Walter Reed National Military Medical Center
Bethesda, MD

Technical Report One:

ASHRAE Standard 62.1-2007 and 90.1-2007 Analysis

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Executive Summary:

The purpose of this report is to determine if the two new buildings being constructed on the new Walter Reed National Military Medical Center Campus, Building A and B, are in compliance with both ASHRAE Standard 62.1-2007 as well as Standard 90.1-2007. Building A and B are close to 600,000sf of new construction and are mainly comprised of patient bedrooms, exam rooms, medical staff offices, and a variety of operating rooms.

ASHRAE Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality, was the first standard to be evaluated for building compliance. This standard describes means and methods to achieve acceptable indoor air quality within the building. An analysis of Section 5 was performed for both buildings which went through and determined compliance with requirements set forth for acceptable indoor air quality such as outdoor air intake requirements, mold resistance, particulate filtration, and building air classification. All HVAC requirements that were examined within Section 5 were determined to be compliant for both buildings. Section 6 outlines requirements for the minimum ventilation rates that must be supplied to the varying space types in order to maintain acceptable indoor air quality. Both buildings were analyzed using the ventilation rate procedure and exceeded the minimum ventilation rates required due to their constant volume supply of 100% outside air.

An analysis of ASHRAE Standard 90.1-2007, Energy Standard for Buildings Except Low Rise Residential Buildings, was then performed to determine the buildings compliance with minimum equipment efficiencies and building insulation values. Both buildings façade and glazing materials exceeded the minimum insulation values set forth within the section. The equipment being installed within the new buildings surpasses the minimum efficiencies stated. Both buildings also comply with special requirements set forth for 24 hour facilities to use both exhaust air energy recovery and chiller condenser energy recovery by the use of total energy wheels and heat recovery chillers respectively. Power distribution and lighting power densities were also determined to be in compliance with the requirements set forth in this section.

It is not surprising that both of these standards have been exceeded due to the fact that this building is striving towards a LEED® Silver certification. These two standards are building blocks to improve on when striving towards an energy efficient healthy building. Both an energy efficient building and a healthy environment to work in are important when designing a building of this size and occupancy classification.

1.0 Building Overview

Two new buildings are being constructed on the existing National Naval Medical Center located in Bethesda, Maryland. Once complete, the campus will be renamed as the Walter Reed National Military Medically Center as part of the Government's Base Realignment and Closure Program (BRAC). Building A and B will flank an existing historical building that was originally sketched by Franklin Delano Roosevelt and constructed during the early 1940's. This large tower building can be seen in Figure 1 shown below. Building A is the larger of the two buildings and is the location for outpatient services such as Children's Health, Cancer Treatment Center, Neurology, and Physical Therapy. Building B is where Patient Bedrooms, Operating Rooms, and the Ambulance Receiving Center are located.

The design of both of the new buildings was influenced heavily by historic preservation requirements. Special considerations were taken into account in order to compliment the design of the existing buildings as well as match the architectural materials that were selected for the original campus facade. Hartman Cox Architects was hired to be part of the design team and work directly with the State Historic Planning Office (SHPO) as well as the National Capitol Planning Commission (NCPC). The historical considerations of this building played a large role in the building material selection as well as the facade and glazing design

Figure 1 - Walter Reed Hospital Final Rendering Provided by HKS, Inc.

2.0 Mechanical System Overview

Building A and B both receive conditioned supply air from custom made air handling units (AHU's). Building A has eight AHU's and Building B has three AHU's, all of which are all rated at 50,000cfm each. Building A and B both are dedicated outdoor air systems which have a constant supply of 100% outside air. Air is supplied at a Constant Air Volume (CAV) to remote CAV boxes located throughout both

Building A and B. In order to reduce some of the energy consumption associated with having a 100% outside air system; total energy wheels in custom housings are being used on all of the AHU's. The pool area in Building A is served by a dedicated packaged air handling unit to better meet the temperature and humidity control requirements.

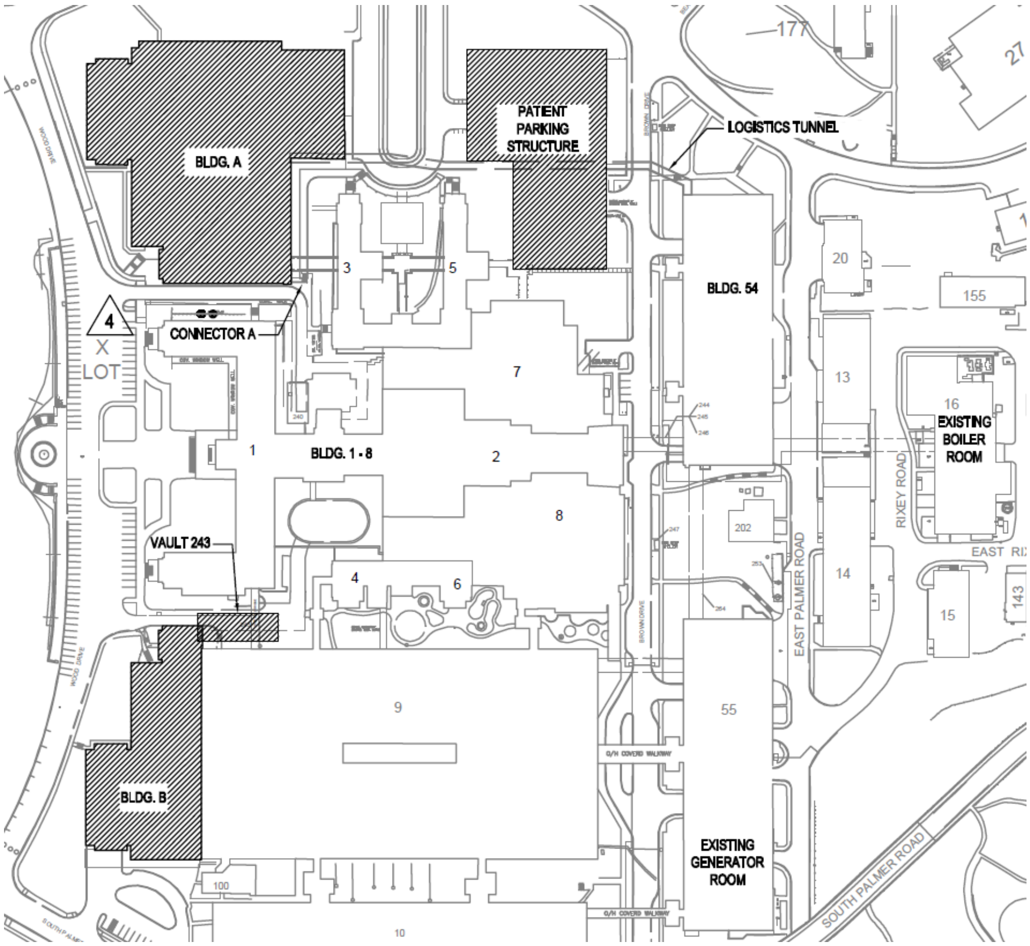

Figure 2 – New Construction Site Plan

Three 1,000 ton water cooled centrifugal chillers are located in the basement of Building A. One 180 ton heat recover chiller is located in the basement of Building A and a 225 ton heat recover chiller is located in the basement of Building B. Three 1,000 ton induced draft cooling towers with a counter flow configuration are located on the adjacent patient parking structure shown in Figure 2 above. Two-pipe fan coil units (FCU's) are used in both the electrical closets and telecommunications closets in both buildings. The heating load requirements of both buildings are met by using the existing campus steam generation plant. The 125 psig supply steam coming from the plant is reduced to either 75 psig or 15 psig through pressure reducing stations located in the basement of Building A. The reduced 75 psig steam is then supplied to a humidification steam generator. The reduced 15 psig steam is fed through heat exchangers which are used for heating hot water or domestic hot water.

