

Technical Report One

ASHRAE Std 62.1 and Std 90.1 Analysis

Army National Guard

Readiness Center Addition

Arlington, Va.

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Executive Summary

The purpose of this report is to determine compliance or non-compliance of the Army National Guard (referred hereafter as ArNG) Readiness Center Addition with ASHRAE Standards 62.1 and 90.1.

The ArNG building will function as an administrative headquarters in conjunction with the existing complex on site. It is an 8 story, 251,000 square foot facility which mainly houses open office spaces and conference centers but will contain an auditorium and training facility as well.

These spaces were analyzed against Standard 62.1 and found to be compliant with most all requirements as specified in Section 5. For the Section 6 analysis two out of the eight levels were studied. Calculations of the air handling units (AHU) on levels 2T and 1P gave a very close approximation for the building as a whole. It was shown that some critical spaces were lacking in ventilation requirements and need to be adjusted. This can be attributed to the use of default values for occupancy which many times are overestimated.

An analysis with respect to ASHRAE Standard 90.1 was also conducted to determine that the building complies with the minimum requirements for energy efficiency. Sections covered deal with the building envelope, HVAC systems, and lighting/electrical design. It was found that the ArNG building as a whole complies with nearly all stipulations from this standard falling short only in computer room air-conditioning (CRAC) units and their efficiencies.

In the end it was determined that the ArNG Building is close to compliance with ASHRAE Standards 62.1 and 90.1. This building is planning on being lead certified and needs to adhere closely to the above standards to be considered for such a status.

System Description

The ArNG building houses a hydronic HVAC system consisting of a heating and chilled water 4 pipe system. This water is supplied to mechanical rooms on every floor containing AHU's as well as VAV terminals. There are a total of 17 AHU with one specified per tower level. The 3 underground levels hold the majority of the units and they range anywhere from 500 cfm to 4250 cfm. Typical size for the 5 tower levels is 1550 cfm.

There are two 400 ton centrifugal water-cooled chillers specified in conjunction with two cooling towers.

For the 62.1 Section 6 analysis, the AHU considered were AHU-2T-A1(Level 2 Tower, other floors typical) and Level 1P (Underground level 1) which houses 5 AHU's. These particular units were selected for symmetry purposes and these spaces mimicked the rest of building appropriately.

ASHRAE 62.1 Analyses

Section 5 Analysis

Section 5.1 Natural Ventilation

None of the windows in the ArNG Readiness Center Addition are operable; the governmental use of the building makes this impossible. As a result, Natural Ventilation is not a valid ventilation method for this particular building.

Section 5.2 Ventilation Air Distribution

Most all spaces meet ventilation requirements. This can only be achieved with the assumption that the Variable Air Volume (VAV) Terminals are appropriately calibrated to allow the minimum flow through the box to maintain minimum ventilation rates as specified by ASHRAE.

Section 5.3 Exhaust Duct Location

Any spaces producing potentially harmful contaminants (restrooms) have negatively pressurized exhaust ducts. These ducts then exit the building directly to be in compliance with this section.

Section 5.4 Ventilation System Controls

Direct digital control is achieved through building automation systems (BAS) and building management systems. The BAS system controls all of the VAV terminals as well as damper systems. Along with this, energy conservation features such as optimal Start/Stop and night setbacks are available and specified to be implemented.

Section 5.5 Airstream Surfaces

All airstream surfaces in equipment and ducts in the HVAC system will be lined with an antimicrobial erosion-resistant coating. Such a coating is registered by the EPA specifically for use in HVAC systems.

Section 5.6 Outdoor Air Intakes

As specified in Table 5-1 of standard 62.1 the ArNG building maintains at least the minimum safe distance for air intakes. This is typical throughout the building including floors with more than one AHU or exhaust fan.

As specified, the intakes are provided with a rain hood as well as bird screening device. These devices are comprised of Aluminum, ½ inch square mesh, and 0.063 inch wire.

Section 5.7 Local Capture of Contaminants

Non-combustion equipment located inside the ArNG building are not producing contaminants which need a direct exhaust. This section does not apply to this building.

Section 5.8 Combustion Air

Combustion air mainly accumulates due to the condensing boilers within the building. This air is exhausted directly outdoors to comply with this section.

Section 5.9 Particulate Matter Removal

The filters specified have a minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

The filters used are as follows

Washable Foam: 70 percent arrestance and 3 MERV.

Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.

Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.

The whole system is to be sealed during construction to prevent particulates from accessing the system.

Section 5.10 Dehumidification Systems

The dehumidification provided by the AHU's is the only form of dehumidification involved with the ArNG building. All spaces in the building are designed to be less than 65% RH at the design condition. Positive pressurization minimizes infiltration.

Section 5.11 Drain Pans

The condensate drain pans are specified to be stainless-steel as instructed by this standard. The condensate pans will be fabricated with slopes in two planes to collect condensate from the cooling coils and humidifiers when the units are operating at maximum catalogued face velocity across coil.

Section 5.12 Finned-Tube Coils and Heat Exchangers

As specified, drain pans are to be provided for each heat exchanger in the building.

Section 5.13 Humidifiers and Water-Spray Systems

Humidification is to be performed in the AHU's. This section does not apply to the ArNG building.

Section 5.14 Access for Inspection, Cleaning and Maintenance

Access Door Sizes are as follows:

One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).

Two-Hand Access: 12 by 6 inches (300 by 150 mm).

Head and Hand Access: 18 by 10 inches (460 by 250 mm).

Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).

Body Access: 25 by 14 inches (635 by 355 mm).

Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).

Sufficient work space is to be provided for all access, maintenance, and cleaning as needed.

