor	AHU F-5	0.0	456	8	3,647	Corridor		122	0	
5250	Corridor	AHU F-5	0.0	553	8	4,422	Corridor		147	0	
5252	Corridor	AHU F-5	0.0	475	8	3,797	Corridor		127	0	
5254	Corridor	AHU F-5	0.0	340	8	2,722	Corridor		91	0	
5248	Corridor	AHU F-5	0.0	474	8	3,791	Corridor		126	0	
5246	Corridor	AHU F-5	0.0	407	8	3,259	Corridor		109	0	
5244	Corridor	AHU F-5	0.0	395	8	3,159	Corridor		105	0	
5240	Corridor	AHU F-5	0.0	356	8	2,846	Corridor		95	0	
				22,729					**8575**	**2035**	**252**
6110	Mechanical	AHU F-6	0.0	946	8	7,567		Electrical Equipment Rooms			0
6108	Corridor	AHU F-6	0.0	263	8	2,107	Corridor		70	0	

6113	Conference	AHU F-6	15.0	545	8	4,358		Conference/meeting			95
6411	Resident Work	AHU F-6	1.0	270	8	2,161		Office Spaces			5
6413	Exam	AHU F-6	2.0	171	8	1,367	Patient Rooms		137	46	
6415	OBS	AHU F-6	2.0	117	8	939	Patient Rooms		94	31	
6417	Exam	AHU F-6	2.0	149	8	1,190	Patient Rooms		119	40	
6419	NP Office	AHU F-6	1.0	160	8	1,283		Office Spaces			5
6421	Clean	AHU F-6	3.0	127	8	1,013	Laboratory, general		101	34	
6303	Shared Conference	AHU F-6	3.0	350	8	2,804		Conference/meeting			35
6301	Shared Break	AHU F-6	3.0	209	8	1,673		Break Rooms			35
6226	Exam	AHU F-6	2.0	156	8	1,248	Patient Rooms		125	42	
6228	Exam	AHU F-6	2.0	139	8	1,110	Patient Rooms		111	37	
6230	Exam	AHU F-6	2.0	143	8	1,144	Patient Rooms		114	38	
6232	Exam	AHU F-6	2.0	136	8	1,091	Patient Rooms		109	36	
6234	Exam	AHU F-6	2.0	134	8	1,072	Patient Rooms		107	36	
6116	Data	AHU F-6	0.0	97	8	773		Electrical Equipment Rooms			0
6236	Coordination	AHU F-6	2.0	156	8	1,246	Patient Rooms		125	42	
6118	Mechanical	AHU F-6	0.0	456	8	3,647		Electrical Equipment Rooms			0
6117	J.C.	AHU F-6	0.0	100	8	798		Janitor Closets, Trash Rooms, Recycling			0
6409	Exam	AHU F-6	2.0	136	8	1,090	Patient Rooms		109	36	
6407	Exam	AHU F-6	2.0	138	8	1,106	Patient Rooms		111	37	
6405	Exam	AHU F-6	2.0	125	8	1,002	Patient Rooms		100	33	
6403	Exam	AHU F-6	2.0	122	8	978	Patient Rooms		98	33	
6401	Vitals	AHU F-6	2.0	94	8	752	Patient Rooms		75	25	
6412	Toilet	AHU F-6	0.0	92	8	739	Toilet room		123	0	
6410	Exam	AHU F-6	2.0	144	8	1,152	Patient Rooms		115	38	
6408	Meds	AHU F-6	0.0	142	8	1,136	Sterile Storage		76	38	
6406	Nurse Work	AHU F-6	2.0	343	8	2,742	Patient Rooms		274	91	
6404	Check-out	AHU F-6	2.0	104	8	830		Booking/Waiting			15
6402	Reception	AHU F-6	2.0	123	8	985		Booking/Waiting			15
6400	Reception	AHU F-6	2.0	126	8	1,008		Booking/Waiting			15
6420	Check-out	AHU F-6	2.0	101	8	806		Booking/Waiting			15
6418	Book	AHU F-6	0.0	136	8	1,087		Booking/Waiting			0
6416	Exam	AHU F-6	2.0	136	8	1,087	Patient Rooms		109	36	

6414	Toilet	AHU F-6	0.0	88	8	706	Toilet room		118	0	
6423	Procedure/Exam	AHU F-6	2.0	160	8	1,283	Patient Rooms		128	43	
6425	Exam	AHU F-6	2.0	132	8	1,056	Patient Rooms		106	35	
6427	Exam	AHU F-6	2.0	128	8	1,024	Patient Rooms		102	34	
6429	Exam	AHU F-6	2.0	132	8	1,054	Patient Rooms		105	35	
6431	Vitals	AHU F-6	1.0	99	8	794	Patient Rooms		79	26	
6430	PPM Storage	AHU F-6	0.0	152	8	1,219	Sterile Storage		81	41	
6428	Ch. Nurse Office	AHU F-6	1.0	134	8	1,072		Office Spaces			5
6426	Ref. Coord. Office	AHU F-6	1.0	132	8	1,053		Office Spaces			5
6424	Nurse Office	AHU F-6	1.0	136	8	1,091		Office Spaces			5
6306	Shared Audio	AHU F-6	2.0	166	8	1,326	Patient Rooms		133	44	
6304	Soiled	AHU F-6	0.0	88	8	702		Storage Rooms			1
6302	Lab	AHU F-6	2.0	105	8	841	Laboratory, general		84	28	
6300	Student Toilet	AHU F-6	0.0	80	8	638	Toilet room		106	0	
6224	Sp. Interview	AHU F-6	2.0	138	8	1,105		Office Spaces			10
6222	OBS	AHU F-6	2.0	142	8	1,139	Patient Rooms		114	38	
6220	Sex. Assualt Exam	AHU F-6	2.0	145	8	1,157	Patient Rooms		116	39	
6216A	Spec Collect	AHU F-6	2.0	75	8	600	Patient Rooms		60	20	
6218	Patient Toilet	AHU F-6	0.0	92	8	738	Toilet room		123	0	
6212	Resident Check-out	AHU F-6	1.0	410	8	3,282		Booking/Waiting			8
6214	Clean	AHU F-6	1.0	98	8	786	Laboratory, general		79	26	
6216	Group Therapy	AHU F-6	5.0	279	8	2,230	Patient Rooms		223	74	
6217	Procedure/Exam	AHU F-6	2.0	157	8	1,253	Patient Rooms		125	42	
6215	Procedure/Exam	AHU F-6	2.0	168	8	1,346	Patient Rooms		135	45	
6219	Exam	AHU F-6	2.0	126	8	1,008	Patient Rooms		101	34	
6210	Exam	AHU F-6	2.0	135	8	1,083	Patient Rooms		108	36	
6208	Nurse Work	AHU F-6	1.0	249	8	1,989	Patient Rooms		199	66	
6221	Toilet	AHU F-6	0.0	76	8	609	Toilet room		102	0	
6206	Toilet	AHU F-6	0.0	85	8	677	Toilet room		113	0	
6223	Vitals	AHU F-6	2.0	91	8	726	Patient Rooms		73	24	
6204	Vitals	AHU F-6	2.0	96	8	769	Patient Rooms		77	26	
6225	Charge/Triage	AHU F-6	2.0	103	8	824	Patient Rooms		82	27	
6202	F.C.	AHU F-6	1.0	114	8	908		Office Spaces			5
6200A	Check-out	AHU F-6	2.0	145	8	1,163		Booking/Waiting			15
6200	Check-In	AHU F-6	2.0	449	8	3,595		Booking/Waiting			15

6211	Exam	AHU F-6	2.0	162	8	1,299	Patient Rooms		130	43	
6209	Exam	AHU F-6	2.0	157	8	1,258	Patient Rooms		126	42	
6207	Exam	AHU F-6	2.0	144	8	1,156	Patient Rooms		116	39	
6205	Exam	AHU F-6	2.0	150	8	1,198	Patient Rooms		120	40	
6203	Exam	AHU F-6	2.0	147	8	1,178	Patient Rooms		118	39	
6201	Exam	AHU F-6	2.0	150	8	1,202	Patient Rooms		120	40	
6213	Student Check-out	AHU F-6	1.0	234	8	1,873		Booking/Waiting			8
6104	Toilet Womens	AHU F-6	0.0	241	8	1,928	Toilet room		321	0	
6103	Toilet Mens	AHU F-6	0.0	236	8	1,890	Toilet room		315	0	
6111	Waiting	AHU F-6	0.0	719	8	5,753	Corridor		192	0	
6109	Waiting	AHU F-6	0.0	792	8	6,336	Corridor		211	0	
6107	Waiting	AHU F-6	0.0	335	8	2,678	Corridor		89	0	
6106	Corridor	AHU F-6	0.0	281	8	2,249	Corridor		75	0	
6105	Waiting	AHU F-6	0.0	459	8	3,675	Corridor		123	0	
6101	Waiting	AHU F-6	0.0	963	8	7,702	Corridor		257	0	
6000	Elevator Lobby	AHU F-6	0.0	478	8	3,826		Lobbies/prefunction			0
6001	Alcove	AHU F-6	0.0	348	8	2,786		Lobbies/prefunction			0
6100	Waiting	AHU F-6	0.0	725	8	5,797	Corridor		193	0	
6002	Corridor	AHU F-6	0.0	410	8	3,276	Corridor		109	0	
6432	Corridor	AHU F-6	0.0	494	8	3,955	Corridor		132	0	
6434	Corridor	AHU F-6	0.0	478	8	3,822	Corridor		127	0	
6436	Corridor	AHU F-6	0.0	417	8	3,339	Corridor		111	0	
6438	Corridor	AHU F-6	0.0	415	8	3,322	Corridor		111	0	
6305	Corridor	AHU F-6	0.0	433	8	3,464	Corridor		115	0	
6227	Corridor	AHU F-6	0.0	367	8	2,934	Corridor		98	0	
6229	Corridor	AHU F-6	0.0	351	8	2,809	Corridor		94	0	
6231	Corridor	AHU F-6	0.0	402	8	3,216	Corridor		107	0	
				22,482					**8783**	**1775**	**321**
7109	Mechanical	AHU F-7	0.0	934	8	7,471		Electrical Equipment Rooms			0
7107	Corridor	AHU F-7	15.0	259	8	2,070	Corridor		69	0	
7110	Conference	AHU F-7	6.0	558	8	4,465		Conference/meeting			50
7612	Phys./Resid.	AHU F-7	1.0	287	8	2,300		Office Spaces			5
7614	NP Office	AHU F-7	1.0	148	8	1,185		Office Spaces			5
7501	Shared Conference	AHU F-7	3.0	252	8	2,018		Conference/meeting			35

7503	Shared Break	AHU F-7	3.0	211	8	1,686		Break Rooms			35
7312	Phys. Work	AHU F-7	2.0	172	8	1,375	Patient Rooms		138	46	
7314	Lab	AHU F-7	3.0	161	8	1,288	Laboratory, general		129	43	
7316	Addl. Med. Office	AHU F-7	1.0	144	8	1,150		Office Spaces			5
7210	Office	AHU F-7	1.0	147	8	1,178		Office Spaces			5
7212	Office	AHU F-7	1.0	154	8	1,235		Office Spaces			5
7214	Phys. Work	AHU F-7	2.0	270	8	2,159	Patient Rooms		216	72	
7216	DR. H Office	AHU F-7	1.0	157	8	1,256		Office Spaces			5
7218	Storage	AHU F-7	0.0	107	8	852		Storage Rooms			1
7114	Data	AHU F-7	0.0	101	8	807		Electrical Equipment Rooms			0
7220	Psych Office	AHU F-7	1.0	176	8	1,410		Office Spaces			5
7116	Mechanical	AHU F-7	0.0	464	8	3,713		Electrical Equipment Rooms			0
7115	J.C.	AHU F-7	0.0	119	8	952		Janitor Closets, Trash Rooms, Recycling			0
7610	Exam	AHU F-7	2.0	147	8	1,173	Patient Rooms		117	39	
7606	Exam	AHU F-7	2.0	139	8	1,112	Patient Rooms		111	37	
7604	Exam	AHU F-7	2.0	143	8	1,143	Patient Rooms		114	38	
7602	Educ./Consult.	AHU F-7	2.0	142	8	1,137	Patient Rooms		114	38	
7611	EEG Exam	AHU F-7	2.0	151	8	1,206	Patient Rooms		121	40	
7609	Toilet	AHU F-7	0.0	76	8	609	Toilet room		101	0	
7607	Phys. Dict.	AHU F-7	2.0	149	8	1,196		Office Spaces			10
7605	Nurse Work	AHU F-7	1.0	152	8	1,216	Patient Rooms		122	41	
7603	Vitals	AHU F-7	2.0	85	8	676	Patient Rooms		68	23	
7600	Reception	AHU F-7	2.0	127	8	1,019		Booking/Waiting			15
7613	EEG Procedure	AHU F-7	2.0	140	8	1,122	Patient Rooms		112	37	
7615	EEG Read Office	AHU F-7	2.0	98	8	786		Office Spaces			10
7406	Phys. Dict.	AHU F-7	2.0	142	8	1,134		Office Spaces			10
7404	Nurse Work	AHU F-7	1.0	142	8	1,137	Patient Rooms		114	38	
7402	Vitals	AHU F-7	2.0	84	8	675	Patient Rooms		68	23	
7400	Reception	AHU F-7	2.0	121	8	968		Booking/Waiting			15
7500	Toilet	AHU F-7	0.0	70	8	557	Toilet room		93	0	
7409	Exam	AHU F-7	2.0	137	8	1,098	Patient Rooms		110	37	
7407	Exam	AHU F-7	2.0	133	8	1,064	Patient Rooms		106	35	
7405	Exam	AHU F-7	2.0	146	8	1,168	Patient Rooms		117	39	