3.0 ASHRAE Standard 62.1 Evaluation

3.1 Section 5 Compliance

5.1 Natural Ventilation

The windows in buildings A and B are inoperable for occupant security and safety reasons. Natural ventilation was not considered as a ventilation strategy for this building due to the complex ventilation requirements of a hospital as well as high internal loads throughout the building.

5.2 Ventilation Air Distribution

Minimum building ventilation is able to be met under any load condition specified within Section 6 of Standard 62.1-2007 which is discussed later in the report. This building easily meets these requirements due to the use of a 100% outdoor air system using a constant air volume supply. WRNMMC uses a fully ducted supply and return system so worries of inadequate ventilation requirements due to a plenum system are not an issue. The construction documents provide air balance schedules that explicitly list out the design supply airflow rate, infiltration rate, exfiltration rate, exhaust rate, air change rate, and pressurization requirements. A sample image of the documentation provided in the construction documents is shown in Appendix A.

5.3 Exhaust Duct Location

Building rooms that contain potentially harmful contaminants are each served with dedicated roof exhaust fans. These dedicated exhaust fans are serving rooms such as flammable storage, decontamination suite, and negative isolation rooms. The discharge of the exhaust fans have a 15' duct extension that reduces in size to provide a 2,000 fpm discharge velocity. Providing such a high discharge velocity helps to ensure that these contaminants will not be recirculated throughout this building as well as surrounding buildings.

5.4 Ventilation System Controls

The mechanical ventilation controls of the building provide a constant supply air volume of 100% outdoor air to spaces while they are both occupied and unoccupied. In Building A, some of the spaces are able to have reduced ventilation rates while they are unoccupied. The RFP enables rooms such as office spaces ventilation rates to be set back by the use of occupancy sensors. However, these reduced ventilation rates are still above the minimum required ventilation rate as outlined in Section 6.

5.5 Airstream Surfaces

The surfaces that are in contact with the airstream in this building are primarily sheet metal duct. Flexible duct is used to branch from the sheet metal supply mains to connect to the supply diffusers. Both of these supply materials are compliant with both the resistance to mold growth and resistance to erosion subsections.

5.6 Outdoor Air Intakes

Building A draws the necessary outdoor air for the mechanical system through an architectural light well. The edge of the outdoor intake with the bird screen is mounted flush with the light well. This outdoor intake location is in accordance with all of the minimum distances located within Table 5-1 in Standard 62.1-2007.

The outdoor air intake for Building B is located in a similar style to Building A except the shaft opening is not an architectural light well. This intake also is equipped with a bird screen and complies with the minimum distances in Table 5-1 in Standard 62.1-2007.

5.7 Local Capture of Contaminants

The exhaust from all spaces with equipment that produces contaminants is directly exhausted to the roof through the use of dedicated exhaust fans.

5.8 Combustion Air

There are no combustion related contaminants in the building from boilers because both of the buildings receive a district steam supply used for heating. The emergency generators that serve Buildings A and B are located in the adjacent patient parking structure shown in Figure 2. With no combustion equipment being placed in either of the buildings this section required no further analysis.

5.9 Particulate Matter Removal

The rating of the filters in Building A's air handlers is MERV 14 and Building B's air handlers is MERV 17. Both of these filters specified exceed the minimum filter rating of MERV 6 that is provided in this section.

5.10 Dehumidification Systems

The relative humidity in all occupied spaces is maintained at a level of 50% which is below the 65% maximum limit. Both Building A and B maintain a positive pressurization at all times by having a greater supply air flow rate than exhaust air flow rate. Some rooms in Building B are maintained at a negative pressure relative to the total building pressure but this negative room is still positively pressurized with respect to the outside environment which prevents infiltration related problems.

5.11 Drain Pans

The air handling unit specifications call out that the drain pans installed on all AHU's located in building A and B are to be constructed of stainless steel and located under the complete cooling coil section and extend beyond the leaving air side of the coil. Cooling coil drain pans are required to be pitched in two planes and pitched towards the drain connection. After the drain pans are installed they are to be leveled and trapped as per the manufacturer's recommendations.

5.12 Finned-Tube Coils and Heat Exchangers

Cooling coils are specified to have a minimum of 18" of separation between which is compliant with this sub section. All of the cooling coils specified have a face area of 102.4 ft^2 with a supply air flow rate of 50,000cfm. These conditions result in a 488 fpm face velocity across the coil which is less than the 500 fpm maximum stated within this section.

5.13 Humidifiers and Water-Spray Systems

The humidifiers that are used in the air handlers use potable water for humidification which meets the water quality requirements of this section. Turning vanes and other obstructions that are installed downstream of the humidifier are placed at distances which exceed the manufacturers recommendation.

5.14 Access for Inspection, Cleaning, and Maintenance

Access panels are located on all AHU's to provide access for maintenance of the all of the areas called specified within this sub section. The construction of all access doors and panels are called out in the air handling unit specifications to be the same as the AHU. All of the access door sizes are large enough to provide unobstructed access to each part that is maintained. Viewing windows are to be provided on all access doors that lead to areas containing moving parts.

5.15 Building Envelope and Interior Surfaces

A vapor barrier is provided in the exterior wall construction assembly to prevent moisture condensation within the wall. Exterior joints where panels meet will be sealed to prevent air leakage within the building. Both pipes and ducts whose surface temperatures may fall below the dew point of the air will be insulated to prevent condensation on their surface.

5.16 Buildings with Attached Parking Garages

The patient parking structure being constructed is not attached to either of the new buildings as shown in Figure 2. As a result this section did not require analysis.

5.17 Air Classification for Recirculation

The air classification for the office areas in Building A is air class 1. Air class 1 is defined in this section as air with a low contaminant concentration, low irritation intensity, and an inoffensive odor. This air classification was determined from Table 6-1 in Standard 62.1-2007. The healthcare areas of the building are not listed within Table 6-1 and follow section 5.17.1 which states that for space types not listed the air classification is to be determined by using the air class from a space that it most similar in terms of occupant activities. Depending on the medical procedure being performed the air class in the medical rooms is going to be either 2 or 3. This comes from using a daycare sickroom and a science laboratory as base comparisons. Class 2 air contains moderate contaminant concentration while class 3 air contains significant contaminant concentration.

Air class recirculation limits do not need to be examined due these buildings supplying 100% outside air. Class 2 and 3 air may be used for energy recovery if they are diluted with class 1 air to levels of 10% and 5% respectively.