Section 5.15 Building Envelope and Interior Surfaces

A sheet membrane waterproofing system (Bituthene 3000 or 4000) will be provided for the envelope of the building. All piping, with temperatures below the dew-point, is insulated to prevent condensation on the surfaces.

Section 5.16 Buildings with Attached Parking Garages

No parking structure is attached to the ArNG building; therefore this section does not apply.

Section 5.17 Air Classification and Recirculation

The return air utilized in the building is characterized as Class 1 (Air with low contaminant concentration and inoffensive odor and sensory-irritation intensity, suitable for recirculation or transfer to any space.) This air type comes from offices, conference rooms, and other similar spaces. All toilet room exhaust is Class 2 as well as the training facilities. The Class 2 air however cannot be resupplied to a space with a lower class.

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

The ArNG building is a smoke free facility. All designated smoking areas are located away from outdoor air supplies and building entrances. Thus section 5.18 does not apply.

Section 6 Analysis

The purpose of section 6 of ASHRAE Standard 62.1 is to determine the minimum outdoor air intake rates based on occupancy type, floor area, and design population. Ventilation rates were calculated for a descriptive section of the building. The ArNg Building has several different types of occupancies varying from offices to training facilities. By picking critical zones of the building it should provide a good representation of the rest of the building. From this it is then possible to label the building for compliance or non-compliance of Section 6 of ASHRAE Standard 62.1. The zones which were checked for ventilation are shown in Figures 62.1-1 and 62.1-2.

Level 1P (First Level Below Grade)

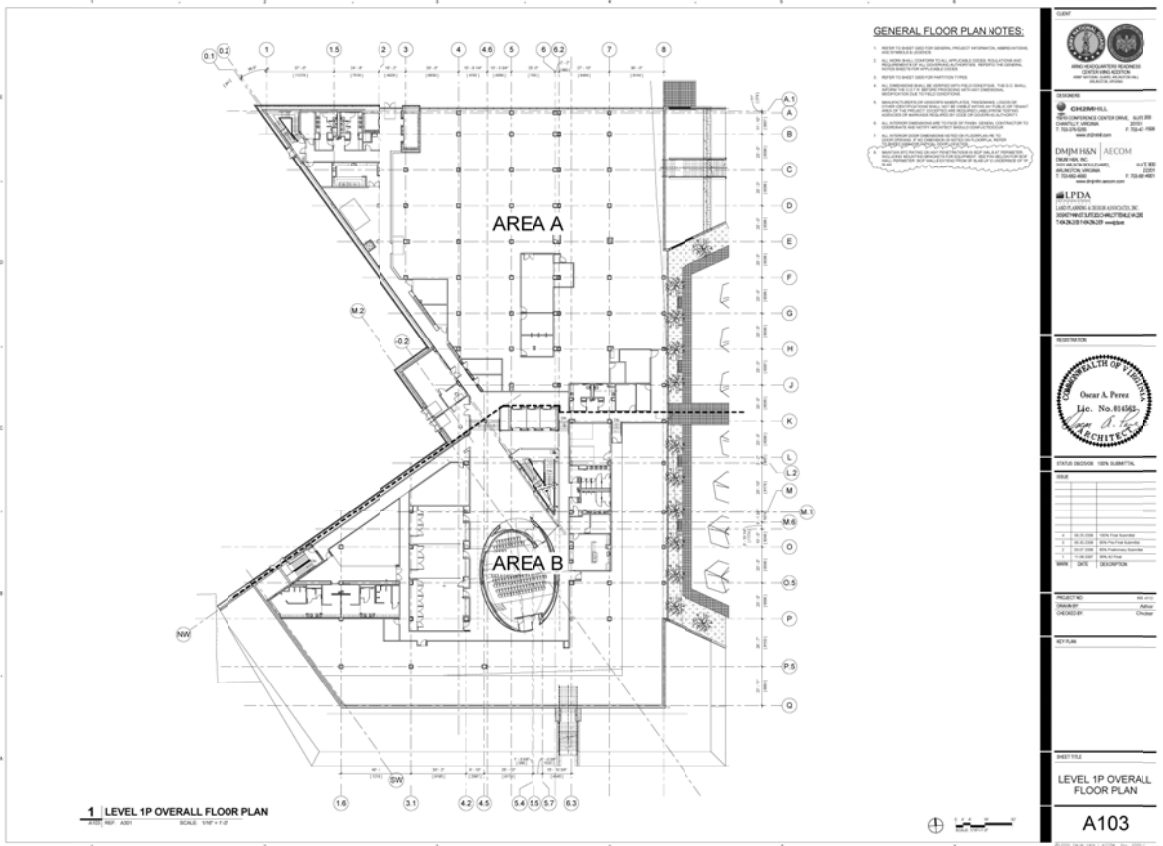


Figure 62.1-1

Level 2T (Second Floor of Tower)