7403	Exam	AHU F-7	2.0	144	8	1,151	Patient Rooms		115	38	
7310	Exam	AHU F-7	2.0	176	8	1,410	Patient Rooms		141	47	
7308	Exam	AHU F-7	2.0	134	8	1,071	Patient Rooms		107	36	
7306	Exam	AHU F-7	2.0	130	8	1,038	Patient Rooms		104	35	
7305	Nurse Work	AHU F-7	1.0	144	8	1,148	Patient Rooms		115	38	
7302	Exam	AHU F-7	2.0	141	8	1,125	Patient Rooms		112	37	
7311	Exam	AHU F-7	2.0	132	8	1,059	Patient Rooms		106	35	
7309	Exam	AHU F-7	2.0	121	8	969	Patient Rooms		97	32	
7307	Meds. Supply	AHU F-7	0.0	125	8	1,001	Sterile Storage		67	33	
7304	Toilet	AHU F-7	0.0	69	8	554	Toilet room		92	0	
7303	Vitals	AHU F-7	2.0	117	8	935	Patient Rooms		93	31	
7300	Reception	AHU F-7	2.0	124	8	988		Booking/Waiting			15
7208	Exam	AHU F-7	2.0	144	8	1,155	Patient Rooms		116	39	
7206	Exam	AHU F-7	2.0	163	8	1,305	Patient Rooms		131	44	
7204	Nurse Work	AHU F-7	1.0	207	8	1,654	Patient Rooms		165	55	
7202	Work	AHU F-7	1.0	118	8	941	Patient Rooms		94	31	
7200	Check-in/check-out	AHU F-7	2.0	110	8	877		Booking/Waiting			15
7209	Exam	AHU F-7	2.0	154	8	1,236	Patient Rooms		124	41	
7207	Exam	AHU F-7	2.0	167	8	1,332	Patient Rooms		133	44	
7211	Exam	AHU F-7	2.0	139	8	1,116	Patient Rooms		112	37	
7213	Exam	AHU F-7	2.0	150	8	1,203	Patient Rooms		120	40	
7231	Cysto	AHU F-7	2.0	274	8	2,190	Patient Rooms		219	73	
7225	Exam	AHU F-7	2.0	150	8	1,199	Patient Rooms		120	40	
7227	Ante	AHU F-7	1.0	118	8	944	Patient Rooms		94	31	
7229	Uro	AHU F-7	2.0	506	8	4,051	Patient Rooms		405	135	
7205	Vitals	AHU F-7	2.0	183	8	1,461	Patient Rooms		146	49	
7203	Short toilet	AHU F-7	0.0	69	8	553	Toilet room		92	0	
7217	Lab	AHU F-7	2.0	152	8	1,218	Laboratory, general		122	41	
7219	Tall Toilet	AHU F-7	0.0	108	8	861	Toilet room		143	0	
7221	Short Toilet	AHU F-7	0.0	109	8	873	Toilet room		146	0	
7223	Ultrasound Exam	AHU F-7	2.0	174	8	1,392	Patient Rooms		139	46	
7226	Telemedicine	AHU F-7	2.0	114	8	911		Telephone/data entry			10
7233	Staff Group	AHU F-7	2.0	177	8	1,415		Office Spaces			10
7228	Toilet	AHU F-7	0.0	62	8	494	Toilet room		82	0	
7236	Office	AHU F-7	1.0	142	8	1,138		Office Spaces			5

7235	Fellow/Resident Office	AHU F-7	1.0	164	8	1,314		Office Spaces			5
7237	Research Area	AHU F-7	3.0	281	8	2,249	Laboratory, general		225	75	
7103	Women	AHU F-7	0.0	224	8	1,795	Toilet room		299	0	
7102	Men	AHU F-7	0.0	203	8	1,620	Toilet room		270	0	
7108	Waiting	AHU F-7	0.0	1120	8	8,958	Corridor		299	0	
7106	Waiting	AHU F-7	0.0	571	8	4,570	Corridor		152	0	
7105	Corridor	AHU F-7	0.0	390	8	3,124	Corridor		104	0	
7201	Waiting	AHU F-7	0.0	278	8	2,222	Corridor		74	0	
7104	Waiting	AHU F-7	0.0	528	8	4,225	Corridor		141	0	
7000	Elevator Lobby	AHU F-7	0.0	772	8	6,174		Lobbies/prefunction			0
7001	Alcove	AHU F-7	0.0	316	8	2,526		Lobbies/prefunction			0
7100	Waiting	AHU F-7	0.0	657	8	5,255	Corridor		175	0	
7002	Corridor	AHU F-7	0.0	450	8	3,598	Corridor		120	0	
7601	Corridor	AHU F-7	0.0	647	8	5,180	Corridor		173	0	
7401	Corridor	AHU F-7	0.0	385	8	3,083	Corridor		103	0	
7301	Corridor	AHU F-7	0.0	416	8	3,330	Corridor		111	0	
7215	Corridor	AHU F-7	0.0	407	8	3,256	Corridor		109	0	
7232	Corridor	AHU F-7	0.0	611	8	4,888	Corridor		163	0	
7236	Corridor	AHU F-7	0.0	510	8	4,080	Corridor		136	0	
7234	Corridor	AHU F-7	0.0	550	8	4,397	Corridor		147	0	
				22072					**8791**	**1810**	**287**
8110	Mechanical	AHU F-8	0.0	951	8	7,611		Electrical Equipment Rooms			0
8113	Corridor	AHU F-8	0.0	250	8	2,000	Corridor		67	0	
8111	Conference	AHU F-8	15.0	563	8	4,501		Conference/meeting			95
8413	Shared Staff Conference	AHU F-8	6.0	293	8	2,341		Conference/meeting			50
8320	Avail	AHU F-8	1.0	157	8	1,254		Office Spaces			5
8322	Avail	AHU F-8	1.0	135	8	1,080		Office Spaces			5
8414	Shared Staff Break	AHU F-8	3.0	213	8	1,703		Break Rooms			35
8318	Avail	AHU F-8	1.0	162	8	1,294		Office Spaces			5
8324	Avail	AHU F-8	1.0	113	8	904		Office Spaces			5
8326	Avail	AHU F-8	1.0	139	8	1,116		Office Spaces			5
8210	Audio Booth	AHU F-8	2.0	227	8	1,820	Patient Rooms		182	61	
8212	Audio Booth	AHU F-8	2.0	220	8	1,760	Patient Rooms		176	59	
8214	Phys. Work	AHU F-8	2.0	221	8	1,770	Patient Rooms		177	59	

8216	Audio Admin Office	AHU F-8	1.0	144	8	1,155		Office Spaces			5
8218	ORL Admin	AHU F-8	1.0	146	8	1,170		Office Spaces			5
8220	ORL Storage	AHU F-8	0.0	145	8	1,160	Sterile Storage		77	39	
8118	Data	AHU F-8	0.0	101	8	811		Electrical Equipment Rooms			0
8222	Opthal Office/Consultation	AHU F-8	1.0	156	8	1,245		Office Spaces			5
8116	Mechanical	AHU F-8	0.0	460	8	3,682		Electrical Equipment Rooms			0
8117	J.C.	AHU F-8	0.0	96	8	768		Janitor Closets, Trash Rooms, Recycling			0
8327	Phys. Office	AHU F-8	1.0	137	8	1,096		Office Spaces			5
8329	Phys. Office	AHU F-8	1.0	133	8	1,061		Office Spaces			5
8331	Phys. Office	AHU F-8	1.0	145	8	1,160		Office Spaces			5
8335	File/Work	AHU F-8	0.0	248	8	1,985		Storage Rooms			1
8400	Reception	AHU F-8	2.0	110	8	884		Booking/Waiting			15
8332	Dental Admin Office	AHU F-8	1.0	116	8	931		Office Spaces			5
8321	Billing Office	AHU F-8	1.0	125	8	999		Office Spaces			5
8300A	Work	AHU F-8	2.0	67	8	539		Office Spaces			10
8334	Consult	AHU F-8	2.0	141	8	1,131		Office Spaces			10
8305	Work-up	AHU F-8	1.0	149	8	1,189	Patient Rooms		119	40	
8312	Surgery	AHU F-8	2.0	156	8	1,245	Patient Rooms		125	42	
8311	Surgery	AHU F-8	2.0	156	8	1,246	Patient Rooms		125	42	
8310	Recovery	AHU F-8	2.0	122	8	977	Patient Rooms		98	33	
8301	Operatories	AHU F-8	2.0	1164	8	9,316	Patient Rooms		932	311	
8313	Sterilization	AHU F-8	2.0	189	8	1,512	Patient Rooms		151	50	
8333	Toilet	AHU F-8	0.0	61	8	486	Toilet room		81	0	
8307	Storage	AHU F-8	0.0	98	8	782		Storage Rooms			1
8304	Lab	AHU F-8	3.0	236	8	1,889	Laboratory, general		189	63	
8309	Dark	AHU F-8	1.0	60	8	476	Laboratory, general		48	16	
8308	Panarex	AHU F-8	1.0	82	8	653	Patient Rooms		65	22	
8411	Exam	AHU F-8	2.0	141	8	1,130	Patient Rooms		113	38	
8409	Exam	AHU F-8	2.0	132	8	1,057	Patient Rooms		106	35	
8407	Exam	AHU F-8	2.0	137	8	1,096	Patient Rooms		110	37	
8405	Phys. Work	AHU F-8	2.0	160	8	1,277	Patient Rooms		128	43	
8403	Toilet	AHU F-8	0.0	90	8	718	Toilet room		120	0	
8408	Shared Toilet	AHU F-8	0.0	85	8	681	Toilet room		113	0	

8406	Future Audio Booth	AHU F-8	2.0	206	8	1,648	Patient Rooms		165	55	
8404	Nurse Work	AHU F-8	1.0	192	8	1,537	Patient Rooms		154	51	
8402	Vitals	AHU F-8	2.0	102	8	820	Patient Rooms		82	27	
8209	Exam/Procedure	AHU F-8	2.0	208	8	1,667	Patient Rooms		167	56	
8207	Exam	AHU F-8	2.0	133	8	1,066	Patient Rooms		107	36	
8205	Exam	AHU F-8	2.0	129	8	1,028	Patient Rooms		103	34	
8203	ORL Admin	AHU F-8	1.0	134	8	1,073		Office Spaces			5
8201	Checkout	AHU F-8	2.0	135	8	1,077		Booking/Waiting			15
8200	Reception	AHU F-8	2.0	109	8	869		Booking/Waiting			15
8208	Exam	AHU F-8	2.0	166	8	1,329	Patient Rooms		133	44	
8206	Exam	AHU F-8	2.0	160	8	1,281	Patient Rooms		128	43	
8204	Exam	AHU F-8	2.0	159	8	1,268	Patient Rooms		127	42	
8202	Nurse Work	AHU F-8	1.0	159	8	1,270	Patient Rooms		127	42	
8224	Eye Exam	AHU F-8	2.0	255	8	2,036	Patient Rooms		204	68	
8226	Eye Exam	AHU F-8	2.0	246	8	1,971	Patient Rooms		197	66	
8228	Eye Exam	AHU F-8	2.0	244	8	1,948	Patient Rooms		195	65	
8230	Eye Exam	AHU F-8	2.0	241	8	1,931	Patient Rooms		193	64	
8103	Women	AHU F-8	0.0	226	8	1,810	Toilet room		302	0	
8102	Men	AHU F-8	0.0	208	8	1,660	Toilet room		277	0	
8223	Nurse Work	AHU F-8	1.0	95	8	761	Patient Rooms		76	25	
8221	Toilet	AHU F-8	0.0	77	8	613	Toilet room		102	0	
8225	Procedure	AHU F-8	2.0	233	8	1,864	Patient Rooms		186	62	
8229	Waiting Area	AHU F-8	0.0	49	8	391	Corridor		13	0	
8227	Fields	AHU F-8	2.0	87	8	697	Patient Rooms		70	23	
8231	Check-in/Check-out	AHU F-8	2.0	202	8	1,617		Booking/Waiting			15
8233	Lab	AHU F-8	2.0	158	8	1,260	Laboratory, general		126	42	
8235	Admin Office	AHU F-8	1.0	120	8	958		Office Spaces			5
8237	Nurse Work	AHU F-8	1.0	139	8	1,110	Patient Rooms		111	37	
8109	Waiting	AHU F-8	0.0	570	8	4,558	Corridor		152	0	
8108	Waiting	AHU F-8	0.0	683	8	5,462	Corridor		182	0	
8107	Waiting	AHU F-8	0.0	465	8	3,723	Corridor		124	0	
8106	Waiting	AHU F-8	0.0	598	8	4,788	Corridor		160	0	
8105	Waiting	AHU F-8	0.0	461	8	3,692	Corridor		123	0	
8104	Corridor	AHU F-8	0.0	277	8	2,217	Corridor		74	0	
8000	Elevator Lobby	AHU F-8	0.0	557	8	4,453		Lobbies/prefunction			0