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

Due to the medical examination and recovery process, all of the buildings on campus including the Building A and B will be smoke free inside. Smoking is permitted on the campus, but must be a minimum distance away from the entrances of the buildings. The intakes of the AHU's draw air through light wells in both buildings so they will not be affected by ETS on the campus.

3.2 Ventilation Rate Procedure Analysis

The ventilation rate procedure is defined in Section 6 of ASHRAE Standard 62.1-2007. The following sets of equations were used in the analysis shown in Appendix B for a variety of rooms to demonstrate that the required minimum ventilation rates are always met. The spreadsheet used for this calculation determines the minimum ventilation rates required based upon user inputs of room size, room type, and supply air volume.

Equation: **Standard 62.1 Location:**

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

Where: A_z = Zone floor area (ft^2)

P_z = Zone population ($people$)

R_p = Outdoor air flow rate ($\frac{cfm}{person}$)

R_a = Outdoor air flow rate ($\frac{cfm}{ft^2}$)

Zone Air Distribution Effectiveness:

$E_z = 1.0$ (Table 6-2)

Zone Outdoor Airflow:

$$V_{oz} = \frac{V_{bz}}{E_z}$$ (Equation 6-2)

100% Outdoor Air Systems:

$$V_{ot} = \sum_{allzones} \cdot V_{oz}$$ (Equation 6-4)

System Ventilation Efficiency:

E_v is found using max Z_p value (Table 6-3)

Uncorrected Outdoor Air Intake:

$$V_{ou} = D \cdot \sum_{allzones} \left(R_p \cdot P_z \right) + \sum_{allzones} \left(R_a \cdot A_z \right)$$ (Equation 6-6)

Occupant Diversity:

$$D = \frac{P_s}{\left(\sum_{allzones} \cdot P_z \right)}$$ (Equation 6-7)

Where: P_s = System Population

Appendix B shows the minimum ventilation requirements for the first floor of Building B along with the minimum air change requirement as stated in the Unified Facilities Criteria (UFC). The first floor of Building B was analyzed due to the variety of occupancy types located on this level which provides an adequate representation of the spaces on the other levels in both buildings. Performing this calculation shows that providing 100% outside air always will meet the minimum ventilation rate and the minimum air change requirement for each room type. The supply airflow rates are rarely driven from the minimum air change requirements given in the UFC and are mainly driven by the loads within the space.

3.3 ASHRAE 62.1-2007 Summary

The HVAC design at Walter Reed National Military Medical Center exceeds minimum ventilation requirements prescribed by this standard by supplying a constant volume of 100% outside air. Having a dedicated outdoor air system (DOAS) that meets both ventilation requirements and room loads will be able to provide a healthy and safe indoor environment for both the patients and medical staff within the hospital.

All of the requirements stated in Section 5 have been exceeded by this HVAC system design. Some of the improvements that were made are providing MERV 14 or 17 filters on all of the AHU's, isolating combustion equipment to separate buildings, and the use of dedicated exhaust systems to limit the spread of potentially harmful contaminants. Another means of improving the indoor air quality of the space is accomplished by having all of the ductwork that is used on the site be covered with plastic before it enters the construction area. This prevents dust and other harmful construction materials from entering the ductwork and having to be cleaned out later. Covering all ductwork before it enters the site is also being used towards a LEED® Indoor Environmental Quality point.

4.0 ASHRAE Standard 90.1 Evaluation

4.1 Section 5 – Building Envelope

5.1.4 Climate Zone

The climate zone for Walter Reed National Military Medical Center (WRNMMC) was determined by using Figure 3 below which is referenced from section 5 of Standard 90.1-2007. WRNMMC is located in Bethesda, Maryland which is shown in Figure 3 below. Bethesda is located in climate zone 4-A which is defined by having mixed weather conditions that can have periods of high humidity.

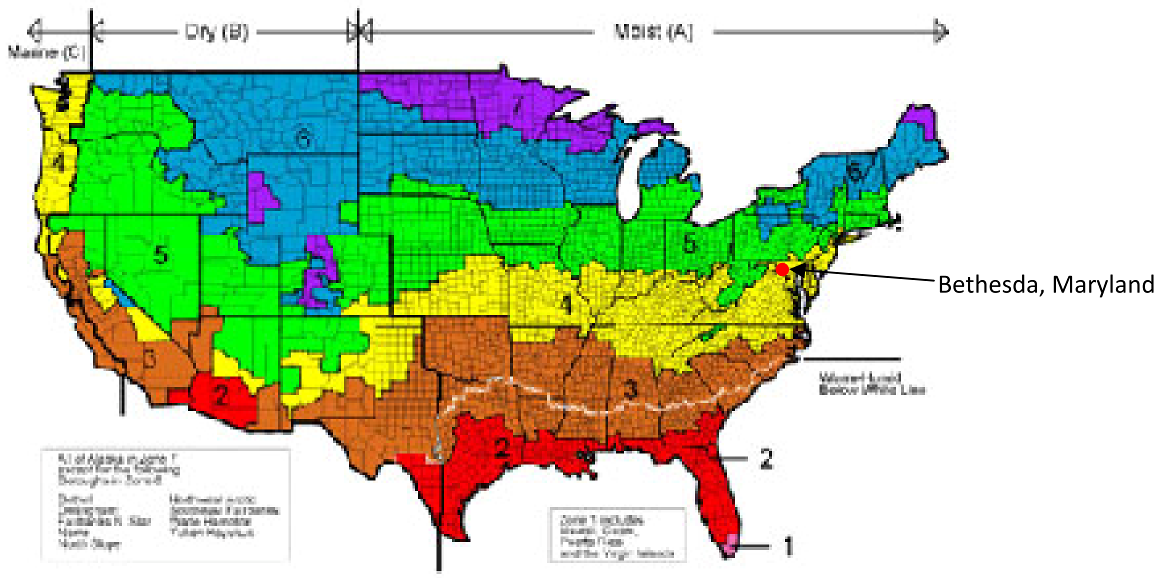

Figure 3 – United States Climate Regions

5.4 Mandatory Provisions

Both buildings will be constructed with vestibules separating the interior conditioned space from the outside weather conditions. The interior and exterior sets of doors are separated by a distance of 10'-8" which is greater than the 7' minimum distance required. The building envelope is specified to be sealed where all precast panels, Centria panels, and windows meet. Providing a building envelope that minimizes air leakage will help to significantly reduce the building energy cost.

5.5 Prescriptive Building Envelope Option

The Prescriptive Building Envelope procedure was used in this paper to analyze the building envelope requirements. Table 5.5-4 located within Standard 90.1-2007 lists building envelope requirements for both residential and non residential construction for climate zone 4A. The maximum vertical fenestration area compared to wall area that is permitted in this subsection cannot exceed 40% as shown in Table 1. No analysis was performed on building skylights due to none being specified for either building. Table 2 outlines the minimum building material insulation values and Table 3 outlines minimum glazing insulation values for the Bethesda climate zone.