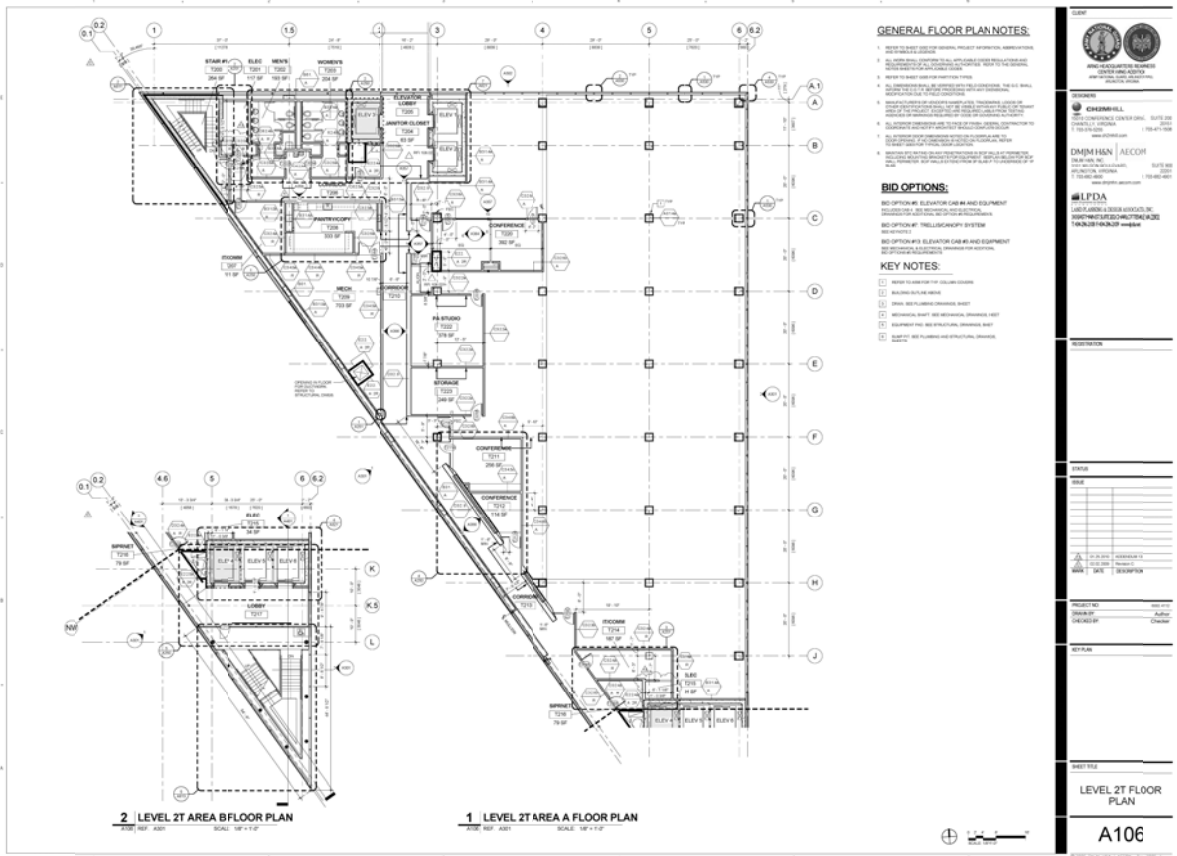


Figure 62.1-2

Ventilation Rate Procedure

Breathing Zone Outdoor Airflow (V_{bz}):

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

Where,

A_z = zone floor area (SF)

P_z = zone population, largest number of people expected to occupy the space during typical usage. (Estimated using values found in Table 6-1)

R_p = outdoor airflow rate per person (cfm/person) (Defined in Table 6-1)

R_a = outdoor airflow rate per unit area (cfm/ft²) (Defined in Table 6-1)

Zone Air Distribution Effectiveness (E_z)

$$E_z = 1 \text{ (As defined by Table 6-2)}$$

Zone Outdoor Airflow (Voz)

$$Voz = Vbz/Ez \text{ (Eq. 6-2)}$$

Zone Primary Outdoor Air Fraction (Zp)

$$Zp = Voz/Vpz \text{ (Eq. 6-5)}$$

Note: For VAV Systems, Vpz is the minimum expected primary airflow for design purposes.
System Ventilation Efficiency (Ev)

Ev is found using the Maximum Zp value. (As defined by Table 6-3)

Uncorrected Outdoor Air Intake (Vou)

$$Vou = D\sum_{\text{all zones}}(Rp \cdot Pz) + \sum_{\text{all zones}}(Ra \cdot Az) \text{ (Eq. 6-6)}$$

Where,

$$D = \text{diversity} = Ps/\sum_{\text{all zones}}(Pz) \text{ (Eq. 6-7)}$$

Ps = system population, total population in the area served by the system

Outdoor Air Intake

$$Vot = Vout/Ev \text{ (Eq. 6-8)}$$

Further calculations can be found in the Appendix attached at the end of the report. These tables contain all information from room areas, occupancy type, supply air, and max Z_p values for both of the calculated zones. See Appendix Tables 62.1-1 and 62.1-2

Outdoor Air Flow Calculation Assumptions

1. Levels 2T and 1P were used to gather an accurate representation of the building as a whole.
2. Zone populations were tabulated based on table 6-1 in ASHRAE Standard 62.1.

Results (ASHRAE 62.1 section 6)

The critical spaces found were both an elevator lobby located in relatively that same area of the building but at different levels. This was the maximum Z_p value resulting from the large default population which ASHRAE specified in table 6-1. The supply air to these spaces ended up being too low as a result. Another interesting note is the amount of cfm's for the primary supply for level 2T. The AHU for level 2T is specified to handle 11,900 cfm's. The calculations are fairly near to this value showing the unit running at an efficient level.

ASHRAE 62.1 Conclusion

From the above analyses it is safe to say that the ArNG building does a very good job of adhering to Section 5 and 6 of ASHRAE Standard 62.1. Areas for improvement would be to reanalyze Section 6 and try and account for the low ventilation rates for a few of the spaces.

ASHRAE 90.1

The purpose of the ASHRAE Standard 90.1 analysis is to determine the compliance of the ArNG building's design on minimum requirements for energy efficiency. Sections covered deal with building envelope, HVAC systems, and lighting/electrical design.