8001	Alcove	AHU F-8	0.0	317	8	2,539		Lobbies/prefunction			0
8100	Waiting	AHU F-8	0.0	675	8	5,401	Corridor		180	0	
8002	Corridor	AHU F-8	0.0	487	8	3,892	Corridor		130	0	
8300	Corridor	AHU F-8	0.0	455	8	3,642	Corridor		121	0	
8418	Corridor	AHU F-8	0.0	660	8	5,284	Corridor		176	0	
83010	Cylinder Storage	AHU F-8	0.0	16	8	125	Sterile Storage		8	4	
8316	Corridor	AHU F-8	0.0	621	8	4,969	Corridor		166	0	
8401	Corridor	AHU F-8	0.0	419	8	3,356	Corridor		112	0	
8200	Corridor	AHU F-8	0.0	839	8	6,712	Corridor		224	0	
				22004					**8574**	**1873**	**349**
9108	Mechanical	AHU F-9	0.0	958	8	7,660		Electrical Equipment Rooms			0
9106	Corridor	AHU F-9	0.0	258	8	2,060	Corridor		69	0	
9111	Conference	AHU F-9	15.0	557	8	4,453		Conference/meeting			95
9617	Shell	AHU F-9	0.0	5378	8	43,026		Office Spaces			0
9408	Shared Conference	AHU F-9	6.0	260	8	2,081		Conference/meeting			50
9410	Avail	AHU F-9	1.0	128	8	1,025		Office Spaces			5
9312	Office	AHU F-9	1.0	121	8	965		Office Spaces			5
9314	Phys. Office	AHU F-9	1.0	285	8	2,279		Office Spaces			5
9212	Avail	AHU F-9	1.0	146	8	1,169		Office Spaces			5
9214	Nutrition Pulm. Office	AHU F-9	1.0	147	8	1,172		Office Spaces			5
9216	NP Pulm. Office	AHU F-9	1.0	142	8	1,137		Office Spaces			5
9114	Data	AHU F-9	0.0	88	8	705		Electrical Equipment Rooms			0
9218	Avail	AHU F-9	1.0	156	8	1,247		Office Spaces			5
9116	Mechanical	AHU F-9	0.0	471	8	3,766		Electrical Equipment Rooms			0
9115	J.C.	AHU F-9	0.0	93	8	743		Janitor Closets, Trash Rooms, Recycling			0
9407	Toilet	AHU F-9	0.0	91	8	730	Toilet room		122	0	
9405	Storage	AHU F-9	0.0	75	8	603		Storage Rooms			1
9403	Exam	AHU F-9	2.0	136	8	1,088	Patient Rooms		109	36	
9401	Exam	AHU F-9	2.0	135	8	1,079	Patient Rooms		108	36	
9503	TV/Education Library	AHU F-9	3.0	266	8	2,128		Libraries			16
9404	Shared Break	AHU F-9	3.0	149	8	1,191		Break Rooms			35
9402	Exam	AHU F-9	2.0	127	8	1,014	Patient Rooms		101	34	
9400	Exam	AHU F-9	2.0	115	8	923	Patient Rooms		92	31	

9504	Counseling Office	AHU F-9	2.0	144	8	1,150		Office Spaces			10
9502	Counseling Office	AHU F-9	2.0	128	8	1,026		Office Spaces			10
9500	Reception	AHU F-9	2.0	119	8	949		Booking/Waiting			15
9310	GI Storage	AHU F-9	0.0	151	8	1,211	Sterile Storage		81	40	
9308	Exam	AHU F-9	2.0	129	8	1,031	Patient Rooms		103	34	
9306	Exam	AHU F-9	2.0	117	8	937	Patient Rooms		94	31	
9304	Nurse Work	AHU F-9	1.0	146	8	1,168	Patient Rooms		117	39	
9302	Work	AHU F-9	2.0	81	8	651	Patient Rooms		65	22	
9300	Reception	AHU F-9	2.0	122	8	973		Booking/Waiting			15
9309	Exam	AHU F-9	2.0	153	8	1,225	Patient Rooms		123	41	
9307	Exam	AHU F-9	2.0	127	8	1,018	Patient Rooms		102	34	
9305	Exam	AHU F-9	2.0	124	8	995	Patient Rooms		99	33	
9303	Vitals	AHU F-9	2.0	130	8	1,038	Patient Rooms		104	35	
9301	Toilet	AHU F-9	0.0	78	8	622	Toilet room		104	0	
9213	Avail	AHU F-9	1.0	272	8	2,179		Office Spaces			5
9210	PFT Lab	AHU F-9	3.0	237	8	1,897	Laboratory, general		190	63	
9211	PFT Work	AHU F-9	2.0	220	8	1,760	Patient Rooms		176	59	
9209	Phys. Work	AHU F-9	2.0	314	8	2,514	Patient Rooms		251	84	
9104	Women	AHU F-9	0.0	223	8	1,782	Toilet room		297	0	
9103	Men	AHU F-9	0.0	200	8	1,597	Toilet room		266	0	
9208	Nurse Work	AHU F-9	1.0	247	8	1,979	Patient Rooms		198	66	
9215	Toilet	AHU F-9	0.0	69	8	552	Toilet room		92	0	
9201	Vitals	AHU F-9	2.0	66	8	525	Patient Rooms		52	17	
9217	Storage	AHU F-9	0.0	133	8	1,066		Storage Rooms			1
9200	Reception	AHU F-9	2.0	178	8	1,426		Booking/Waiting			15
9203	Exam	AHU F-9	2.0	125	8	1,001	Patient Rooms		100	33	
9205	Exam	AHU F-9	2.0	129	8	1,036	Patient Rooms		104	35	
9207	Exam	AHU F-9	2.0	133	8	1,065	Patient Rooms		107	36	
9202	Exam	AHU F-9	2.0	128	8	1,021	Patient Rooms		102	34	
9204	Exam	AHU F-9	2.0	134	8	1,075	Patient Rooms		108	36	
9206	Exam	AHU F-9	2.0	135	8	1,081	Patient Rooms		108	36	
9109	Waiting	AHU F-9	0.0	899	8	7,191	Corridor		240	0	
9501	Waiting	AHU F-9	0.0	557	8	4,456	Corridor		149	0	
9107	Waiting	AHU F-9	0.0	598	8	4,788	Corridor		160	0	
9105	Waiting	AHU F-9	0.0	512	8	4,099	Corridor		137	0	

9000	Elevator Lobby	AHU F-9	0.0	730	8	5,836		Lobbies/prefunction			0
9001	Alcove	AHU F-9	0.0	329	8	2,633		Lobbies/prefunction			0
9100	Waiting	AHU F-9	0.0	759	8	6,068	Corridor		202	0	
9002	Corridor	AHU F-9	0.0	507	8	4,060	Corridor		135	0	
9409	Corridor	AHU F-9	0.0	568	8	4,542	Corridor		151	0	
9311	Corridor	AHU F-9	0.0	438	8	3,502	Corridor		117	0	
9313	Corridor	AHU F-9	0.0	261	8	2,084	Corridor		69	0	
9219	Corridor	AHU F-9	0.0	485	8	3,880	Corridor		129	0	
9221	Corridor	AHU F-9	0.0	550	8	4,396	Corridor		147	0	
9220	Corridor	AHU F-9	0.0	454	8	3,635	Corridor		121	0	
				22620					**5499**	**944**	**312**
10108	Mechanical	AHU F-10	0.0	928	8	7,424		Electrical Equipment Rooms			0
10264	Corridor	AHU F-10	0.0	695	8	5,561	Corridor		185	0	
10263	Conference	AHU F-10	15.0	536	8	4,289		Conference/meeting			95
10231	PN/PNP	AHU F-10	1.0	299	8	2,396		Office Spaces			5
10221	Sickle Cell	AHU F-10	2.0	216	8	1,729	Patient Rooms		173	58	
10233	Exam	AHU F-10	2.0	144	8	1,148	Patient Rooms		115	38	
10235	Exam	AHU F-10	2.0	142	8	1,136	Patient Rooms		114	38	
10237	Exam	AHU F-10	2.0	140	8	1,117	Patient Rooms		112	37	
10239	Procedure	AHU F-10	2.0	251	8	2,009	Patient Rooms		201	67	
10241	Recovery	AHU F-10	2.0	136	8	1,091	Patient Rooms		109	36	
10243	Recovery	AHU F-10	2.0	135	8	1,080	Patient Rooms		108	36	
10245B	ISO Exam	AHU F-10	2.0	199	8	1,589	Patient Rooms		159	53	
10245A	Toilet	AHU F-10	0.0	70	8	560	Toilet room		93	0	
10245	Special Consult	AHU F-10	2.0	254	8	2,031	Patient Rooms		203	68	
10250	Special Exam	AHU F-10	2.0	129	8	1,028	Patient Rooms		103	34	
10111	Data	AHU F-10	0.0	89	8	716		Electrical Equipment Rooms			0
10251	Patient Education	AHU F-10	2.0	156	8	1,246	Patient Rooms		125	42	
10116	Mechanical	AHU F-10	0.0	463	8	3,707		Electrical Equipment Rooms			0
10115	JC	AHU F-10	0.0	92	8	733		Janitor Closets, Trash Rooms, Recycling			0
10238	Hemophilia	AHU F-10	2.0	271	8	2,168	Patient Rooms		217	72	
10230	Available	AHU F-10	1.0	149	8	1,192		Office Spaces			5
10229	Shared Staff conf	AHU F-10	3.0	228	8	1,826		Conference/meeting			35

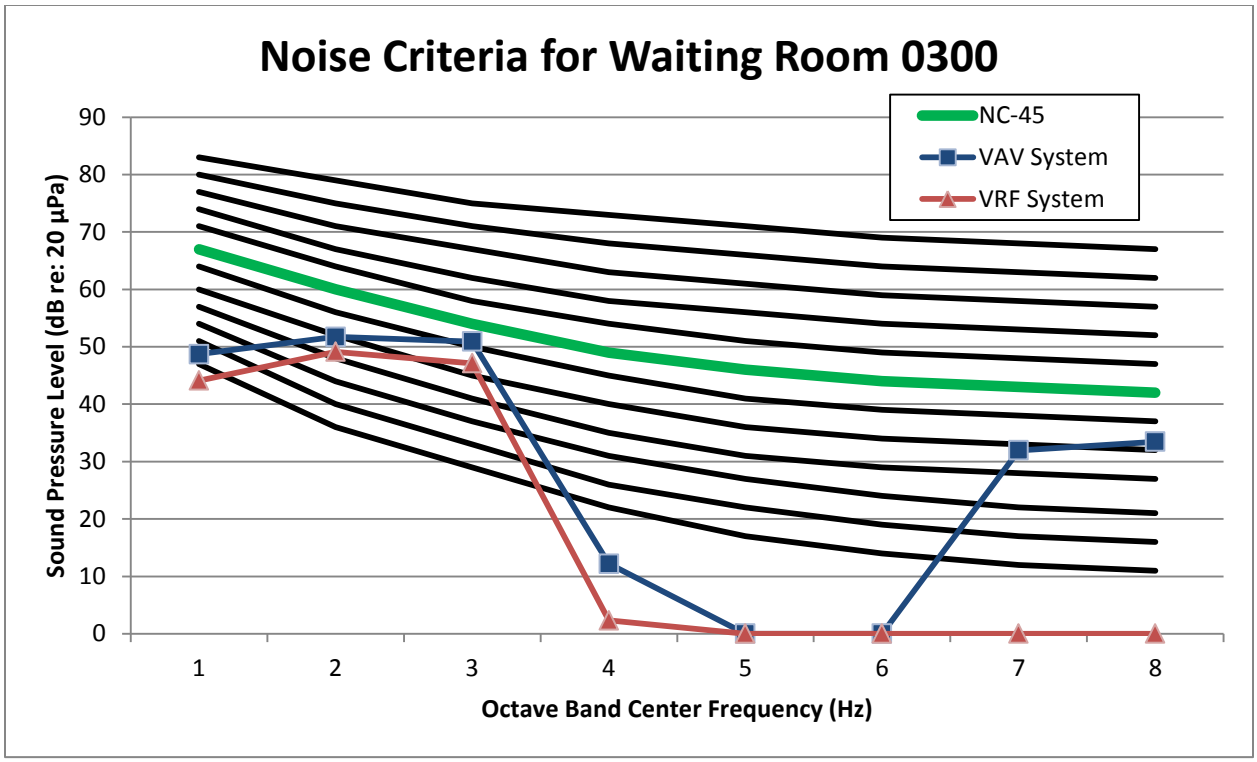
10227	Kitchen	AHU F-10	0.0	165	8	1,319		Break Rooms			20
10223	Storage	AHU F-10	0.0	73	8	584		Storage Rooms			1
10219	Toilet	AHU F-10	0.0	60	8	481	Toilet room		80	0	
10217	toilet	AHU F-10	0.0	68	8	547	Toilet room		91	0	
10236	Support	AHU F-10	1.0	161	8	1,284	Patient Rooms		128	43	
10225	Shared Break	AHU F-10	3.0	219	8	1,748		Break Rooms			35
10240	Exam	AHU F-10	2.0	134	8	1,070	Patient Rooms		107	36	
10242	Exam	AHU F-10	2.0	131	8	1,046	Patient Rooms		105	35	
10228	Family Pantry	AHU F-10	0.0	251	8	2,008		Storage Rooms			1
10244	Exam	AHU F-10	2.0	131	8	1,049	Patient Rooms		105	35	
10246	Exam	AHU F-10	2.0	133	8	1,066	Patient Rooms		107	36	
10226	Soiled Linen	AHU F-10	0.0	96	8	768		Storage Rooms			1
10224	toilet	AHU F-10	0.0	45	8	357	Toilet room		60	0	
10222	toy Storage	AHU F-10	0.0	85	8	677		Storage Rooms			1
10216	Infusion	AHU F-10	2.0	3160	8	25,278	Patient Rooms		2528	843	
10248	Nurse Work	AHU F-10	1.0	339	8	2,708	Patient Rooms		271	90	
10215	MD/PA work	AHU F-10	2.0	149	8	1,196	Patient Rooms		120	40	
10213	Copy	AHU F-10	0.0	121	8	967		Copy/Printing Rooms			0
10211	Nurse work	AHU F-10	1.0	215	8	1,716	Patient Rooms		172	57	
10209	Meds	AHU F-10	0.0	179	8	1,433	Medication room		96	48	
10232	File	AHU F-10	0.0	74	8	592		Storage Rooms			1
10234	CRA	AHU F-10	2.0	248	8	1,981		Office Spaces			10
10249	Patient Consultation	AHU F-10	2.0	179	8	1,429	Patient Rooms		143	48	
10214	MD/PA Work	AHU F-10	2.0	176	8	1,406	Patient Rooms		141	47	
10252	SP Exam	AHU F-10	2.0	120	8	961	Patient Rooms		96	32	
10201	Microscope	AHU F-10	1.0	118	8	946	Laboratory, general		95	32	
10254	SP Exam	AHU F-10	2.0	129	8	1,034	Patient Rooms		103	34	
10256	SP Exam	AHU F-10	2.0	130	8	1,039	Patient Rooms		104	35	
10203	Lab	AHU F-10	2.0	251	8	2,008	Laboratory, general		201	67	
10207	Lab Office	AHU F-10	1.0	106	8	846		Office Spaces			5
10205	Phleb/Draw	AHU F-10	1.0	108	8	864	Patient Rooms		86	29	
10253	Psych	AHU F-10	1.0	139	8	1,110	Patient Rooms		111	37	
10255	FC Office	AHU F-10	1.0	152	8	1,216		Lobbies/prefunction			8
10200	Schedule/Check-In	AHU F-10	2.0	317	8	2,539		Booking/Waiting			15
10212	Head CRA	AHU F-10	1.0	110	8	883		Office Spaces			5