	Glazing Area (ft^2)	Wall Area (ft^2)	Percentage Glazing	Compliance (Y/N)
Building A and B	35,549	138,459	25.70%	Y

Table 1 - Total Building Glazing Area

		Prescribed Nonresidential		Acual Construction Assemblies		Compliance (Y/N)
Area	Construction Method	Assembly Maximum	Insulation Minimum	Assembly Maximum	Insulation Minimum	
Roof	Insulation Entirely Above Deck	U-0.048	R-20.0 c.i.	U-0.024	R-41.66	Y
Walls Above Grade	Mass	U-0.104	R-9.5 c.i.	U-0.0535	R-18.7	Y
Walls Below Grade	Below Grade Wall	C-1.14	NR	C-0.01	NR	Y
Floors	Mass	U-0.087	R-8.3 c.i.	U-0.052	R-19.2	Y
Slab on Grade Floors	Unheated	F-0.73	NR	F-0.69	NR	Y

Table 2 - Building Material Properties

	Prescribed Nonresidential Assembly Values		Acual Construction Assembly Values		Compliance (Y/N)
Vertical Glazing Wall Area	Assembly Maximum U-Value	Assembly Maximum SHGC	Assembly Maximum U-Value	Assembly Maximum SHGC	
Metal Framing (window)	0.5	0.4	0.41	0.31	Y

Table 3 - Glazing Material Properties

4.2 Section 6 – Heating, Ventilation, and Air Conditioning

6.2 Compliance Path

There are two options to evaluate the efficiency of a buildings HVAC system, the simplified approach and the prescriptive path. The prescriptive path was used for this evaluation because WRNMMC was over the 25,000sf maximum size and over the maximum two story requirement as stated in order to use the simplified approach.

6.4 Mandatory Provisions

Tables 6.8.1 A-G in Standard 90.1-2007 provide minimum performance requirements that must be met for the mechanical equipment in the building. The minimum efficiency of the chillers was determined from section 6.4.1.2 due to the fact that the chiller was not designed for operation within the set points specified by the ARI Standard 550/590 test conditions. The minimum efficiency was interpolated from Table 6.8.1J in Standard 90.1-2007 using a 42°F evaporator LWT, 83°F condenser EWT, and a flow rate of 1.875 gpm/ton. The minimum efficiencies for the equipment installed within the building are shown in Table 4.

HVAC controls have been located in every zone to provide occupant comfort and space adjustability. The ventilation rate in some occupancy zones is able to be setback during unoccupied hours, but this is not applicable to all HVAC zones as per the RFP. The specifications state that ductwork must be designed to operate at static pressures in excess of 3 in w.c. which complies with the requirements within this section.

ASHRAE Minimum Equipment Efficiency vs Actual Efficiency				
Equipment Type	Size	Minimum Efficiency	Equipment Efficiency	Compliance (Y/N)
Water Cooled Centrifiugal Chiller	>300 Tons	COP-5.3	COP-5.6	**Y**
Axial Fan Cooling tower	95°F EWT 85° LWT 75° WB	>38.2 gpm/hp	46.9 gpm/hp	**Y**

Table 4 - Minimum Equipment Efficiencies

6.5.3 Air System Design and Control

Since both groups of air handlers in Building A and B supply 100% outside air the economizer mode of the air handlers is able to supply 100% outside air as well. All of the fans that are used in Buildings A and B have been analyzed for their compliance with Table 6.5.3.1.1A in Standard 90.1-2007.

The variable volume maximum brake horsepower equation was able to be used as per exception a in section 6.5.3.1.1 which states that this is acceptable for hospitals that utilize flow control devices to maintain space pressure relationships. Appendix D shows outlines the maximum brake horsepower equation procedure as described from Standard 90.1-2007. Appendix E lists the compliance for both supply and exhaust fans for Buildings A and B.

6.5.5 Heat Rejection Equipment

The fans that are installed on the cooling towers are rated at 40 hp which means that the fans must meet the requirements in section 6.5.5.2. This section states that condensing equipment with fans larger than 7.5 hp must be able to operate at 2/3 power. The fans specified for WRNMMC will be able to accomplish this by being equipped with variable frequency drives (VFD).

6.5.6 Energy Recovery

Since WRNMMC supplies 100% outside air at a volumetric flow rate of greater than 5,000 cfm then it must use exhaust energy recovery as stated in section 6.5.6.1. The exhaust air energy recovery system shall be at least 50% effective in the transfer of enthalpy between air streams. Controls must allow for the energy recovery system to be bypassed when the AHU is operating in economizer mode. WRNMMC uses total energy wheels with a total efficiency of 85.9% with each wheel recovering 1,778 MBH of energy from the exhaust stream.

Heat recovery for service water heating must also be utilized due to WRNMMC meeting all of the design criteria stated within section 6.5.6.2.1 in Standard 90.1-2007. This is obtained through the use of two pass heat recovery chillers located in both Building A and B. These heat recovery chillers utilize heat from the centrifugal chillers condenser section that would otherwise be rejected through the cooling tower. These heat recovery chillers are used to preheat the both the domestic and heating hot water needs of the building.

6.7 Submittals
Construction documents, operation and maintenance manuals, and submittal information will all be turned over to the owner in compliance with this section. Air and hydronic systems will be balanced in accordance with applicable NEBB standards. Air balance documentation will be provided to the owner and is listed in the mechanical construction documents. A sample air balance schedule that is provided in the construction documents is shown in Appendix A.

4.3 Section 7 – Service Water Heating

Section 7 of ASHRAE Standard 90.1-2007 evaluates service water heating requirements for additions to existing buildings and new buildings. The heating hot water system and equipment for new building construction must comply with section 7.2. The minimum hot water pipe insulation thickness is shown in Table 5 below. Since both new buildings are using an existing campus steam plant for all of the heating needs there are no minimum equipment efficiencies that need to be met within this category.

Operating Temperatures	Pipe Diameter	Minimum Insulation Thickness	Specified Insulation Thickness	Compliance (Y/N)
<250°F	< 1.5"	1.5"	1.5"	Y
	2"-6"	2"	2"	Y
	>8"	2"	2"	Y
251°F-353°F	< 1.5"	2.5"	2.5"	Y
	2"-4"	3"	3"	Y
	5"-6"	3"	3"	Y
	>8"	3"	3"	Y

Table 5 - Minimum Pipe Insulation Thickness

4.4 Section 8 – Power

Section 8 outlines prescriptive requirements for the buildings power distribution system. A sample branch and feeder section of wire was taken from the voltage drop calculations and shown in Table 6 below. Electrical drawings as well as equipment operation and maintenance manuals will be turned over to the owner upon completion of the building.

	Maximum Voltage Drop %	Calculated Voltage Drop %	Compliance (Y/N)
Feeder Circuit	2	1.93	**Y**
Branch Circuit	3	2.22	**Y**

Table 6 - Maximum Voltage Drop Calculations

4.5 Section 9 – Lighting

Section 9 provides information on how to calculate the lighting power density within the building. Two separate methods are provided for this calculation, the space by space method and the building area method. Lighting that has been designed for either medical or dental procedures or lighting that is on medical equipment is not included in the power density due to exception c of section 9.2.2.3. Automatic light shutoffs are provided in the office areas of the building, but many areas fall under the exceptions in section 9.4.1.1 due to the nature of the building tasks.