Section 5 Analysis- Building Envelope

This section specifies minimum R-Values or maximum U-Values and glazing factors based on building location.

Section 5.1.4 Climate

The ArNG site is located in Arlington, VA. From Table B-1 of ASHRAE 90.1 this site is situated in Climate Zone 4A.

Section 5.2 Compliance Paths

The glazing on the ArNG building is well over the prescribed 40% maximum value given by ASHRAE Standard 90.1. This could be easily adjusted, however the glass specified has a U-value well below the maximum and could possibly still comply with this section. The skylight fenestration area does not exceed 5% of the gross roof area, and therefore does comply with this section.

Section 5.4 Mandatory Provisions

The exterior joints on all vertical surfaces are specified to be sealed appropriately. All exterior and interior joints in vertical surfaces and non-traffic horizontal surfaces shall be sealed. Such joints included fenestration, door frames, floor/roof/wall junctions, as well as utility service openings. This will significantly minimize infiltration issues and losses.

Section 5.5 Prescriptive Building Envelope Option

Two compliance paths for fenestration exist: the prescriptive option and the trade-off option. The following table 90.1-1 sums the building envelope analysis.

Value	Minimum Roof R-Value		Minimum Wall R-Value		Fenestration Max U-Value	Percent Fenestration	Fenestration Max SHGC
Required	R-20		R-9.5		U-0.40	40%	0.4
Material	Roof Type 1	Roof Type 2	Wall Type 1	Wall Type 2	Curtain Wall 1		
Design	24	28	20	23	0.29	26400/40905=65%	0.3
Compliance	Yes	Yes	Yes	Yes	Yes	No	Yes

Table 90.1-1

The above R-values were found from the following construction materials:

Roof Type 1: This is the tower roofing material which consists of a structural concrete slab covered with a vapor barrier, sloped rigid insulation, and a single-ply waterproofing membrane with a ballast topping.

Roof Type 2: This roofing material covers the plaza level and is a green roof. This system is comprised of a structural concrete slab with a topping of concrete sloped for drainage. Included is a rubberized membrane containing clay filler, flashing membrane, polyester fabric reinforcing, fiberglass root barrier, drainage retention mat, filter fabric and a specified soil for planting.

Wall Type 1: This wall type is a combination of batter/ribbed precast concrete panels and glazed aluminum.

Curtain Wall Type 1: This system is a glaze aluminum combination with glass panels. It consists of a clear Low e glass 1/4" panel, followed by a 1/2" air space, and then another 1/4" Low e panel for a total U-Value of 0.29. See Figure 90.1-1 on page 12.

The ArNG building is in accordance with a majority of ASHRAE Standard 90.1 section 5. Both the roof and wall construction adhere to the guidelines as specified above. The only non-compliance is that of the percent fenestration allowable for vertical walls as discussed above.