10210	RN Office	AHU F-10	1.0	104	8	831		Office Spaces			5
10208	Toilet	AHU F-10	0.0	78	8	621	Toilet room		103	0	
10206	Vitals	AHU F-10	2.0	103	8	822	Patient Rooms		82	27	
10204	Vitals	AHU F-10	2.0	102	8	816	Patient Rooms		82	27	
10202	File	AHU F-10	0.0	128	8	1,021		Storage Rooms			1
10104	Women Restroom	AHU F-10	0.0	229	8	1,831	Toilet room		305	0	
10103	Men Restroom	AHU F-10	0.0	206	8	1,645	Toilet room		274	0	
10218	Corridor	AHU F-10	0.0	768	8	6,148	Corridor		205	0	
10074	Corridor	AHU F-10	0.0	255	8	2,037	Corridor		68	0	
10101	Waiting	AHU F-10	0.0	1111	8	8,884	Corridor		296	0	
10000	Elevator Lobby	AHU F-10	0.0	588	8	4,702		Lobbies/prefunction			0
10001	Alcove	AHU F-10	0.0	301	8	2,411		Lobbies/prefunction			0
10075	Corridor	AHU F-10	0.0	988	8	7,904	Corridor		263	0	
10260	Corridor	AHU F-10	0.0	495	8	3,956	Corridor		132	0	
10261	Corridor	AHU F-10	0.0	531	8	4,248	Corridor		142	0	
10259	Corridor	AHU F-10	0.0	471	8	3,770	Corridor		126	0	
10258	Corridor	AHU F-10	0.0	239	8	1,908	Corridor		64	0	
10262	Corridor	AHU F-10	0.0	304	8	2,430	Corridor		81	0	
10257	Corridor	AHU F-10	0.0	631	8	5,047	Corridor		168	0	
				21621					**9454**	**2255**	**255**
	Total			**394,815**		**1,579,259**					

APPENDIX B: Acoustics Breadth, Sound Power Level Attenuation Calculations

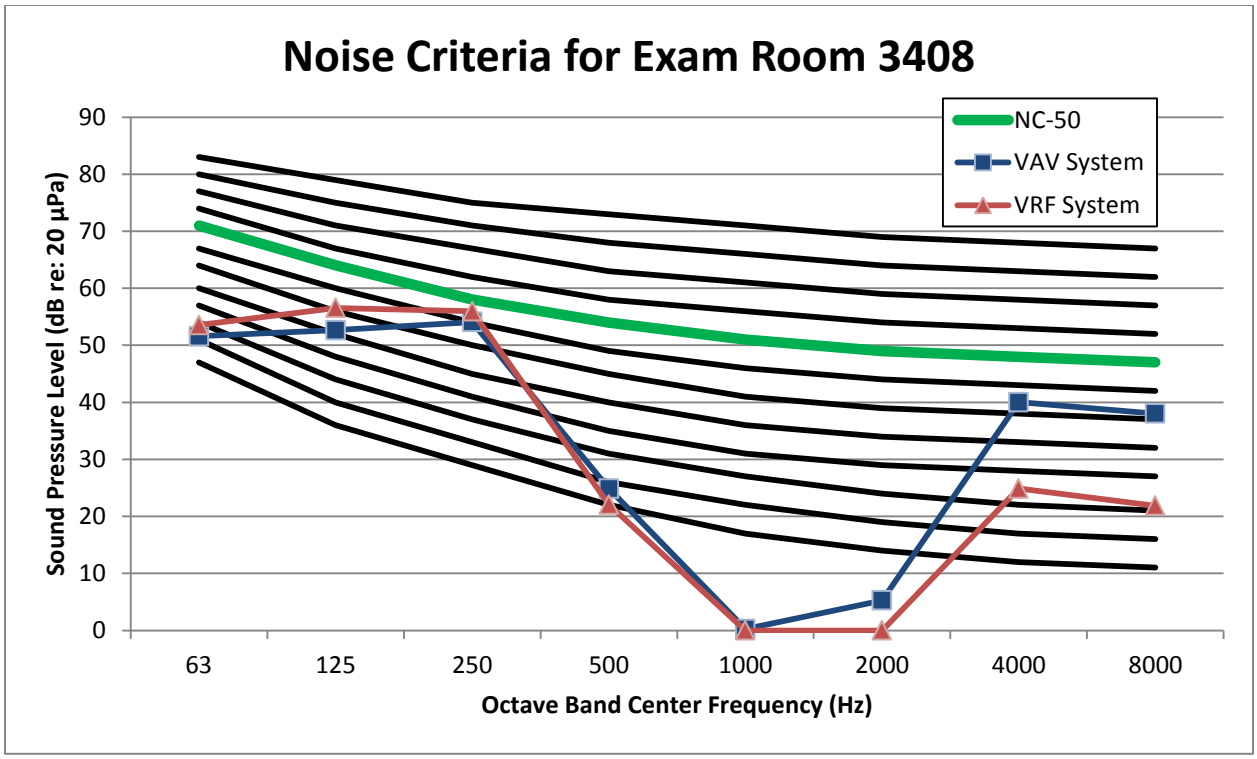
Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
AHU Sound Power Level, L_w (dB)		**94**	**94**	**88**	**87**	**85**	**83**	**78**	**72**
46	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 44x28	9.20	9.20	9.20	50.60	101.20	46.00	4.60	4.60
10	Attenuation	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.05
	40x28	2.00	2.00	1.00	0.50	0.50	0.50	0.50	0.50
5	Attenuation	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.05
	38x26	1.00	1.00	0.50	0.25	0.25	0.25	0.25	0.25
Radial Elbow		0	1	1	2	3	3	3	3
8	Attenuation	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.05
	38x26	1.60	1.60	0.80	0.40	0.40	0.40	0.40	0.40
Split		3	3	3	3	3	3	3	3
3	Attenuation	0.03	0.03	0.05	0.05	0.10	0.10	0.10	0.10
	10" Round	0.09	0.09	0.15	0.15	0.30	0.30	0.30	0.30
Spectrum Level at VAV Terminal Box		**77**	**76**	**72**	**30**	**-24**	**30**	**66**	**60**
VAV Sound Power Level, L_w (dB)		**60**	**60**	**54**	**44**	**42**	**39**	**34**	**34**
1.5	Attenuation	0	0	0	2	4	5	2	1
	6x10 Lined	0	0	0	2	6	7	3	2
2	Attenuation	0	0	0	2	4	5	2	1
	6x10 Lined	0	0	0	3	8	9	4	2
4	Attenuation	0	0	0	2	4	5	2	1
	8" Round Lined	1	1	1	6	15	18	8	4
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**60**	**63**	**62**	**23**	**6**	**-3**	**43**	**44**
Sound Pressure Level		**49**	**52**	**51**	**12**	**-5**	**-14**	**32**	**33**

Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
DOAS Sound Power Level, L_w (dB)		**90**	**91**	**85**	**84**	**84**	**81**	**76**	**71**
46	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 14x28	9.20	9.20	9.20	50.60	101.20	46.00	4.60	4.60
10	Attenuation	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.05
	20x18	2.00	2.00	1.00	0.50	0.50	0.50	0.50	0.50
5	Attenuation	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.05
	16x18	1.00	1.00	0.50	0.25	0.25	0.25	0.25	0.25
Radial Elbow		0	0	0	1	2	3	3	3
8	Attenuation	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.05
	16x18	1.60	1.60	0.80	0.40	0.40	0.40	0.40	0.40
Split		3	3	3	3	3	3	3	3
3	Attenuation	0.20	0.20	0.40	2.40	5.50	7.60	6.40	6.40
	4" Round	0.60	0.60	1.20	7.20	16.50	22.80	19.20	19.20
Spectrum Level at VRF Terminal Box		**73**	**74**	**69**	**21**	**-40**	**5**	**45**	**40**
VRF Sound Power Level, L_w (dB)		**44**	**49**	**40**	**37**	**38**	**34**	**22**	**14**
1.5	Attenuation	0.20	0.20	0.40	2.40	5.50	7.60	6.40	6.40
	4x8 Lined	0.30	0.30	0.60	3.60	8.25	11.40	9.60	9.60
2	Attenuation	0.20	0.20	0.40	2.40	5.50	7.60	6.40	6.40
	4x8 Lined	0.40	0.40	0.80	4.80	11.00	15.20	12.80	12.80
4	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	0.80	0.80	0.80	6.40	15.20	18.40	8.00	4.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**55**	**60**	**58**	**13**	**-4**	**-19**	**7**	**6**
Sound Pressure Level		**44**	**49**	**47**	**2**	**-15**	**-30**	**-4**	**-5**


Noise Criteria for Waiting Room 0300
NC-45
VAV System
VRF System
Sound Pressure Level (dB re: 20 µPa)
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
Octave Band Center Frequency (Hz)

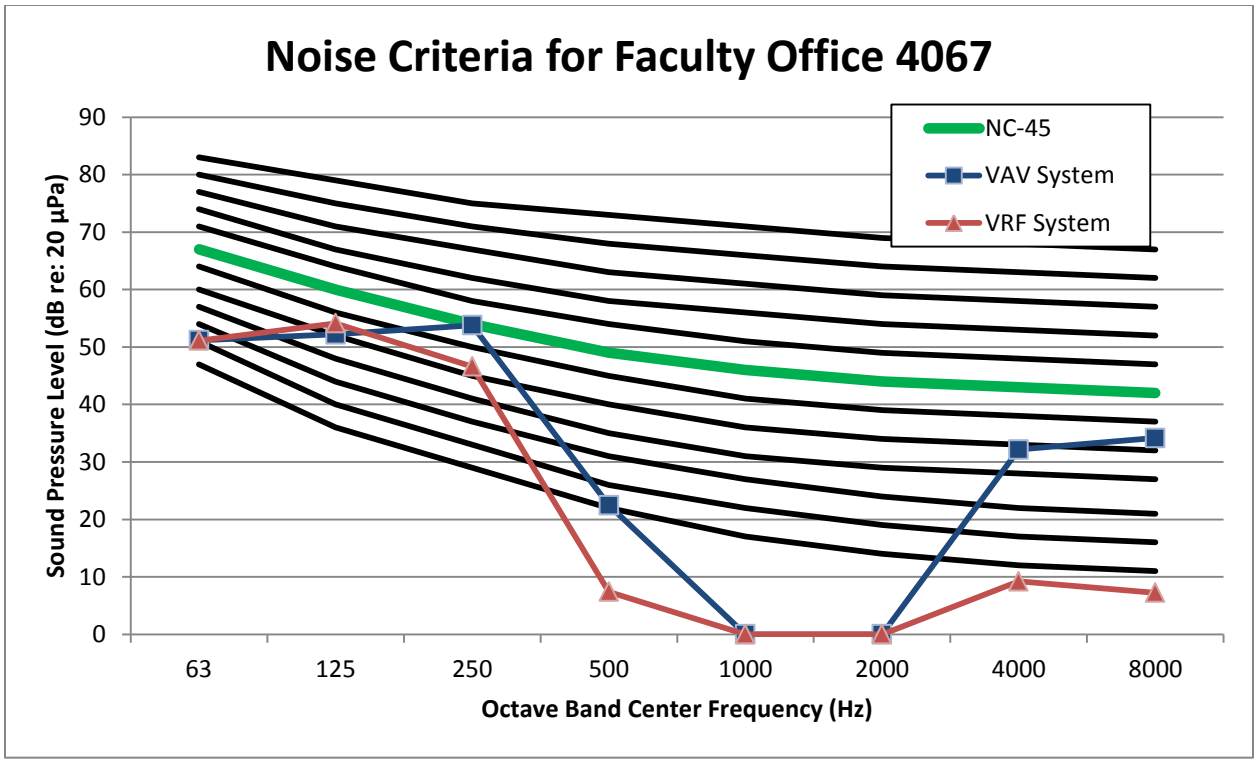
Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
AHU Sound Power Level, L_w (dB)		**96**	**93**	**89**	**90**	**86**	**85**	**81**	**73**
26.00	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 80x22	5.20	5.20	5.20	28.60	57.20	26.00	2.60	2.60
Split		3	3	3	3	3	3	3	3
5.00	Attenuation	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.05
	44x18	1.00	1.00	0.50	0.25	0.25	0.25	0.25	0.25
14.00	Attenuation	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.05
	42x18	2.80	2.80	1.40	0.70	0.70	0.70	0.70	0.70
6.00	Attenuation	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.05
	40x18	1.20	1.20	0.60	0.30	0.30	0.30	0.30	0.30
Split		3	3	3	3	3	3	3	3
2.00	Attenuation	0.03	0.03	0.03	0.05	0.07	0.07	0.07	0.07
	12" Round	0.06	0.06	0.06	0.10	0.14	0.14	0.14	0.14
Spectrum Level at VAV Terminal Box		**80**	**77**	**75**	**54**	**21**	**52**	**71**	**63**
VAV Sound Power Level, L_w (dB)		**60**	**60**	**54**	**44**	**42**	**39**	**34**	**34**
4.00	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	6x10 Lined	0.80	0.80	0.80	6.40	15.20	18.40	8.00	4.00
2.00	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	0.40	0.40	0.40	3.20	7.60	9.20	4.00	2.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**63**	**64**	**65**	**36**	**11**	**16**	**51**	**49**
Sound Pressure Level		**52**	**53**	**54**	**25**	**0**	**5**	**40**	**38**

Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
DOAS Sound Power Level, L_w (dB)		**98**	**97**	**93**	**92**	**91**	**89**	**84**	**79**
26	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 24x23	5.20	5.20	5.20	28.60	57.20	26.00	2.60	2.60
Split		3	3	3	3	3	3	3	3
5	Attenuation	0.20	0.20	0.15	0.10	0.07	0.07	0.07	0.07
	18x15	1.00	1.00	0.75	0.50	0.35	0.35	0.35	0.35
14	Attenuation	0.20	0.20	0.15	0.10	0.07	0.07	0.07	0.07
	18x13	2.80	2.80	2.10	1.40	0.98	0.98	0.98	0.98
6	Attenuation	0.20	0.20	0.15	0.10	0.07	0.07	0.07	0.07
	18x13	1.20	1.20	0.90	0.60	0.42	0.42	0.42	0.42
Split		3	3	3	3	3	3	3	3
2	Attenuation	0.03	0.03	0.05	0.05	0.10	0.10	0.10	0.10
	4" Round	0.06	0.06	0.10	0.10	0.20	0.20	0.20	0.20
Spectrum Level at VRF Terminal Box		**82**	**81**	**78**	**55**	**26**	**55**	**73**	**68**
VRF Sound Power Level, L_w (dB)		**44**	**49**	**40**	**37**	**38**	**34**	**22**	**14**
4	Attenuation	0.20	0.20	0.40	2.40	5.50	7.60	6.40	6.40
	4x8 Lined	0.80	0.80	1.60	9.60	22.00	30.40	25.60	25.60
2	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	0.40	0.40	0.40	3.20	7.60	9.20	4.00	2.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**65**	**68**	**67**	**33**	**1**	**7**	**36**	**33**
Sound Pressure Level		**54**	**57**	**56**	**22**	**-10**	**-4**	**25**	**22**


Noise Criteria for Exam Room 3408
NC-50
VAV System
VRF System
Sound Pressure Level (dB re: 20 µPa)
90
80
70
60
50
40
30
20
10
0
63
125
250
500
1000
2000
4000
8000
Octave Band Center Frequency (Hz)

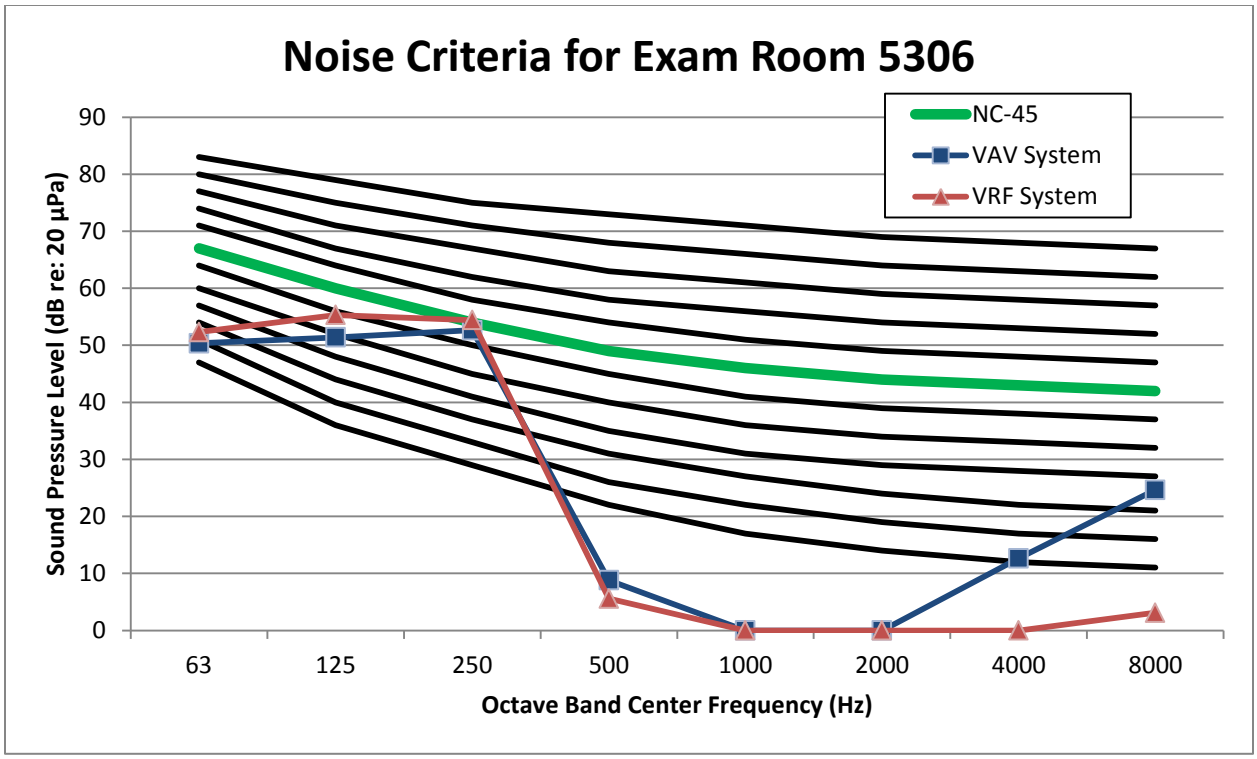
Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
AHU Sound Power Level, L_w (dB)		**96**	**93**	**89**	**90**	**86**	**85**	**81**	**73**
22	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 80x22	4.40	4.40	4.40	24.20	48.40	22.00	2.20	2.20
Split		3	3	3	3	3	3	3	3
27	Attenuation	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.05
	46x18	5.40	5.40	2.70	1.35	1.35	1.35	1.35	1.35
Split		3	3	3	3	3	3	3	3
3	Attenuation	0.03	0.03	0.05	0.05	0.10	0.10	0.10	0.10
	10" Round	0.09	0.09	0.15	0.15	0.30	0.30	0.30	0.30
Spectrum Level at VAV Terminal Box		**80**	**77**	**76**	**58**	**30**	**55**	**71**	**63**
VAV Supply Fan Power Level, L_w (dB)		**60**	**60**	**54**	**44**	**42**	**39**	**34**	**34**
6	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	6x10 Lined	1.20	1.20	1.20	9.60	22.80	27.60	12.00	6.00
4	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	0.80	0.80	0.80	6.40	15.20	18.40	8.00	4.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**62**	**63**	**65**	**33**	**-4**	**1**	**43**	**45**
Sound Pressure Level		**51**	**52**	**54**	**22**	**-15**	**-10**	**32**	**34**

Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
DOAS Sound Power Level, L_w (dB)		**96**	**95**	**90**	**90**	**88**	**86**	**81**	**75**
22	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 24x22	4.40	4.40	4.40	24.20	48.40	22.00	2.20	2.20
Split		3	3	3	3	3	3	3	3
27	Attenuation	0.20	0.20	0.15	0.10	0.07	0.07	0.07	0.07
	14x18	5.40	5.40	4.05	2.70	1.89	1.89	1.89	1.89
Split		3	3	3	3	3	3	3	3
3	Attenuation	0.03	0.03	0.05	0.05	0.10	0.10	0.10	0.10
	4" Round	0.09	0.09	0.15	0.15	0.30	0.30	0.30	0.30
Spectrum Level at VRF Terminal Box		**80**	**79**	**75**	**57**	**31**	**56**	**71**	**65**
VRF Sound Power Level, L_w (dB)		**44**	**49**	**40**	**37**	**38**	**34**	**22**	**14**
6	Attenuation	0.20	0.20	0.40	2.40	5.50	7.60	6.40	6.40
	4x8 Lined	1.20	1.20	2.40	14.40	33.00	45.60	38.40	38.40
4	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	0.80	0.80	6.40	15.20	18.40	8.00	4.00	0.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**62**	**65**	**58**	**18**	**-21**	**-6**	**20**	**18**
Sound Pressure Level		**51**	**54**	**47**	**7**	**-32**	**-17**	**9**	**7**


Noise Criteria for Faculty Office 4067
Sound Pressure Level (dB re: 20 µPa)
90
80
70
60
50
40
30
20
10
0
63
125
250
500
1000
2000
4000
8000
Octave Band Center Frequency (Hz)
NC-45
VAV System
VRF System

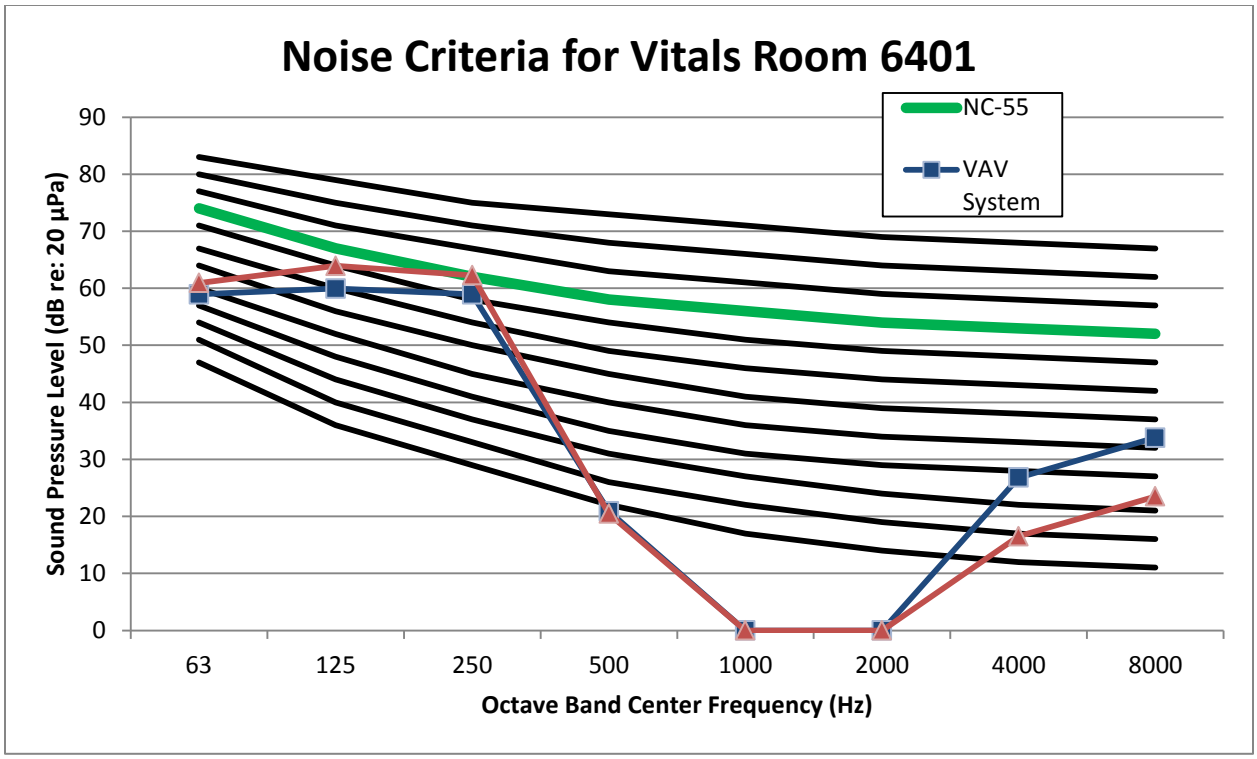
Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
AHU Sound Power Level, L_w (dB)		**96**	**93**	**89**	**90**	**86**	**85**	**81**	**73**
20	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 80x22	4.00	4.00	4.00	22.00	44.00	20.00	2.00	2.00
Split		3	3	3	3	3	3	3	3
23	Attenuation	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.05
	36x16	4.60	4.60	2.30	1.15	1.15	1.15	1.15	1.15
Split		3	3	3	3	3	3	3	3
3	Attenuation	0.03	0.03	0.03	0.05	0.07	0.07	0.07	0.07
	12" Round	0.09	0.09	0.09	0.15	0.21	0.21	0.21	0.21
Spectrum Level at VAV Terminal Box		**81**	**78**	**77**	**61**	**35**	**58**	**72**	**64**
VAV Sound Power Level, L_w (dB)		**60**	**60**	**54**	**44**	**42**	**39**	**34**	**34**
5	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	6x10 Lined	1.00	1.00	1.00	8.00	19.00	23.00	10.00	5.00
15	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	3.00	3.00	3.00	24.00	57.00	69.00	30.00	15.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**61**	**62**	**64**	**20**	**-41**	**-42**	**24**	**36**
Sound Pressure Level		**50**	**51**	**53**	**9**	**-52**	**-53**	**13**	**25**

Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
DOAS Sound Power Level, L_w (dB)		**98**	**97**	**93**	**92**	**91**	**89**	**84**	**79**
20	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 24x22	4.00	4.00	4.00	22.00	44.00	20.00	2.00	2.00
Split		3	3	3	3	3	3	3	3
23	Attenuation	0.20	0.20	0.15	0.10	0.07	0.07	0.07	0.07
	12x16	4.60	4.60	3.45	2.30	1.61	1.61	1.61	1.61
Split		3	3	3	3	3	3	3	3
3	Attenuation	0.03	0.03	0.05	0.05	0.10	0.10	0.10	0.10
	4" Round	0.09	0.09	0.15	0.15	0.30	0.30	0.30	0.30
Spectrum Level at VRF Terminal Box		**83**	**82**	**79**	**62**	**39**	**61**	**74**	**69**
VRF Sound Power Level, L_w (dB)		**44**	**49**	**40**	**37**	**38**	**34**	**22**	**14**
5	Attenuation	0.20	0.20	0.40	2.40	5.50	7.60	6.40	6.40
	4x8 Lined	1.00	1.00	2.00	12.00	27.50	38.00	32.00	32.00
15	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	3.00	3.00	3.00	24.00	57.00	69.00	30.00	15.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**63**	**66**	**65**	**17**	**-51**	**-54**	**4**	**14**
Sound Pressure Level		**52**	**55**	**54**	**6**	**-62**	**-65**	**-7**	**3**