9.5 Building Area Method Compliance Path

Table 9.5.1 within Standard 90.1-2007 lists lighting power densities for various building area types. The maximum lighting power density for a hospital building is 1.2 W/ft^2 and 1.0 W/ft^2 for an office building. Since Building A is zoned as a Business Occupancy, it is assumed that it will use the office lighting power density of 1.0 W/ft^2. Building B is zoned as a Health Care Occupancy and is assumed to use the 1.2 W/ft^2 lighting power density. Table 7 outlines the lighting power density calculations for both Building A and B.

Building	Floor Number	Area (ft^2)	Number of Fixture A	Number of Fixture B	Watts per Fixture A	Watts per Fixture B	Total Watts (W)	Total Lighting Power Density (W/ft^2)	Maximum Lighting Power Density (W/ft^2)	Compliance
A	1	69356	846	52	70	44	61508	0.89	1	Y
	2	69356	839	27	70	44	59918	0.86	1	Y
	3	69356	849	48	70	44	61542	0.89	1	Y
	4	69356	896	36	70	44	64304	0.93	1	Y
	5	39573	429	19	70	44	30866	0.78	1	Y
	6	39573	441	24	70	44	31926	0.81	1	Y
B	1	34105	451	18	70	44	32362	0.95	1.2	Y
	2	34105	469	15	70	44	33490	0.98	1.2	Y
	3	26845	364	15	70	44	26140	0.97	1.2	Y
	4	26845	355	12	70	44	25378	0.95	1.2	Y

Table 7 - Building Lighting Power Densities

4.6 Section 10 – Other Equipment

This section defines minimum efficiencies for equipment using electric motors. These efficiencies are based upon rated motor horsepower and motor speed. All of the pumps within Building A and B have been analyzed within Table 8 (Industries) (Industries) which resulted in none of the electric pump motors within compliance. None of the pumps called out in the equipment schedules meet the minimum efficiencies of Section 10. The efficiency ratings that are given within this section are based upon a fixed frequency motor type. Variable frequency drives (VFD) have been specified to be installed with all of the pumps in both buildings. Comparing the efficiencies of pumps with VFD's to fixed frequency pumps may be the reason that no electric motors comply with this section.

Building	Pump ID	Motor Size (hp)	Pump Efficiency	Motor RPM	Minimum Efficiency	Compliance (Y/N)
A	CHWP-1	60	79%	1770	94%	**N**
	CHWP-2	60	79%	1770	94%	**N**
	CHWP-3	60	79%	1770	94%	**N**
	CWP-1	60	88%	1770	94%	**N**
	CWP-2	60	88%	1770	94%	**N**
	CWP-3	60	88%	1770	94%	**N**
	HHWP-1A	40	85%	1800	93%	**N**
	HHWP-2A	40	85%	1800	93%	**N**
	HRP-1A	5	76%	1800	88%	**N**
	HRP-2A	5	76%	1800	88%	**N**
	HRP-3A	5	74%	1800	88%	**N**
	HRP-4A	5	74%	1800	88%	**N**
B	HHWP-1B	20	83%	1800	91%	**N**
	HHWP-2B	20	83%	1800	91%	**N**
	HRP-1B	7.5	76%	1800	90%	**N**
	HRP-2B	7.5	76%	1800	90%	**N**
	HRP-3B	5	74%	1800	88%	**N**
	HRP-4B	5	74%	1800	88%	**N**

Table 8 - Minimum Electric Motor Efficiencies

4.7 ASHRAE 90.1-2007 Summary

The prescriptive performance evaluation method was used to determine compliance of within all of the sections of this standard. Due to the fact that this building is striving for a LEED® Silver rating the equipment that is specified well exceeds the minimum efficiencies outlined in Standard 90.1-2007. Coupling increased equipment efficiencies with improved building construction methods will help gain Energy Efficiency credits.

Hospitals usually consume enormous amounts of energy due to 24 hour operation, increased ventilation requirements, and the increased equipment and human load. But WRNMMC is able to provide an energy efficient world class medical facility without compromising the life safety of its occupants. All areas that were examined in this Standard 90.1 analysis were determined to meet or exceed the minimum requirements stated.

References:

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Appendix A – Sample Air Balance Schedule