Curtain Wall

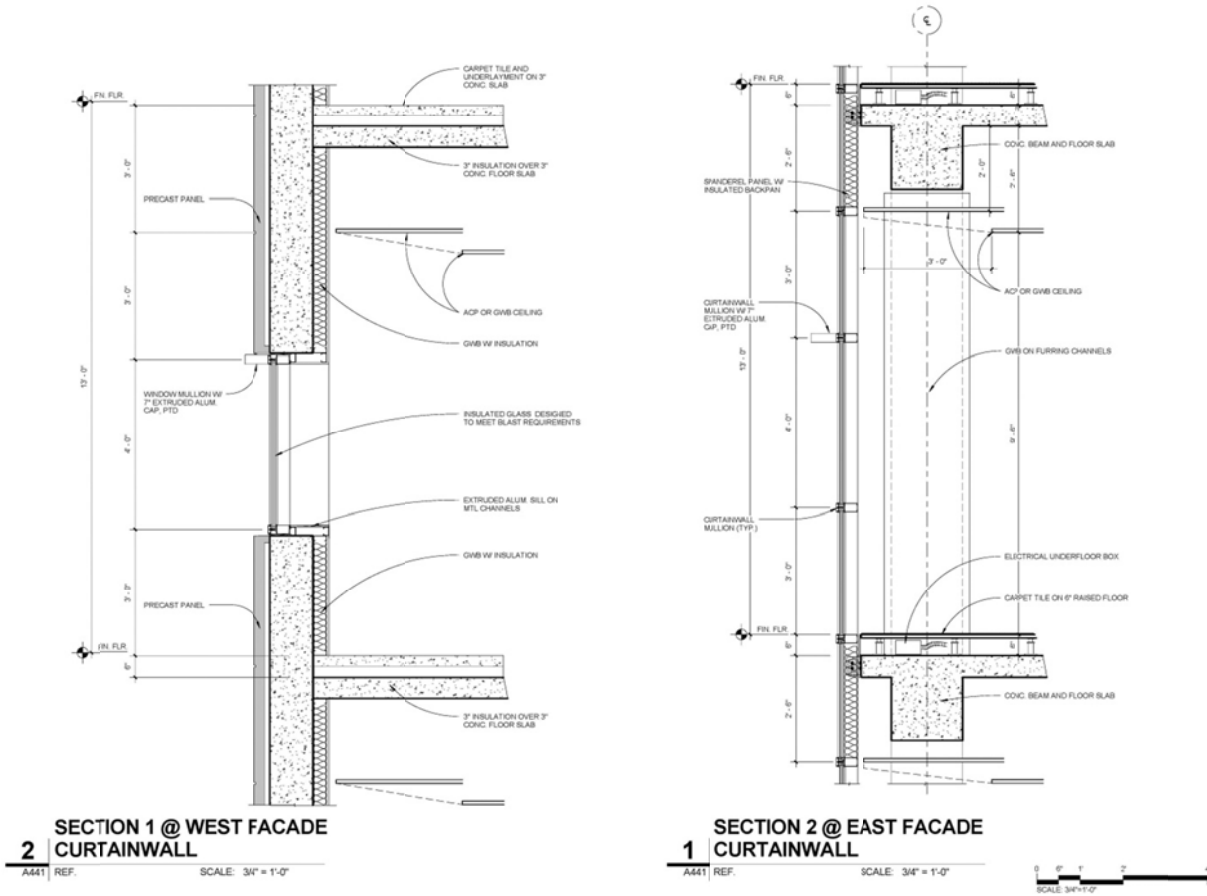


Figure 90.1-1

Section 6 Analysis- Heating Ventilating and Air Conditioning (HVAC)

This section provides minimum efficiencies of equipment to be used for HVAC systems.

Section 6.2 Compliance Path

There are two compliance paths for assessing the efficiency of the building’s HVAC system: the Simplified Approach and the Mandatory Provisions and Prescriptive Path.

Section 6.3 Simplified Approach Option for HVAC Systems

The Simplified Approach to check for compliance can only be utilized for buildings fewer than 25,000 square feet. As the ArNG building is 251,000 square feet, this approach cannot be implemented.

Section 6.4 Mandatory Provisions

Thermostatic controls stipulate the supply of heating and cooling energy to each zone individually. These controls offer an accuracy of $\pm 0.5^{\circ}\text{C}$. Automatic setbacks for minimum capacity loads have been determined and are set to come on at the end of the work day.

The use of dampers is throughout the ArNG building. These motorized dampers automatically shut when the spaces it serves are not in use.

All ductwork is sealed at the joints with either mastic sealer or slip and drive connections for a leakage of a max of 1%.

Section 6.5 Prescriptive Path

The following table 90.1-2 shows the supply fan compliance with section 6.2. Many of the supply fans meet the requirements as stipulated by standard 90.1 for fan power limitation however a few exceed the max HP allowable. These spaces are critical ones with sensitive equipment and as a result require the increased HP.

Supply Fan Compliance				
Unit	CFM(max)	HP	CFM*0.0015	Compliance HP<cfm*0.0015
AHU-3P-A1	11,800	15	17.7	Yes
AHU-3P-B1	9,500	15	14.25	No
AHU-3P-B2	2,900	5	4.35	No
AHU-3P-B3	1,650	3	2.475	No
AHU-3P-B4	12,000	15	18	Yes
AHU-3P-B5	12,000	15	18	Yes
AHU-2P-A1	11,800	15	17.7	Yes
AHU-1P-A1	13,400	20	20.1	Yes
AHU-1P-A1	9,100	7.5	13.65	Yes
AHU-1P-B1	5,700	7.5	8.55	Yes
AHU-1P-B2	5,400	7.5	8.1	Yes
AHU-1P-B3	6,400	7.5	9.6	Yes
AHU-1T-A1	11,900	15	17.85	Yes
AHU-2T-A1	11,900	15	17.85	Yes
AHU-3T-A1	11,900	15	17.85	Yes
AHU-4T-A1	11,900	15	17.85	Yes
AHU-5T-A1	12,600	20	18.9	No

Table 90.1-2

The following table 90.1-3 shows the exhaust fan power limitations for the ArNG building. All fans complied with this section.

Exhaust Fan Compliance				
Unit	CFM(max)	HP	CFM*0.0015	Compliance HP<cfm*0.0015
EF-3P-A1	200	0.25	0.3	Yes
EF-3P-A2	200	0.25	0.3	Yes
EF-3P-B1	200	0.25	0.3	Yes
EF-2P-A1	1,000	0.333	1.5	Yes
EF-1P-A1	28,000	10	42	Yes
EF-1P-A2	15,000	15	22.5	Yes
EF-1P-B1	400	0.25	0.6	Yes
EF-P-A1	14,200	7.5	21.3	Yes
EF-P-A2	9,700	5	14.55	Yes
EF-P-A3	4,500	1	6.75	Yes
EF-P-A4	3,750	1	5.625	Yes

Table 90.1-3

Section 6.7 Submittals

All HVAC systems are specified to be tested in the field to ensure that control elements are calibrated, adjusted, and in proper working condition.

Section 6.8 Minimum Equipment Efficiency Tables

There were three types of equipment tested for compliance with section 6.8. The ArNG building will use two 400 ton centrifugal chillers with a COP of 6.10. This exceeds the AHSRAE minimum of 5.50 COP.

These chillers are both connected to cooling towers with a capacity of 1,200 gpm (each) and a 25 HP fan motor. From this the design performance of the towers was calculated as 48 gpm/HP. This value clearly exceeds the 38.2 gpm/HP required by ASHRAE.

Next the CRAC units were analyzed and found to be slightly lower than the required EER values from ASHRAE.

Section 6.8 is met and exceeded for equipment efficiency ratings as seen in table 90.1-4. The CRAC units must be reassessed due to non-compliance.

Equipment Compliance				
Unit	Capacity	Required	Design	Compliance
CH-1	400 tons	5.5COP	6.10COP	Yes
CH-2	400 tons	5.5COP	6.10COP	Yes
CT-1	1200gpm @25HP	>38.3gpm/hp	48gpm/hp	Yes
CT-2	1200gpm @25HP	>38.3gpm/hp	48gpm/hp	Yes
CRAC-1P-A1	245 MBH	9.8 EER	9.8 EER	Yes
CRAC-2P-A1	140 MBH	10.8 EER	9.33 EER	No
CRAC-2P-A2	140 MBH	10.8 EER	9.33 EER	No
CRAC-3P-BA	72 MBH	11.0 EER	4.8 EER	No

Table 90.1-4

Section 7 Analysis- Service Water Heating

Discusses requirements for service water heaters and its conveyance through the building.