Noise Criteria for Exam Room 5306
NC-45
VAV System
VRF System
Sound Pressure Level (dB re: 20 µPa)
90
80
70
60
50
40
30
20
10
0
63
125
250
500
1000
2000
4000
8000
Octave Band Center Frequency (Hz)

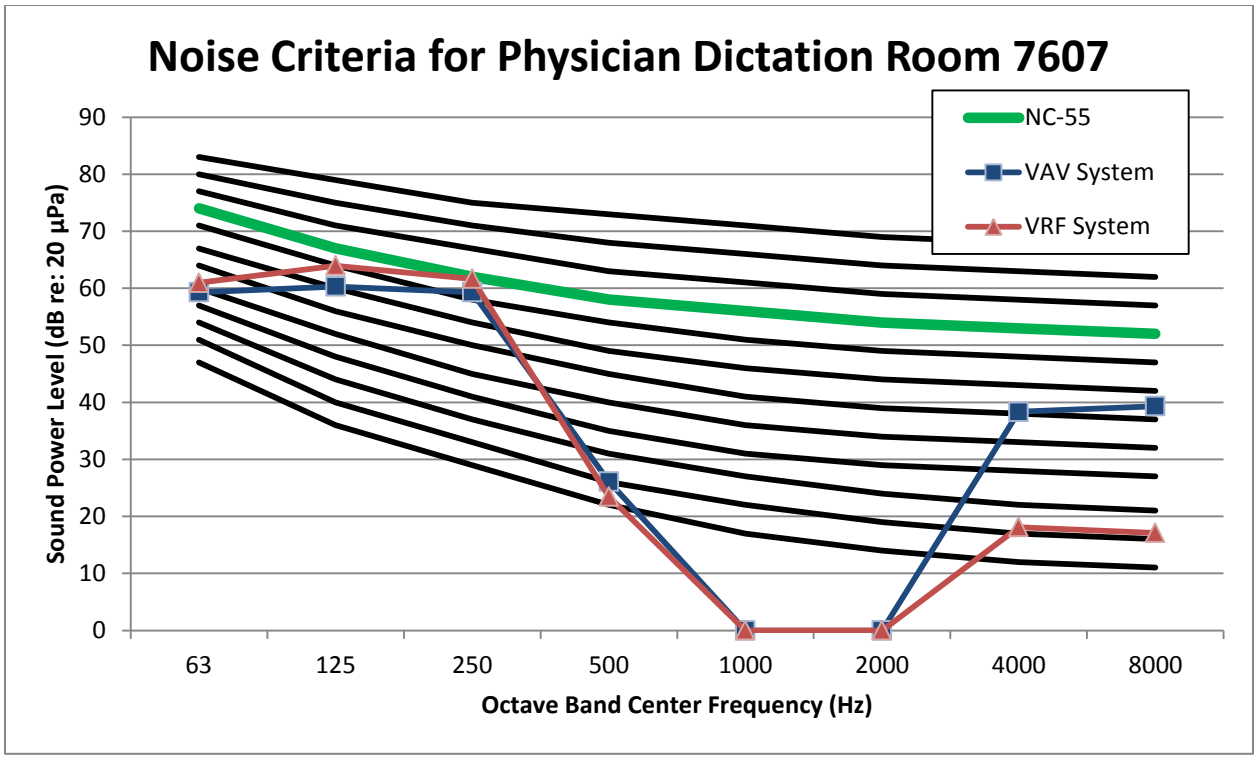
Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
AHU Sound Power Level, L_w (dB)		**96**	**93**	**89**	**90**	**86**	**85**	**81**	**73**
20	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 80x22	4.00	4.00	4.00	22.00	44.00	20.00	2.00	2.00
Split		3	3	3	3	3	3	3	3
3	Attenuation	0.03	0.03	0.03	0.05	0.07	0.07	0.07	0.07
	10" Round	0.09	0.09	0.09	0.15	0.21	0.21	0.21	0.21
Spectrum Level at VAV Terminal Box		**89**	**86**	**82**	**65**	**39**	**62**	**76**	**68**
VAV Sound Power Level, L_w (dB)		**60**	**60**	**54**	**44**	**42**	**39**	**34**	**34**
3	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	6x10 Lined	0.60	0.60	0.60	4.80	11.40	13.80	6.00	3.00
12	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	2.40	2.40	2.40	19.20	45.60	55.20	24.00	12.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**70**	**71**	**70**	**32**	**-21**	**-15**	**38**	**45**
Sound Pressure Level		**59**	**60**	**59**	**21**	**-32**	**-26**	**27**	**34**

Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
DOAS Sound Power Level, L_w (dB)		**98**	**97**	**93**	**92**	**91**	**89**	**84**	**79**
20	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 24x22	4.00	4.00	4.00	22.00	44.00	20.00	2.00	2.00
Split		3	3	3	3	3	3	3	3
3	Attenuation	0.03	0.03	0.05	0.05	0.10	0.10	0.10	0.10
	4" Round	0.09	0.09	0.15	0.15	0.30	0.30	0.30	0.30
Spectrum Level at VRF Terminal Box		**91**	**90**	**86**	**67**	**44**	**66**	**79**	**74**
VRF Sound Power Level, L_w (dB)		**44**	**49**	**40**	**37**	**38**	**34**	**22**	**14**
3	Attenuation	0.20	0.20	0.40	2.40	5.50	7.60	6.40	6.40
	4x8 Lined	0.60	0.60	1.20	7.20	16.50	22.80	19.20	19.20
12	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	2.40	2.40	2.40	19.20	45.60	55.20	24.00	12.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level Ceiling Diffuser		**72**	**75**	**73**	**31**	**-25**	**-20**	**28**	**35**
Sound Pressure Level		**61**	**64**	**62**	**20**	**-36**	**-31**	**17**	**24**


Noise Criteria for Vitals Room 6401
NC-55
VAV System
Sound Pressure Level (dB re: 20 µPa)
90
80
70
60
50
40
30
20
10
0
63
125
250
500
1000
2000
4000
8000
Octave Band Center Frequency (Hz)

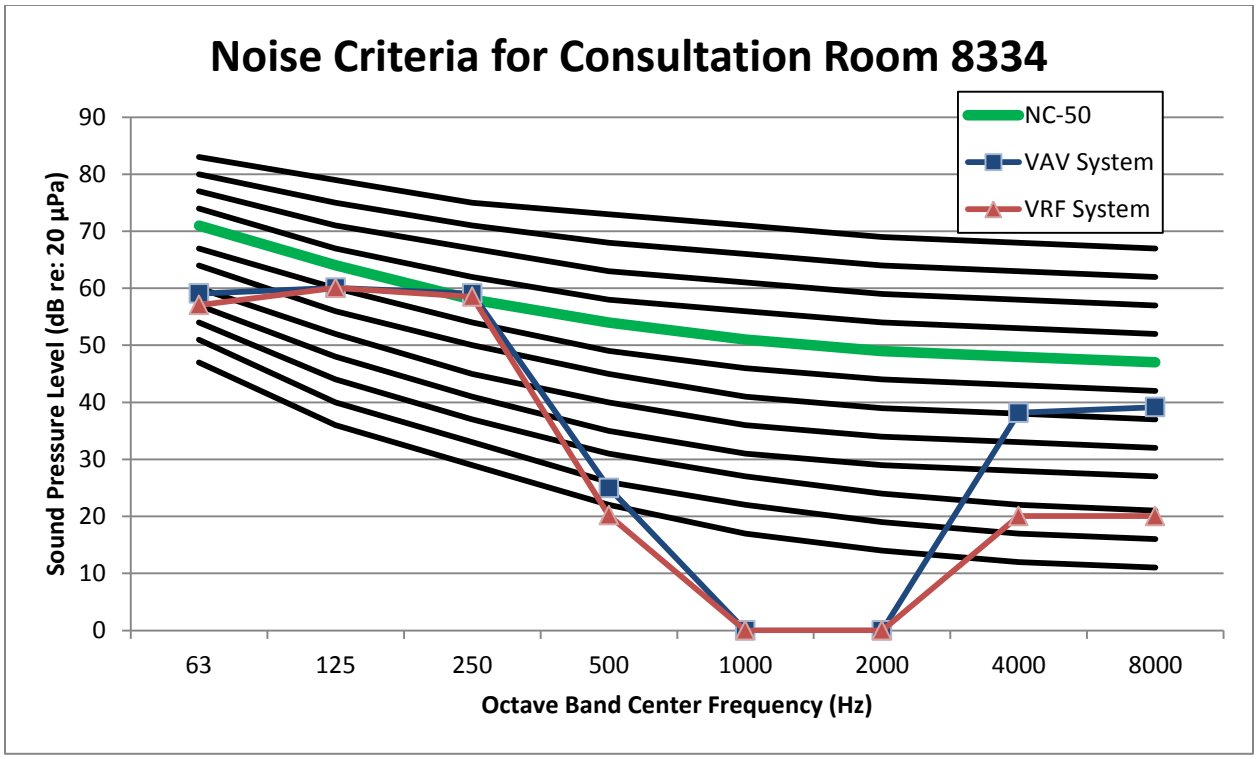
Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
AHU Sound Power Level, L_w (dB)		**96**	**93**	**89**	**90**	**86**	**85**	**81**	**73**
24	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 80x22	4.80	4.80	4.80	26.40	52.80	24.00	2.40	2.40
Split		3	3	3	3	3	3	3	3
15	Attenuation	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.05
	34x16	3.00	3.00	1.50	0.75	0.75	0.75	0.75	0.75
Split		3	3	3	3	3	3	3	3
4	Attenuation	0.03	0.03	0.03	0.05	0.07	0.07	0.07	0.07
	10" Round	0.12	0.12	0.12	0.20	0.28	0.28	0.28	0.28
Spectrum Level at VAV Terminal Box		**88**	**85**	**81**	**60**	**30**	**58**	**75**	**67**
VAV Sound Power Level, L_w (dB)		**60**	**60**	**54**	**44**	**42**	**39**	**34**	**34**
5	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	6x10 Lined	1.00	1.00	1.00	8.00	19.00	23.00	10.00	5.00
4	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	0.80	0.80	0.80	6.40	15.20	18.40	8.00	4.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**70**	**71**	**70**	**37**	**0**	**8**	**49**	**50**
Sound Pressure Level		**59**	**60**	**59**	**26**	**-11**	**-3**	**38**	**39**

Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
DOAS Sound Power Level, L_w (dB)		**98**	**97**	**93**	**92**	**91**	**89**	**84**	**79**
24	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 26x20	4.80	4.80	4.80	26.40	52.80	24.00	2.40	2.40
Split		3	3	3	3	3	3	3	3
15	Attenuation	0.20	0.20	0.15	0.10	0.07	0.07	0.07	0.07
	12x14	3.00	3.00	2.25	1.50	1.05	1.05	1.05	1.05
Split		3	3	3	3	3	3	3	3
4	Attenuation	0.03	0.03	0.05	0.05	0.10	0.10	0.10	0.10
	4" Round	0.45	0.45	0.75	0.75	1.50	1.50	1.50	1.50
Spectrum Level at VRF Terminal Box		**90**	**89**	**84**	**62**	**34**	**61**	**77**	**72**
VRF Sound Power Level, L_w (dB)		**44**	**49**	**40**	**37**	**38**	**34**	**22**	**14**
5	Attenuation	0.20	0.20	0.40	2.40	5.50	7.60	6.40	6.40
	4x8 Lined	1.00	1.00	2.00	12.00	27.50	38.00	32.00	32.00
4	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	0.80	0.80	0.80	6.40	15.20	18.40	8.00	4.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**72**	**75**	**73**	**34**	**-11**	**-4**	**29**	**28**
Sound Pressure Level		**61**	**64**	**62**	**23**	**-22**	**-15**	**18**	**17**


Noise Criteria for Physician Dictation Room 7607
NC-55
VAV System
VRF System
Sound Power Level (dB re: 20 µPa)
90
80
70
60
50
40
30
20
10
0
63
125
250
500
1000
2000
4000
8000
Octave Band Center Frequency (Hz)