AIR BALANCE SCHEDULE – BLDG B – FOURTH FLOOR

ROOM NO.	ROOM NAME	UFC ROOM TEMPLATE	DESIGN SUPPLY (CFM)	DESIGN INFILTN (CFM)	DESIGN EXFLTN (CFM)	DESIGN RETURN (CFM)	TOTAL AC/H		RELATIVE PRESSURE**		
							UFC 4-510	DESIGN	UFC 4-510	AIRFLOW (CFM)	AIRFLOW (CFM)
S.Corridor		CORR1	2,450	85	1,865	670	2	6.2	0	0	1780
N. Corridor		CORR1	2,675	485	1,610	1,550	2	6.6	0	0	1125
4004	OFF	OFA02	70	0	0	70	4	4.9	0	0	0
4007	ICU	SL001	350	0	120	230	5	8.9	0	0	120
4009	TLT	TLTU1	50	50	0	100	10	10.5	EX	0	-50
4011	NCOIC	OFA02	125	0	25	100	4	8.3	0	0	25
4013	NRS	OFA02	60	0	0	60	4	5.6	0	0	0
4014	STAFF	TLTU1	0	85	0	85	10	10.4	EX	0	-85
4015/4017	PAT BED/TLT	BRII1	435	125	35	525	12	12.3	--	-90	-90
4016	STAFF	TLTU1	0	85	0	85	10	10.4	EX	0	-85
4021/4023	PAT BED/TLT	BRII1	435	125	35	525	12	12.3	--	-90	-90
4022	EQPM	SRE01	100	0	0	100	4	4.6	0	0	0
4025/4027	PAT BED/TLT	BRII1	435	125	35	525	12	12.3	--	-90	-90
4026	SOIL	USCL1	115	50	0	165	6	6.5	-	-20	-50
4031	VEST	CORR1	60	75	135	0	2	4.2	0	0	60
4033	M	LR001	330	50	220	160	4	9.7	0	0	170
4034	TEAM	CRA01	120	0	0	120	6	6.1	0	0	0
4035	TLT/SHWR/CH	TLTS1	50	85	0	135	10	10.0	EX	0	-85
4036	CLN	UCCL1	85	0	85	0	4	6.0	+	10	85
4037	F	LR001	85	50	135	0	4	4.0	0	0	85
4039	TLT	TLTU1	50	100	25	125	10	11.3	EX	0	-75
4041/4043	PAT BED/TLT	BRII1	420	125	35	510	12	12.3	--	-90	-90
4047/4049	PAT BED/TLT	BRII1	425	125	35	515	12	12.1	--	-90	-90
4050	MEDS	MEDP1	45	0	0	45	4	4.3	0	0	0
4051/4053	PAT BED/TLT	BRII1	425	125	35	515	12	12.1	--	-90	-90
4057/4059	PAT BED/TLT	BRII1	425	125	35	515	12	12.1	--	-90	-90
4061	STAFF	TLTU1	0	80	0	80	10	10.7	EX	0	-80
4063	DAY ROOM 2	WRF01	585	50	120	515	6	10.9	0	0	70
4065	FAMILY	TLTU1	0	90	0	90	10	10.4	EX	0	-90
4067	CONSULT	OFDC2	110	30	30	110	4	9.2	0	0	0
4071/4073	PAT BED/TLT	BRII1	425	125	35	515	12	12.3	--	-90	-90
4075/4077	PAT BED/TLT	BRII1	430	125	35	520	12	12.3	--	-90	-90
4081/4083	PAT BED/TLT	BRII1	430	125	35	520	12	12.3	--	-90	-90
4085/4087	PAT BED/TLT	BRII1	430	125	35	520	12	12.3	--	-90	-90
4091/4093	PAT BED/TLT	BRII1	420	125	35	510	12	12.1	--	-90	-90
4095	NCOIC	OFA02	50	0	0	50	4	4.2	0	0	0
4097	STAFF	SL001	335	0	95	240	5	13.4	0	0	95
4099	TLT	OFA02	50	65	20	95	4	4.5	0	0	-45
4101	NRS	OFA02	50	0	0	50	4	4.3	0	0	0
4102	ANTE-ROOM	BRAR2	125	50	75	100	10	13.8	+	20	25
4103	JAN	JANC1	0	75	0	75	10	11.7	-	0	-75
4107/4109	PAT BED/TLT	BRII2	535	0	210	325	12	12.1	++	110	210
4111/4113	PAT BED/TLT	BRII1	425	125	35	515	12	12.2	--	-90	-90
4112	TEAM	CRA01	175	0	0	175	6	8.8	0	0	0
4117/4119	PAT BED/TLT	BRII1	425	125	35	515	12	12.2	--	-90	-90
4120	CLN	UCCL1	85	0	85	0	4	4.7	+	10	85
4121/4123	PAT BED/TLT	BRII1	420	125	35	510	12	12.2	--	-90	-90
4129	DAY	WRF01	410	0	200	210	6	10.4	0	0	200
4130	MEDS	MEDP1	45	0	0	45	4	4.0	0	0	0
4131	CONSULT	OFDC2	140	0	25	115	4	10.7	0	0	25
4133	FAMILY	TLTU1	0	90	0	90	10	10.6	EX	0	-90
4135	STAFF	TLTU1	0	80	0	80	10	10.2	EX	0	-80
4137/4139	PAT BED/TLT	BRII1	425	125	35	515	12	12.2	--	-90	-90
4143/4145	PAT BED/TLT	BRII1	425	125	35	515	12	12.2	--	-90	-90
4147/4149	PAT BED/TLT	BRII1	425	125	35	515	12	12.2	--	-90	-90
4153/4155	PAT BED/TLT	BRII1	425	125	35	515	12	12.3	--	-90	-90
4157	EQPM	SRE01	205	0	90	115	4	4.0	0	0	90
4159	RESP THER	SRE01	85	0	20	65	4	5.9	0	0	20
4161	ANTE-	BRAR2	125	50	100	75	10	13.4	+	20	50
4165/4167	PAT BED/TLT	BRII2	535	0	210	325	12	12.5	++	110	210
4168	SOIL	USCL1	125	50	0	175	6	6.4	-	-20	-50
4169/4171	PAT BED/TLT	BRII1	435	125	35	525	12	12.3	--	-90	-90
4175/4177	PAT BED/TLT	BRII1	435	125	35	525	12	12.3	--	-90	-90
4179/4181	PAT BED/TLT	BRII1	470	135	35	570	12	12.4	--	-100	-100

Appendix B – Minimum Ventilation Calculation

Building:	Walter Reed National Military Medical Center								
System Tag/Name:	Building B - Level 1								
Operating Condition Description:									
Units (select from pull-down list)	IP								

	Name	Units	Formula	System					
Inputs for System									
Floor area served by system	As	sf		16,253					
System population (including diversity)	Ps	P		271					
Design primary supply fan airflow rate	Vpsd	cfm		16,060					
Average outdoor airflow rate per unit area for the system	Ras	cfm/sf		0.06					
Average outdoor airflow rate per person for the system	Rps	cfm/p		5.4					
Inputs for Potentially Critical Zones									
Zone Name			*Zone title turns purple italic for critical zone(s)*		Conference	Conference	Corridor	Corridor	Office
Zone Tag					1607	1605	1600	1500	1603
Space type		Select from pull-down list			Conference/ meeting	Conference/ meeting	Corridors	Corridors	Office space
Floor Area of zone	Az	sf			453	566	407	468	119
Design population of zone	Pz	P	(default value listed; may be overridden)		23	29	0	0	1
Design discharge airflow to zone (total primary plus local recirculated)	Vdzd	cfm			575	630	350	402	75
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A			None	None	None	None	None
Local recirc.air fraction representative of ave system return air	Er								
Inputs for Operating Condition Analyzed									
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list			CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep								
Results									
System Ventilation Efficiency	Ev			0.34					
Outdoor air intake airflow rate required at condition analyzed	Vot	cfm		7105					
Outdoor air intake rate per unit floor area	Vot/As	cfm/sf		0.44					
Outdoor air intake rate per person served by system (including diversity)	Vot/Ps	cfm/p		26.2					
Outdoor air intake rate as a % of design primary supply air	Vot/Vpsd	%		44%					
Uncorrected outdoor air intake airflow rate	Vou	cfm		2435					
Detailed Calculations									
Initial Calculations for the System as a whole									
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= Vpsd Ds =	16060					
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	2435					
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.15					
Initial Calculations for individual zones									
OA rate per unit area for zone	Ra	cfm/sf			0.06	0.06	0.06	0.06	0.06
OA rate per person for zone	Rp	cfm/p			5.00	5.00	0.00	0.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm	= Vdsd Ds		575	630	350	402	75
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		142.2	179.0	24.4	28.1	12.1
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		142	179	24	28	12
Fraction of supply air to zone from sources outside the zone	Fa		= Ep + (1-Ep)Er =		1.00	1.00	1.00	1.00	1.00
Fraction of supply air to zone from fully mixed primary air	Fb		= Ep =		1.00	1.00	1.00	1.00	1.00
Fraction of outdoor air to zone from sources outside the zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er) =		1.00	1.00	1.00	1.00	1.00
Outdoor air fraction required in air discharged to zone	Zd		= Voz / Vdz =		0.25	0.28	0.07	0.07	0.16
System Ventilation Efficiency									
Zone Ventilation Efficiency	Evz		= (Fa + FbXs - FcZ) / Fa =		0.90	0.87	1.08	1.08	0.99
System Ventilation Efficiency	Ev		= min (Evz) =	0.34					