Service water heating for the ArNG building is supplied by 5 condenser boilers. These boilers are 98% efficient which meet and exceed the ASHRAE minimum requirements of 80% for a gas fired boiler being used for service water heating.

Section 9 Analysis- Lighting

Contains information on the required power distribution and density for lighting systems.

There are two ways to calculate Lighting Power Density:

1. Find the total wattage serving the lighting and divide by the square footage of the building or
2. Calculate the density for each space and compare this to a specified density based on occupancy type. The first method yielded the following given in Table 90.1-5

Lighting Power Density				
Level	Total Watts	W/SF	ASHRAE W/SF	Compliance
2T	9011	0.5713	1	Yes
3P	24109	0.4818	1	Yes

Table 90.1-5

ASHRAE 90.1 Conclusion

The ArNG Readiness Center Addition was design very efficiently. The building is expected to reach a LEED Silver rating and this can easily be done with the appropriate use of equipment. From this analysis it was shown that much of the specified equipment is far more efficient than the requirements of ASHRAE Standard 90.1.

It was determined that the building is compliant with this standard with a few exceptions. First is the CRAC equipment compliance yielding EER values lower than desired. The second non-compliance deals with the percent of fenestration which was much larger than ASHRAE prescribed. With that said, a few minor changes could go a long way to allowing this building to truly achieve its LEED certification.

References

ASHRAE. 2007, ANSI/ASHRAE, Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality. American Society of Heating Refrigeration and Air-Conditioning Engineers, Inc., Atlanta, GA.

ASHRAE. 2007, ANSI/ASHRAE, Standard 90.1-2007, Energy Standard for Building Except Low-Rise Residential Buildings. American Society of Heating Refrigeration and Air-Conditioning Engineers, Inc., Atlanta, GA.

Appendix A

The following is the calculation spreadsheet used to check for compliance of ASHRAE Standard 62.1 Section 6. These tables show the two zones which were analyzed, level 2T and Level 3P respectively. As follows is all the appropriate spaces and their corresponding square footage, occupancy, and supply air.

Also attached is the lighting schedule used to calculate the lighting power density. These tables represent all of the lighting components on the levels 2T as well as 3P.

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Building:		Army National Guard Readiness Center Addition	
System Tag/Name:		Level 1P(AHU-1P-A1 A2,8a,82,83)	
Operating Condition Description:		IP	
Units (select from pull-down list)			
Inputs for System			
Floor area served by system	Name	Units	System
Population of area served by system (including diversity)	As	SF	42342
Design primary supply fan airflow rate	Pz	CFM	576
CA req'd per unit area for system (Weighted average)	Vpzd	CFM	32.340
CA req'd per person for system area (Weighted average)	Rps	CFM/sqft	0.05
	Rps	CFM/sqft	0.7
Inputs for Potentially Critical zones			
Zone Name	Zone file name (purple text for critical zones)		
Zone Tag			
Space type	Selected from pull-down list		
Floor Area of zone	Az	SF	
Design population of zone	Pz	P	(default value listed, may be overridden)
Design total supply to zone (primary plus local recirculated)	Vztd	CFM	
Induction Terminal Unit, Dual Fan Dual Out or Transfer Fan?	Vztd	CFM	Selected from pull-down list or leave blank if N/A
Local recirc. air % representative of zone system return air	Er	%	
Inputs for Operating Condition Analyzed			
Percent of total design airflow rate at conditioned analyzed	Ds	%	
Air distribution type at conditioned analyzed	Ez		Selected from pull-down list
Zone air distribution effectiveness at conditioned analyzed	Ez		
Primary air fraction of supply air at conditioned analyzed	Ep		
Results			
Ventilation System Efficiency	EV		WVALUE Critical zone needs more ventilation
Outdoor air intake required for system	Vot	CFM	WVALUE
Outdoor air per unit floor area	Vot/Az	CFM/sqft	WVALUE
Outdoor air per person served by system (including diversity)	Vot/Ps	CFM/sqft	WVALUE
Outdoor air as a % of design primary supply air	Vot/Ds	%	WVALUE
Detailed Calculations			
Initial Calculations for the System as a whole			
Primary supply air flow to system at conditioned analyzed	Vps	CFM	= Vpzd/Ds = 32340
Uncorrected CA requirement for system	Vou	CFM	= Rps Ps + Rps As = 5994
Uncorrected CA req'd as a fraction of primary SA	Xs		= Vou/Vps = 0.19
Initial Calculations for Individual Zones			
CA rate per person	Raz	CFM/sqft	
Total supply air to zone (at condition being analyzed)	Vztd	CFM	
Unused OA req'd to breathing zone	Vztd	CFM	Critical zone needs more ventilation
Unused OA requirement for zone	Vztd	CFM	= Vpzd/Ez - Raz Az =
Fraction of zone supply not directly recirc. from zone	Fa		= Vztd/Ez
Fraction of zone supply from fully mixed primary air	Fp		= Ep + (1-Ep)Er
Fraction of zone CA not directly recirc. from zone	Fz		= 1 - (1-Ep)(1-Er)
Unused OA fraction required in supply air to zone	Zd		= Vztd/Vztd
Unused OA fraction required in primary air to zone	Zp		=
System Ventilation Efficiency			
Zone Ventilation Efficiency (App A Method)	Ez		= (Fz + FpXs - FzZ) / Fz = (0.27)
System Ventilation Efficiency (App A Method)	Ev		= min (Ez) = 0.27
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 = 0.27
Minimum outdoor air intake airflow			
Outdoor Air Intake Flow required to System	Vot	CFM	= Vou / Ev = No Solution
CA intake req'd as a fraction of primary SA	Y		= Vou / Vps = Would need over 100% OA intake
Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	CFM	= Vou / Ev = 0.27
CA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		= Vou / Vps = 0.27
OA Temp at which Min OA overrides all cooling			
OA1 below which OA intake flow is minimum	Deg F		= ((Tb-DTb)-(1-Y)Tt+DTd) = #VALUE!