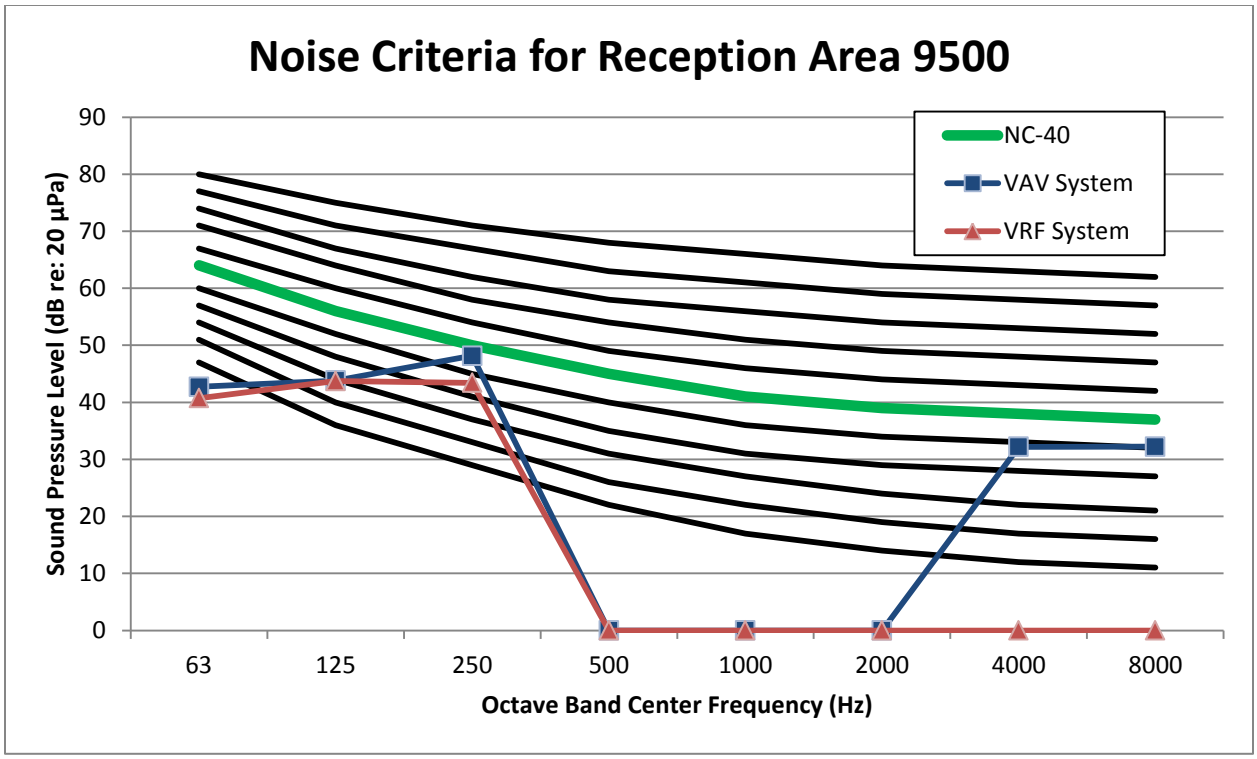
Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
AHU Sound Power Level, L_w (dB)		**96**	**93**	**89**	**90**	**86**	**85**	**81**	**73**
25	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 80x22	5.00	5.00	5.00	27.50	55.00	25.00	2.50	2.50
	Split	3	3	3	3	3	3	3	3
5	Attenuation	0.20	0.20	0.15	0.10	0.07	0.07	0.07	0.07
	18x14	1.00	1.00	0.75	0.50	0.35	0.35	0.35	0.35
	Split	3	3	3	3	3	3	3	3
5	Attenuation	0.03	0.03	0.03	0.05	0.07	0.07	0.07	0.07
	10" Round	0.15	0.15	0.15	0.25	0.35	0.35	0.35	0.35
Spectrum Level at VAV Terminal Box		**88**	**85**	**81**	**59**	**28**	**57**	**75**	**67**
VAV Sound Power Level, L_w (dB)		**60**	**60**	**54**	**44**	**42**	**39**	**34**	**34**
4	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	6x10 Lined	0.80	0.80	0.80	6.40	15.20	18.40	8.00	4.00
5	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	1.00	1.00	1.00	8.00	19.00	23.00	10.00	5.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**70**	**71**	**70**	**36**	**0**	**7**	**49**	**50**
Sound Pressure Level		**59**	**60**	**59**	**25**	**-11**	**-4**	**38**	**39**

Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
DOAS Sound Power Level, L_w (dB)		**98**	**97**	**93**	**92**	**91**	**89**	**84**	**79**
25	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 26x20	5.00	5.00	5.00	27.50	55.00	25.00	2.50	2.50
	Split	3	3	3	3	3	3	3	3
5	Attenuation	0.20	0.20	0.15	0.10	0.10	0.10	0.10	0.10
	10x8	1.00	1.00	0.75	0.50	0.50	0.50	0.50	0.50
	Split	3	3	3	3	3	3	3	3
5	Attenuation	0.03	0.03	0.03	0.05	0.07	0.07	0.07	0.07
	8" Round	0.15	0.15	0.15	0.25	0.35	0.35	0.35	0.35
Spectrum Level at VRF Terminal Box		**86**	**85**	**81**	**58**	**29**	**57**	**75**	**70**
VRF Sound Power Level, L_w (dB)		**44**	**49**	**40**	**37**	**38**	**34**	**22**	**14**
4	Attenuation	0.20	0.20	0.40	2.40	5.50	7.60	6.40	6.40
	4x8 Lined	0.80	0.80	1.60	9.60	22.00	30.40	25.60	25.60
5	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	1.00	1.00	1.00	8.00	19.00	23.00	10.00	5.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**68**	**71**	**70**	**31**	**-10**	**-4**	**31**	**31**
Sound Pressure Level		**57**	**60**	**59**	**20**	**-21**	**-15**	**20**	**20**


Noise Criteria for Consultation Room 8334
NC-50
VAV System
VRF System
Sound Pressure Level (dB re: 20 µPa)
90
80
70
60
50
40
30
20
10
0
63
125
250
500
1000
2000
4000
8000
Octave Band Center Frequency (Hz)

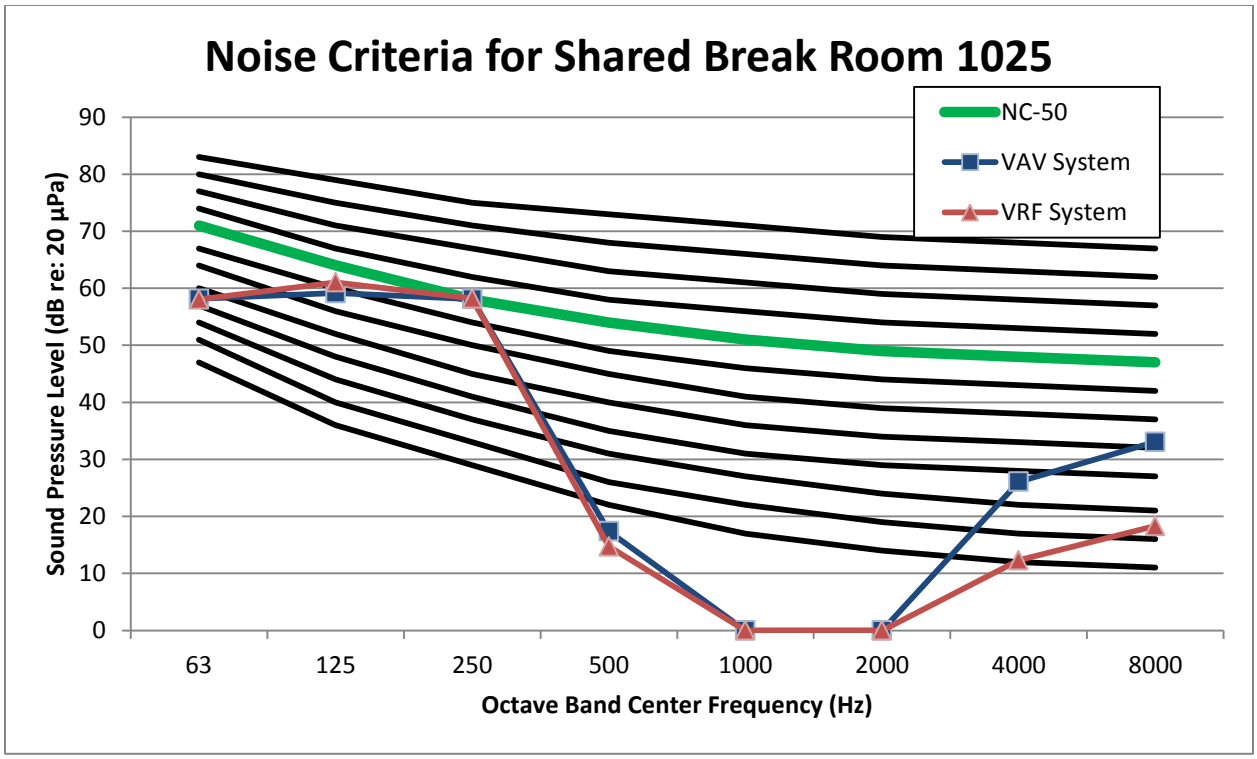
Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
AHU Sound Power Level, L_w (dB)		**96**	**93**	**89**	**90**	**86**	**85**	**81**	**73**
29	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 80x22	5.80	5.80	5.80	31.90	63.80	29.00	2.90	2.90
55	Attenuation	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.05
	60x20	11.00	11.00	5.50	2.75	2.75	2.75	2.75	2.75
Split		3	3	3	3	3	3	3	3
5	Attenuation	0.02	0.02	0.02	0.03	0.05	0.05	0.05	0.05
	16" Round	0.10	0.10	0.10	0.15	0.25	0.25	0.25	0.25
Spectrum Level at VAV Terminal Box		**76**	**73**	**75**	**52**	**16**	**50**	**72**	**64**
VAV Sound Power Level, L_w (dB)		**60**	**60**	**54**	**44**	**42**	**39**	**34**	**34**
8	Attenuation	0.10	0.10	0.10	1.10	2.20	1.00	0.10	0.10
	16x10	0.80	0.80	0.80	8.80	17.60	8.00	0.80	0.80
Split		3	3	3	3	3	3	3	3
11	Attenuation	0.10	0.10	0.10	1.10	2.20	1.00	0.10	0.10
	16x10	1.10	1.10	1.10	12.10	24.20	11.00	1.10	1.10
8	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	1.60	1.60	1.60	12.80	30.40	36.80	16.00	8.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**54**	**55**	**59**	**7**	**-41**	**-16**	**43**	**43**
Sound Presure Level		**43**	**44**	**48**	**-4**	**-52**	**-27**	**32**	**32**

Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
DOAS Sound Power Level, L_w (dB)		**96**	**95**	**90**	**90**	**88**	**86**	**81**	**75**
29	Attenuation	0.20	0.20	0.20	1.10	2.20	1.00	0.10	0.10
	Double Wall, 20x26	5.80	5.80	5.80	31.90	63.80	29.00	2.90	2.90
55	Attenuation	0.20	0.20	0.10	0.05	0.05	0.05	0.05	0.05
	20x18	11.00	11.00	5.50	2.75	2.75	2.75	2.75	2.75
Split		3	3	3	3	3	3	3	3
5	Attenuation	0.02	0.02	0.02	0.03	0.05	0.05	0.05	0.05
	6" Round	0.10	0.10	0.10	0.15	0.25	0.25	0.25	0.25
Spectrum Level at VRF Terminal Box		**76**	**75**	**76**	**52**	**18**	**51**	**72**	**66**
VRF Sound Power Level, L_w (dB)		**44**	**49**	**40**	**37**	**38**	**34**	**22**	**14**
8	Attenuation	0.20	0.20	0.40	2.40	5.50	7.60	6.40	6.40
	8x6	1.60	1.60	3.20	19.20	44.00	60.80	51.20	51.20
Split		3	3	3	3	3	3	3	3
11	Attenuation	0.20	0.20	0.40	2.40	5.50	7.60	6.40	6.40
	8x6	2.20	2.20	4.40	26.40	60.50	83.60	70.40	70.40
8	Attenuation	0.20	0.20	0.20	1.60	3.80	4.60	2.00	1.00
	8" Round Lined	1.60	1.60	1.60	12.80	30.40	36.80	16.00	8.00
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**52**	**55**	**54**	**-18**	**-108**	**-141**	**-76**	**-74**
Sound Presure Level		**41**	**44**	**43**	**-29**	**-119**	**-152**	**-87**	**-85**


Noise Criteria for Reception Area 9500
Sound Pressure Level (dB re: 20 µPa)
90
80
70
60
50
40
30
20
10
0
63
125
250
500
1000
2000
4000
8000
Octave Band Center Frequency (Hz)
NC-40
VAV System
VRF System

Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
AHU Sound Power Level, L_w (dB)		**96**	**93**	**89**	**90**	**86**	**85**	**81**	**73**
23	Attenuation	0.2	0.2	0.2	1.1	2.2	1	0.1	0.1
	Double Wall, 80x22	4.6	4.6	4.6	25.3	50.6	23	2.3	2.3
Split		3	3	3	3	3	3	3	3
10	Attenuation	0.02	0.02	0.02	0.03	0.05	0.05	0.05	0.05
	18" Round	0.2	0.2	0.2	0.3	0.5	0.5	0.5	0.5
2	Attenuation	0.03	0.03	0.05	0.05	0.07	0.07	0.07	0.07
	8" Round	0.06	0.06	0.1	0.1	0.14	0.14	0.14	0.14
Spectrum Level at VAV Terminal Box		**88**	**85**	**81**	**61**	**32**	**58**	**75**	**67**
VAV Sound Power Level, L_w (dB)		**60**	**60**	**54**	**44**	**42**	**39**	**34**	**34**
3	Attenuation	0.2	0.2	0.2	1.6	3.8	4.6	2	1
	6x10 Lined	0.6	0.6	0.6	4.8	11.4	13.8	6	3
12	Attenuation	0.2	0.2	0.2	1.6	3.8	4.6	2	1
	8" Round Lined	2.4	2.4	2.4	19.2	45.6	55.2	24	12
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**69**	**70**	**69**	**28**	**-23**	**-19**	**37**	**44**
Sound Pressure Level		**58**	**59**	**58**	**17**	**-34**	**-30**	**26**	**33**

Octave Band (Hz)		63	125	250	500	1000	2000	4000	8000
DOAS Sound Power Level, L_w (dB)		**96**	**95**	**90**	**90**	**88**	**86**	**81**	**75**
23	Attenuation	0.2	0.2	0.2	1.1	2.2	1	0.1	0.1
	Double Wall, 22x24	4.6	4.6	4.6	25.3	50.6	23	2.3	2.3
Split		3	3	3	3	3	3	3	3
10	Attenuation	0.03	0.03	0.05	0.05	0.1	0.1	0.1	0.1
	6" Round	0.3	0.3	0.5	0.5	1	1	1	1
2	Attenuation	0.03	0.03	0.05	0.05	0.1	0.1	0.1	0.1
	4" Round	0.06	0.06	0.1	0.1	0.2	0.2	0.2	0.2
Spectrum Level at VRF Terminal Box		**88**	**87**	**82**	**61**	**33**	**59**	**75**	**69**
VRF Sound Power Level, L_w (dB)		**44**	**49**	**40**	**37**	**38**	**34**	**22**	**14**
3	Attenuation	0.2	0.2	0.4	2.4	5.5	7.6	6.4	6.4
	4x8 Lined	0.6	0.6	1.2	7.2	16.5	22.8	19.2	19.2
12	Attenuation	0.2	0.2	0.2	1.6	3.8	4.6	2	1
	8" Round Lined	2.4	2.4	2.4	19.2	45.6	55.2	24	12
Acoustical Tile Insertion Loss		2	4	6	8	8	8	8	8
End Reflection Loss		14	8	3	1	0	0	0	0
Spectrum Level at Ceiling Diffuser		**69**	**72**	**69**	**26**	**-31**	**-27**	**23**	**29**
Sound Pressure Level		**58**	**61**	**58**	**15**	**-42**	**-38**	**12**	**18**