Office	Office	Staff Lounge	Patient Waiting	Office	Office	Ante Room	IV Prep	Corridor	Office	Locker Room	Locker Room	Office	Office
1601	1602	1533	1529	1606	1608	1525	1527	1523	1302	1301	1305	1328	1330
Office space	Office space	Conference/ meeting	Office space	Office space	Office space	Office space	Office space	Corridors	Office space	Health club/ weight rooms	Health club/ weight rooms	Office space	Office space
118	111	171	112	98	112	46	87	264	94	417	176	125	118
1	1	9	1	1	1	1	1	0	1	5	2	1	1
75	70	320	190	60	80	205	475	540	60	250	240	70	70
None	None	None	None	None	None	None	None	None	None	None	None	None	None

100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	0.00	5.00	20.00	20.00	5.00	5.00
75	70	320	190	60	80	205	475	540	60	250	240	70	70
12.1	11.7	55.3	11.7	10.9	11.7	7.8	10.2	15.8	10.6	125.0	50.6	12.5	12.1
12	12	55	12	11	12	8	10	16	11	125	51	13	12
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.16	0.17	0.17	0.06	0.18	0.15	0.04	0.02	0.03	0.18	0.50	0.21	0.18	0.17
0.99	0.99	0.98	1.09	0.97	1.01	1.11	1.13	1.12	0.97	0.65	0.94	0.97	0.98

Potentially Critical Zones

Office	Office	Office	Office	Corridor	Office	Office	Office	Office	Office	Corridor	Corridor	Corridor	Corridor
1332	1326	1308	1310	1306	1324	1322	1320	1318	1314A	1212	1100	1200	1227
Office space	Office space	Office space	Office space	Corridors	Office space	Office space	Office space	Office space	Office space	Corridors	Corridors	Corridors	Corridors
123	137	113	99	131	109	109	109	119	198	19	1,141	1,352	141
1	1	1	1	0	1	1	1	1	1	0	0	0	0
70	160	70	70	80	85	85	85	85	150	16	981	1163	121
None	None	None	None	None	None	None	None	None	None	None	None	None	None
100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
5.00	5.00	5.00	5.00	0.00	5.00	5.00	5.00	5.00	5.00	0.00	0.00	0.00	0.00
70	160	70	70	80	85	85	85	85	150	16	981	1163	121
12.4	13.2	11.8	10.9	7.9	11.5	11.5	11.5	12.1	16.9	1.1	68.5	81.1	8.5
12	13	12	11	8	12	12	12	12	17	1	68	81	8
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.18	0.08	0.17	0.16	0.10	0.14	0.14	0.14	0.14	0.11	0.07	0.07	0.07	0.07
0.97	1.07	0.98	1.00	1.05	1.02	1.02	1.02	1.01	1.04	1.08	1.08	1.08	1.08

Nurse Station	Private Work	Nurse Station	Secured Holding	Meds	Nour	Corridor	Corridor	Corridor	Corridor	Corridor	Office	Corridor	Lounge
1116	1114	1112	1108	1207	1010	1006	1012	1030	1004	1018	1035	1031	1029
Office space	Office space	Office space	Office space	Office space	Office space	Corridors	Corridors	Corridors	Corridors	Corridors	Office space	Corridors	Lobbies
377	653	316	118	69	82	240	695	240	188	284	134	257	142
2	4	2	1	1	1	0	0	0	0	0	1	0	22
320	660	295	215	45	90	206	597	206	162	244	150	360	250
None	None	None	None	None	None	None	None	None	None	None	None	None	None

100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
5.00	5.00	5.00	5.00	5.00	5.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	5.00
320	660	295	215	45	90	206	597	206	162	244	150	360	250
32.6	59.2	29.0	12.1	9.1	9.9	14.4	41.7	14.4	11.3	17.0	13.0	15.4	118.5
33	59	29	12	9	10	14	42	14	11	17	13	15	119
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.10	0.09	0.10	0.06	0.20	0.11	0.07	0.07	0.07	0.07	0.07	0.09	0.04	0.47
1.05	1.06	1.05	1.10	0.95	1.04	1.08	1.08	1.08	1.08	1.08	1.06	1.11	0.68

Ambulance Reception	Family Consulting	Waiting	*Reception*	Waiting	Lobby	Corridor	Corridor	Corridor	Nurse Office	NCOIC	Conference	Ambulance Dispatch	First Response
1011	1009	1001	*1002*	1001A	1401	1400	1340	1300	1037	1039	1033	1015	1017
Office space	Conference/ meeting	Conference/ meeting	Lobbies	Conference/ meeting	Conference/ meeting	Corridors	Corridors	Corridors	Office space	Office space	Conference/ meeting	Office space	Office space
207	90	574	216	939	289	345	610	611	86	86	199	118	63
2	5	29	33	47	15	0	0	0	1	1	10	1	1
200	55	585	220	955	290	297	525	525	55	55	225	200	40
None	None	None	None	None	None	None	None	None	None	None	None	None	None
100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS	CS
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
5.00	5.00	5.00	5.00	5.00	5.00	0.00	0.00	0.00	5.00	5.00	5.00	5.00	5.00
200	55	585	220	955	290	297	525	525	55	55	225	200	40
22.4	30.4	179.4	178.0	291.3	92.3	20.7	36.6	36.7	10.2	10.2	61.9	12.1	8.8
22	30	179	178	291	92	21	37	37	10	10	62	12	9
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.11	0.55	0.31	0.81	0.31	0.32	0.07	0.07	0.07	0.18	0.18	0.28	0.06	0.22
1.04	0.60	0.84	0.34	0.85	0.83	1.08	1.08	1.08	0.97	0.97	0.88	1.09	0.93

	Check Figures	
	16.7 P/1000 sf	
	0.99 cfm/sf	
	0.06 ave cfm/sf	
	5.4 ave cfm/p	
Work Room	**Totals/averages**	
1007		
Conference/ meeting		
63	16253 total sf	
4	271 total P	
75	16060 total cfm	
None		
	1.00 average	
100%	100% average	
CS		
1.00	1.00 average	Primary airflow rate to zones
	1.00 average	16060 cfm
		100% Percent of design
	271 System population without diversity	
	1.00 System population diversity, D	
0.06		
5.00		
75	16060	
23.8	2435	
24	2435	
1.00		
1.00		
1.00		
0.32	0.81 Maximum Zd	
0.83		