Building: Army National Guard Readiness Center Addition System Tag/Name: Level 1P(AHU-1P-A1A2.Ba.B3) Operating Condition Description: Units (select from pull-down list)		System 42342 5/75 32.340 0.05 5.7	
Inputs for System Floor area served by system Population of area served by system (including diversity) Design primary supply fan airflow rate OA req'd per unit area for system (Weighted average) OA req'd per person for system area (Weighted average)		Name Units Ag sf Pa p Vpsd cfm Rss cfm/sf Rps cfm/y	
Inputs for Potentially Critical zones Zone Name Zone Tag Space type Floor Area of zone Design population of zone Design total supply to zone (primary plus local recirculated) Induction Terminal Unit, Dual Fan Dual Out or Transfer Fan? Local recirc air % representative of ave system return air		Zone Name Units Az sf Pz p Vzd cfm Et Ds % Ez Selected from pull-down list Ep	
Inputs for Operating Condition Analyzed Percent of total design airflow rate at conditioned analyzed Air distribution type at conditioned analyzed Zone air distribution effectiveness at conditioned analyzed Primary air fraction of supply air at conditioned analyzed		Ds % Ez Selected from pull-down list Ep	
Results Ventilation System Efficiency Outdoor air intake required for system Outdoor air per unit floor area Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air		EV #VALUE! Vot cfm Vot/s cfm/sf Vot/Ps cfm/y Vpd cfm #VALUE! #VALUE! #VALUE!	
Detailed Calculations Initial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed Uncorrected OA requirement for system Uncorrected OA req'd as a fraction of primary SA		Vps cfm = Vpd/Ds = 32340 Vsu cfm = Rps Ps + Rss As = 5994 Xs = Vsu/Vps = 0.19	
Initial Calculations for Individual Zones OA rate per unit areas for zone Total supply air to zone (at condition being analyzed) Unused OA req'd to breathing zone Unused OA requirement for zone Fraction of zone supply not directly recirc. from zone Fraction of zone supply from fully mixed primary air Fraction of zone OA not directly recirc. from zone Unused OA fraction required in supply air to zone Unused OA fraction required in primary air to zone		Rsz cfm/sf Rsz cfm Vbz cfm Vbz cfm Fa = Vbz/Ez Ep = (1-Eg)E Fg = 1-(1-Eg)(1-Ep)(1-Er) Zg = Vbz/Vbz Zp = Vbz/Vbz Critical zone needs more ventilation	
System Ventilation Efficiency Zone Ventilation Efficiency (App A Method) System Ventilation Efficiency (App A Method) Ventilation System Efficiency (Table 6.3 Method)		Evz = (Fa + FRbx - Fez) / Fa = (0.27) Ev = min(Evz) Value from Table 6.3 = r/s	
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OA Temp at which Min OA exceeds all cooling OAT Device which OA intake flow is minimum		Deg F = ((Tpd-cfm)(1-V) + TindTid) = #VALUE!	

Building: System Tag/Name: Operating Condition Description: Units (select from pull-down list)		Army/National Guard Readiness Center Addition Level 1P/AHU-1P-A1,A2,Ba,B2,B3 1P																																																																																																																																																																																																																	
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Building: Army National Guard Readiness Center Addition System TagName: Level 1P(AHU-1P-A1,A2,Ba,B2,B3) Operating Condition Description: Units (select from pull-down list)			
Inputs for System Floor area served by system Population of area served by system (including diversity) Design primary supply fan airflow rate OA req'd per unit area for system (Weighted average) OA req'd per person for system area (Weighted average)		Name Units As sf <input type="text" value="100%"/> diversity Ps p <input type="text" value="5.75"/> Vpzd cfm Ras cfm/sf Rps cfm/sq ft	System #VALUE! #VALUE! 32,340 0.09 5.7
Inputs for Potentially Critical Zones Zone Name Zone Tag Space type		Zone #/s turns purple table for critical zones(s)	
Floor Area of zone Design population of zone Design total supply to zone (primary plus local recirculated) Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan? Local recirc. air % (representative of area system return air)		Az sf Selected from pull-down list Pz p (default value listed; may be overridden) Vzd cfm Selected from pull-down list or leave blank if N/A Er %	Fitness Cen. P141 Health club/weight rooms 1,966 13.68 900
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OA Terms at which Min OA provides all cooling DAT below which OA intake flow is @ minimum			