Noise Criteria for Shared Break Room 1025
NC-50
VAV System
VRF System
Sound Pressure Level (dB re: 20 µPa)
90
80
70
60
50
40
30
20
10
0
63
125
250
500
1000
2000
4000
8000
Octave Band Center Frequency (Hz)

APPENDIX C: Rooftop/Outdoor Condenser Connections Schedule

Condenser Unit Schedule

Unit - Size		Volt	Phase	Fan HP	FLA	kVA	Wire	Wire amps	Conduit	Starter	Load Amps	CB Size	Gnd Size	Disc. A
Floor 0	20-Ton	460	3	20	2	0.9	#14	2.5	3/4"	NEMA 4	3	60	#10	80
Floor 3	28-Ton	460	3	25	2.6	1.2	#14	3.3	3/4"	NEMA 4	3.9	85	#8	110
	10-Ton	460	3	10	1.4	0.6	#14	1.8	3/4"	NEMA 4	2.1	25	#10	35
Floor 4	26-Ton	460	3	25	2.6	1.2	#14	3.3	3/4"	NEMA 4	3.9	80	#8	110
	12-Ton	460	3	7.5	1.2	0.6	#14	1.5	3/4"	NEMA 4	1.8	50	#10	70
Floor 5	26-Ton	460	3	25	2.6	1.2	#14	3.3	3/4"	NEMA 4	3.9	80	#8	110
	12-Ton	460	3	7.5	1.2	0.6	#14	1.5	3/4"	NEMA 4	1.8	50	#10	70
Floor 6	28-Ton	460	3	25	2.6	1.2	#14	3.3	3/4"	NEMA 4	3.9	85	#8	110
	12-Ton	460	3	7.5	1.2	0.6	#14	1.5	3/4"	NEMA 4	1.8	50	#10	70
Floor 7	28-Ton	460	3	25	2.6	1.2	#14	3.3	3/4"	NEMA 4	3.9	85	#8	110
	10-Ton	460	3	10	1.4	0.6	#14	1.8	3/4"	NEMA 4	2.1	25	#10	35
Floor 8	28-Ton	460	3	25	2.6	1.2	#14	3.3	3/4"	NEMA 4	3.9	85	#8	110
	10-Ton	460	3	10	1.4	0.6	#14	1.8	3/4"	NEMA 4	2.1	25	#10	35
Floor 9	26-Ton	460	3	25	2.6	1.2	#14	3.3	3/4"	NEMA 4	3.9	80	#8	110
	8-Ton	460	3	7.5	1.2	0.6	#14	1.5	3/4"	NEMA 4	1.8	25	#10	35
Floor 10	28-Ton	460	3	25	2.6	1.2	#14	3.3	3/4"	NEMA 4	3.9	85	#8	110
	8-Ton	460	3	7.5	1.2	0.6	#14	1.5	3/4"	NEMA 4	1.8	25	#10	35
TOTALS						**15.2**								

Notes:
1. Wires are type RHW
2. Conduit material is EMT

APPENDIX D: Required Equipment Efficiencies for Compliance

TABLE 6.8.1A Electronically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements *(continued)*

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Air conditioners, water cooled	≥760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER (before 6/1/2011) 12.2 EER (as of 6/1/2011) 11.1 IEER (before 6/1/2011) 12.4 IEER (as of 6/1/2011)	AHRI 340/360
		All other	Split System and Single Package	10.8 EER (before 6/1/2011) 12.0 EER (as of 6/1/2011) 10.9 IEER (before 6/1/2011) 12.2 IEER (as of 6/1/2011)	
Air conditioners, evaporatively cooled	< 65,000 Btu/h	All	Split System and Single Package	12.1 EER 12.3 IEER	AHRI 210/240
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.5 EER (before 6/1/2011) 12.1 EER (as of 6/1/2011) 11.7 IEER (before 6/1/2011) 12.3 IEER (as of 6/1/2011)	AHRI 340/360
		All other	Split System and Single Package	11.3 EER (before 6/1/2011) 11.9 EER (as of 6/1/2011) 11.5 IEER (before 6/1/2011) 12.1 IEER (as of 6/1/2011)	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER (before 6/1/2011) 12.0 EER (as of 6/1/2011) 11.2 IEER (before 6/1/2011) 12.2 IERR (as of 6/1/2011)	
		All other	Split System and Single Package	10.8 EER (before 6/1/2011) 11.8 EER (as of 6/1/2011) 11.0 IEER (before 6/1/2011) 12.0 IEER (as of 6/1/2011)	
	≥240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER (before 6/1/2011) 11.9 EER (as of 6/1/2011) 11.1 IEER (before 6/1/2011) 12.1 IEER (as of 6/1/2011)	
		All other	Split System and Single Package	10.8 EER (before 6/1/2011) 12.2 EER (as of 6/1/2011) 10.9 IEER (before 6/1/2011) 11.9 IEER (as of 6/1/2011)	
	≥760,000 Btu/h	Electric Resistance (or None	Split System and Single Package	11.0 EER (before 6/1/2011) 11.7 EER (as of 6/1/2011) 11.1 IEER (before 6/1/2011) 11.9 IEER (as of 6/1/2011)	
		All other	Split System and Single Package	10.8 EER (before 6/1/2011) 11.5 EER (as of 6/1/2011) 10.9 IEER (before 6/1/2011) 11.7 IEER (as of 6/1/2011)	
Condensing units, air cooled	≥135,000 Btu/h	–	–	10.1 EER(before 6/1/2011) 10.5 EER (as of 6/1/2011 11.4 IEER (before 6/1/2011) 11.8 IEER (as of 6/1/2011)	AHRI 365
Condensing units, water cooled	≥135,000 Btu/h	–	–	13.1 EER(before 6/1/2011) 13.5 EER (as of 6/1/2011) 13.6 IEER (before 6/1/2011) 14.0 IEER (as of 6/1/2011)	
Condensing units, evaporatively cooled	≥135,000 Btu/h	–	–	13.1 EER (before 6/1/2011) 13.5 EER (as of 6/1/2011) 13.6 IEER (before 6/1/2011) 14.0 IEER (as of 6/1/2011	

[a] IPLVs and part-load rating conditions are only applicable to equipment with capacity modulation.
[b] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[c] Single-phase, air-cooled air conditioners <65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.

TABLE 6.8.1D Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-Package Vertical Air Conditioners, Single-Package Vertical Heat Pumps, Room Air Conditioners, and Room Air-Conditioner Heat Pumps—Minimum Efficiency Requirements

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure[a]
PTAC (cooling mode) standard size	All capacities	95°F db outdoor air	12.5 – (0.213 × Cap/1000)[c] EER (before 10/08/2012) 13.8 – (0.300 × Cap/1000)[c] EER (as of 10/08/2012)	AHRI 310/380
PTAC (cooling mode) nonstandard size[b]	All capacities	95°F db outdoor air	10.9 – (0.213 × Cap/1000)[c] EER	
PTHP (cooling mode) standard size	All capacities	95°F db outdoor air	12.3 – (0.213 × Cap/1000)[c] EER (before 10/08/2012) 14.0 – (0.300 × Cap/1000)[c] EER (as of 10/08/2012)	
PTHP (cooling mode) nonstandard size[b]	All capacities	95°F db outdoor air	10.8 – (0.213 × Cap/1000)[c] EER	
PTHP (heating mode) standard size	All capacities	—	3.2 – (0.026 × Cap/1000)[c] COP_H (before 10/08/2012) 3.7 – (0.052 × Cap/1000)[c] COP_H (as of 10/08/2012)	
PTHP (heating mode) nonstandard size[b]	All capacities	—	2.9 – (0.026 × Cap/1000)[c] COP_H	
SPVAC (cooling mode)	<65,000 Btu/h	95°F db/75°F wb outdoor air	9.0 EER	AHRI 390
	≥65,000 Btu/h and <135,000 Btu/h	95°F db/75°F wb outdoor air	8.9EER	
	≥135,000 Btu/h and <240,000 Btu/h	95°F db/75°F wb outdoor air	8.6 EER	
SPVHP (cooling mode)	<65,000 Btu/h	95°F db/75°F wb outdoor air	9.0 EER	
	≥65,000 Btu/h and <135,000 Btu/h	95°F db/75°F wb outdoor air	8.9EER	
	≥135,000 Btu/h and <240,000 Btu/h	95°F db/75°F wb outdoor air	8.6 EER	
SPVHP (heating mode)	<65,000 Btu/h	47°F db/43°F wb outdoor air	3.0 COP	
	≥65,000 Btu/h and <135,000 Btu/h	47°F db/43°F wb outdoor air	3.0 COP	
	≥135,000 Btu/h and <240,000 Btu/h	47°F db/43°F wb outdoor air	2.9 COP	
Room air conditioners, with louvered sides	<6000 Btu/h	—	9.7 SEER	ANSI/AHAM RAC-1
	≥6000 Btu/h and <8000 Btu/h		9.7 SEER	
	≥8000 Btu/h and <14,000 Btu/h		9.8 EER	
	≥14,000 Btu/h and <20,000 Btu/h		9.7 SEER	
	≥20,000 Btu/h		8.5 EER	

TABLE 6.8.1E Warm-Air Furnaces and Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces, and Unit Heaters

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure[a]
Warm-Air Furnace, Gas-Fired	<225,000 Btu/h	Maximum capacity[c]	78% AFUE or 80% E_t [b,d]	DOE 10 CFR Part 430 or Section 2.39, Thermal Efficiency, ANSI Z21.47
	≥225,000 Btu/h	Maximum capacity[c]	80% E_t [d]	Section 2.39, Thermal Efficiency, ANSI Z21.47
Warm-Air Furnace, Oil-Fired	<225,000 Btu/h	Maximum capacity[c]	78% AFUE or 80% E_t [b,d]	DOE 10 CFR Part 430 or Section 42, Combustion, UL 727
	≥225,000 Btu/h	Maximum capacity[c]	81% E_t [d]	Section 42, Combustion, UL 727
Warm-Air Duct Furnaces, Gas-Fired	All Capacities	Maximum capacity[c]	80% E_c [e]	Section 2.10, Efficiency, ANSI Z83.8
Warm-Air Unit Heaters, Gas-Fired	All capacities	Maximum capacity[c]	80% E_c [e,f]	Section 2.10, Efficiency, ANSI Z83.8
Warm-Air Unit Heaters, Oil-Fired	All capacities	Maximum capacity[c]	80% E_c [e,f]	Section 40, Combustion, UL 731

[a] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[b] Combination units not covered by NAECA (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h) may comply with either rating.
[c] Compliance of multiple firing rate units shall be at the maximum firing rate.
[d] E_t = thermal efficiency. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a *flue damper*. A *vent damper* is an acceptable alternative to a *flue damper* for those furnaces where combustion air is drawn from the *conditioned space*.
[e] E_c = combustion efficiency (100% less flue losses). See test procedure for detailed discussion.
[f] As of August 8, 2008, according to the Energy Policy Act of 2005, units must also include an interrupted or intermittent ignition device (IID) and have either power venting or an automatic *flue damper*.

TABLE 6.8.1F Gas- and Oil-Fired Boilers, Minimum Efficiency Requirements

Equipment Type[a]	Subcategory or Rating Condition	Size Category (Input)	Minimum Efficiency[b,c]	Efficiency as of 3/2/2010 (Date 3 yrs after ASHRAE Board Approval)	Efficiency as of 3/2/2020 (Date 13 yrs after ASHRAE Board Approval)	Test Procedure
Boilers, hot water	Gas-fired	<300,000 Btu/h	80% AFUE	80% AFUE	80% AFUE	10 CFR Part 430
		≥300,000 Btu/h and ≤2,500,000 Btu/h[d]	75% E_t	80% E_t	80% E_t	10 CFR Part 431
		>2,500,000 Btu/h[a]	80% E_c	82% E_c	82% E_c	
	Oil-fired[e]	<300,000 Btu/h	80% AFUE	80% AFUE	80% AFUE	10 CFR Part 430
		≥300,000 Btu/h and ≤2,500,000 Btu/h[d]	78% E_t	82% E_t	82% E_t	10 CFR Part 431
		>2,500,000 Btu/h[a]	83% E_c	84% E_c	84% E_c	
Boilers, steam	Gas-fired	<300,000 Btu/h	75% AFUE	75% AFUE	75% AFUE	10 CFR Part 430
	Gas-fired—all, except natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h[d]	75% E_t	79% E_t	79% E_t	10 CFR Part 431
		>2,500,000 Btu/h[a]	80% E_c	79% E_t	79% E_t	
	Gas-fired—natural draft	≥300,000 Btu/h and ≤2,500,000 Btu/h[d]	75% E_t	77% E_t	79% E_t	
		>2,500,000 Btu/h[a]	80% E_c	77% E_t	79% E_t	
	Oil-fired[e]	<300,000 Btu/h	80% AFUE	80% AFUE	80% AFUE	10 CFR Part 430
		≥300,000 Btu/h and ≤2,500,000 Btu/h[d]	78% E_t	81% E_t	81% E_t	10 CFR Part 431
		>2,500,000 Btu/h[a]	83% E_c	81% E_t	81% E_t	

a These requirements apply to *boilers* with rated input of 8,000,000 Btu/h or less that are not *packaged boilers* and to all *packaged boilers*. Minimum efficiency requirements for *boilers* cover all capacities of *packaged boilers*.
b E_c = combustion efficiency (100% less flue losses). See reference document for detailed information.
c E_t = thermal efficiency. See reference document for detailed information.
d Maximum capacity – minimum and maximum ratings as provided for and allowed by the unit's controls.
e Includes oil-fired (residual).