Appendix C – Minimum Ventilation and Air Change Check

Room Number	Room Name	Minimum Ventilation (cfm)	Design Ventilation (cfm)	Minimum Ventilation Met (Y/N)	UFC 4-510 Required Air Changes per Hour	System Design Air Changes per Hour	Minimum Air Changes Met (Y/N)
1607	Conference/Library	143	575	Y	4	8	Y
1605	Conference/Library	179	630	Y	4	6.7	Y
1600	Corridor	25	350	Y	2	4.6	Y
1500	Corridor	29	402	Y	2	4.5	Y
1603	Staff Office	13	75	Y	4	4.9	Y
1601	Staff Office	13	75	Y	4	4.8	Y
1602	Staff Office	12	70	Y	4	4.9	Y
1533	Staff Office	56	320	Y	5	14.6	Y
1529	Hot Patient Waiting	12	190	Y	6	11.5	Y
1606	Secretary	11	60	Y	4	4.6	Y
1608	Resident Director	12	80	Y	4	5.5	Y
1525	Ante Room	8	205	Y	4	28.4	Y
1527	IV-Prep	11	475	Y	4	4	Y
1523	Hot Lab	16	540	Y	6	16.8	Y
1302	Staff Office	11	60	Y	4	4.9	Y
1301	Locker Room	126	250	Y	10	12.5	Y
1305	Locker Room	51	240	Y	10	12.3	Y
1328	NM Fellow Office	13	70	Y	4	4.2	Y
1330	NM Fellow Office	13	70	Y	4	4.2	Y
1332	NM Fellow Office	13	70	Y	4	4.3	Y
1326	NM Fellow Office	14	160	Y	4	9.6	Y
1308	NM Director Office	12	70	Y	4	4.7	Y
1310	Program Director Office	11	70	Y	4	5.3	Y
1306	Corridor	8	80	Y	4	4.5	Y
1324	NM Office	12	85	Y	4	5.1	Y
1322	NM Office	12	85	Y	4	5.9	Y
1320	NM Office	12	85	Y	4	5.9	Y
1318	NM Office	13	85	Y	4	5.5	Y
1314A	Office	17	150	Y	4	9.1	Y
1212	Corridor	2	16	Y	2	4.2	Y
1100	Corridor	69	981	Y	2	4.9	Y
1200	Corridor	82	1163	Y	2	4.6	Y
1227	Corridor	9	121	Y	2	4.6	Y
1116	Nurse Station	33	320	Y	4	8.3	Y
1114	Private Work	60	660	Y	4	89.3	Y
1112	Nurse Station	29	295	Y	4	7.8	Y
1108	Secured Holding	13	215	Y	4	13.9	Y
1207	Meds	10	45	Y	4	4.9	Y
1010	Nourishment	10	90	Y	6	9.8	Y
1006	Corridor	15	206	Y	2	4.5	Y
1012	Corridor	42	597	Y	2	4.6	Y
1030	Corridor	15	206	Y	2	4.8	Y
1004	Corridor	12	162	Y	2	4.6	Y
1018	Corridor	18	244	Y	2	4.7	Y
1035	Office	14	150	Y	4	8.5	Y
1031	Office	16	360	Y	4	35.2	Y
1029	Staff Office	119	250	Y	5	14	Y
1011	Ambulance Receiving	23	200	Y	6	7.2	Y
1009	Family Consulting	31	55	Y	4	4.6	Y
1001	Wating	180	574	Y	6	7.7	Y
1002	Reception	178	216	Y	6	7.7	Y
1001A	Waiting	292	939	Y	6	7.7	Y
1401	Lobby	93	289	Y	4	5.2	Y
1400	Corridor	21	297	Y	2	4.6	Y
1340	Corridor	37	525	Y	2	4.8	Y
1300	Corridor	37	525	Y	2	4.8	Y
1037	Nurse Manager	11	55	Y	4	4.8	Y
1039	NCOIC Office	11	55	Y	4	4.8	Y
1033	Conference	62	225	Y	6	8.5	Y
1015	Ambulance Receiving	13	200	Y	4	13	Y
1017	First Aid	9	40	Y	4	4.2	Y
1007	Work Room	24	75	Y	4	7.1	Y

Appendix D – Fan Power Limitation Reference

TABLE 6.5.3.1.1A Fan Power Limitation[a]

	Limit	Constant Volume	Variable Volume
Option 1: Fan System Motor Nameplate hp	Allowable Nameplate Motor hp	$hp \le CFM_S \cdot 0.0011$	$hp \le CFM_S \cdot 0.0015$
Option 2: Fan System bhp	Allowable Fan System bhp	$bhp \le CFM_S \cdot 0.00094 + A$	$bhp \le CFM_S \cdot 0.0013 + A$

[a] where
CFM_S = the maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute
hp = the maximum combined motor nameplate horsepower
bhp = the maximum combined fan brake horsepower
A = sum of $(PD \times CFM_D/4131)$
where
PD = each applicable pressure drop adjustment from Table 6.5.3.1.1B in in. w.c.
CFM_D = the design airflow through each applicable device from Table 6.5.3.1.1B in cubic feet per minute

TABLE 6.5.3.1.1B Fan Power Limitation Pressure Drop Adjustment

Device	Adjustment
Credits	
Fully ducted return and/or exhaust air systems	0.5 in. w.c.
Return and/or exhaust airflow control devices	0.5 in. w.c.
Exhaust filters, scrubbers, or other exhaust treatment	The pressure drop of device calculated at fan system design condition
Particulate Filtration Credit: MERV 9 through 12	0.5 in. w.c.
Particulate Filtration Credit: MERV 13 through 15	0.9 in. w.c.
Particulate Filtration Credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2× clean filter pressure drop at fan system design condition
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition
Heat recovery device	Pressure drop of device at fan system design condition
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design condition
Sound Attenuation Section	0.15 in. w.c.
Deductions	
Fume Hood Exhaust Exception (required if 6.5.3.1.1 Exception [c] is taken)	–1.0 in. w.c.

Appendix E – Fan Power Limitation Calculation

Fan Power Limitation				
Fan Tag	Flow Rate (CFM)	Nameplate Motor bhp	Allowable Motor bhp (VAV)	Compliance (Y/N)
EF-1A	70500	86	109.4	Y
EF-2A	70500	86	109.4	Y
EF-3A	70500	86	109.4	Y
EF-4A	70500	86	109.4	Y
EF-5A	70500	86	109.4	Y
EF-6A	2250	0.49	3.2	Y
EF-7A	500	0.49	0.71	Y
EF-8A	800	0.57	1.14	Y
EF-9A	500	0.66	0.71	Y
EF-10A	800	1.21	1.13	Y
EF-11A	800	1.21	1.13	Y
EF-12A	5500	2.68	7.82	Y
EF-13A	800	0.44	1.13	Y
EF-14A	1500	0.64	2.13	Y
EF-15A	800	0.26	1.13	Y
EF-16A	800	0.57	1.13	Y
EF-17A	800	0.26	1.13	Y
EF-18A	800	0.26	1.13	Y
EF-19A	1200	0.56	1.7	Y
AHU-1A	50000	87.4	84.5	Y
AHU-2A	50000	87.4	84.5	Y
AHU-3A	50000	87.4	84.5	Y
AHU-4A	50000	87.4	84.5	Y
AHU-5A	50000	87.4	84.5	Y
AHU-6A	50000	87.4	84.5	Y
AHU-7A	50000	87.4	84.5	Y
AHU-8A	50000	87.4	84.5	Y
AHU-9A	5500	4.3	7.82	Y
AHU-1B	50000	90.5	84.5	Y
AHU-2B	50000	90.5	84.5	Y
AHU-3B	50000	90.5	84.5	Y
EF-1B	60000	75	85.2	Y
EF-2B	60000	75	85.2	Y
EF-3B	1771	3.2	2.51	Y
EF-5B	125	0.5	0.18	Y
EF-6B	550	1.2	0.78	Y
EF-8B	14000	20.8	19.89	Y
EF-9B	14000	20.8	19.89	Y
EF-10B	11000	16.5	15.63	Y
EF-11B	11000	16.5	15.63	Y