Building:		Army National Guard Readiness Center Addition	
System Tag Name:		Level 21(AHU-21-A1)	
Operating Condition Description:		Unit tested from pull-down list	
Input for System		Name	Units
Floor area served by system		As	sf
Population of area served by system (including diversity)		Ps	P
Design primary supply fan airflow rate		Vpsd	cm ³ /s
OA req'd per unit area for system (Weighted average)		Ras	cm ³ /sf
OA req'd per person for system area (Weighted average)		Rps	cm ³ /p
Input for Potentially Critical Zones		Zone Area Served (sq ft)	
Zone Name		Zone Tag	
Space type		Select from pull-down list	
Floor Area of zone		Az	sf
Design population of zone		Pz	P
Design total supply to zone (primary plus local recirculated)		Vzsd	cm ³ /s
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Vzsd	cm ³ /s
Local recirc. air % representative of ave system return air		Er	%
Input for Operating Condition Analyzed		Ds	%
Percent of total design airflow rate at conditioned analyzed		Ez	Select from pull-down list
Air distribution type at conditioned analyzed		Ed	Select from pull-down list
Zone air distribution effectiveness at conditioned analyzed			
Primary air fraction of supply air at conditioned analyzed			
Results		EV	0.28
Ventilation System Efficiency		Vot	7898
Outdoor air intake required for system		Vol/As	0.60
Outdoor air per unit floor area		Vol/Ps	37.4
Outdoor air per person served by system (including diversity)		Vol/Ps	37.4
Outdoor air as a % of design primary supply air		Vol/d	88%
Detailed Calculations		Initial Calculations for the System as a Whole	
Primary supply air flow to system at conditioned analyzed		Vps	cm ³ /s
Uncorrected OA requirement for system		Vou	cm ³ /s
Uncorrected OA req'd as a fraction of primary SA		Xs	0.18
Initial Calculations for Individual Zones		OA rate per unit area for zone	
Total supply air to zone (at condition being analyzed)		Raz	cm ³ /sf
OA rate per person		Roz	cm ³ /p
Unused OA req'd to breathing zone		Voz	cm ³ /s
Unused OA requirement for zone		Voz	cm ³ /s
Fraction of zone supply not directly recirc. from zone		Fz	
Fraction of zone supply from fully mixed primary air		Fp	
Unused OA fraction recirc. from zone		Fc	
Unused OA fraction required in supply air to zone		Zd	
Unused OA fraction required in primary air to zone		Zo	
System Ventilation Efficiency		Ez	
Zone Ventilation Efficiency (App A Method)		Ez	
System Ventilation Efficiency (App A Method)		Ev	0.28
Ventilation System Efficiency (Table 5.3 Method)		Ev	n/a
Minimum outdoor air intake airflow		Value from Table 5.3	
Outdoor Air Intake Flow required to System		Vou / Ev	7898
OA intake req'd as a fraction of primary SA		Vou / Vps	0.60
Outdoor Air Intake Flow required to System (Table 5.3 Method)		Vou / Ev	n/a
OA intake req'd as a fraction of primary SA (Table 5.3 Method)		Vou / Vps	n/a
OA Terms at Which Min. OA Intake Flow is @ minimum		Deg F	47
			(T _{ps} -T _{tr})/(T _{ps} -T _{tr})

System	Units	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units	Value	Units
15,772	sf	100%	diversity	11,545	cm ³ /p	0.05	0.12	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
212	P	0	cm ³ /s	575	cm ³ /s	0.00	0.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
11,545	cm ³ /s	1.00	cm ³ /sf	7.8	cm ³ /s	275.4	cm ³ /s	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4
0.05	cm ³ /p	0	cm ³ /p	7	cm ³ /p	275	cm ³ /p	20	20	20	20	20	20	20	20	20	20	20	20
5.0	cm ³ /p	0	cm ³ /p	8	cm ³ /p	275	cm ³ /p	20	20	20	20	20	20	20	20	20	20	20	20
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
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		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
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		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
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		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
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		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%	1.00	%
		100%	%	1.00	%	1.00	%	1.00	%	1.00	%								

Building: Army National Guard Readiness Center Addition System TagName: Level 2T(AHU-2T-A1) Operating Condition Description: Units tested from pull-down list Units tested from pull-down list		<table border="1"> <tr> <th colspan="2">System</th> </tr> <tr> <td>Name</td> <td>System</td> </tr> <tr> <td>As</td> <td>15,772</td> </tr> <tr> <td>Ps</td> <td>212</td> </tr> <tr> <td>Vps</td> <td>11,648</td> </tr> <tr> <td>Rps</td> <td>0.06</td> </tr> <tr> <td>Rps</td> <td>5.0</td> </tr> </table>		System		Name	System	As	15,772	Ps	212	Vps	11,648	Rps	0.06	Rps	5.0										
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OA Terms at which Min. OA exceeds all conditions OAT below which OA intake flow is @ minimum																											

Tabulations for Lighting Power Density

Level 3P			
Fixture	Amount	Watts/per fixture	Total Watts
KA	70	38	2660
KA-1	24	76	1824
KA-D	12	41	492
KA-1D	3	76	228
KB	115	29	3335
KB-D	23	29	667
KC	65	41	2665
KD	32	62	1984
KD-1	7	41	287
KD-2	1	33	33
KD-D	3	62	186
KF	6	46	276
KI	33	29	957
KI-D	57	31	1767
KJ	5	33	165
KL	2	36	72
KL-D	4	36	144
KP	11	33	363
KQ	7	20	140
KR	16	62	992
KR-1	4	41	164
KS	3	62	186
KS-D	15	62	930
K2	13	9	117
K3	11	9	99
L2	8	41	328
A	42	32	1344
B	14	32	448
C	2	32	64
D	3	32	96
F	5	32	160
H	9	104	936
		Total watts:	24109
		Total SF:	15772
		WATTS/SF:	1.53

Level 2T			
Fixture	Amount	Watts/per fixture	Total Watts
KA	29	38	1102
KA-1	6	76	456
KB	34	29	986
KC	31	41	1271
KC-1	5	41	205
KD	25	62	1550
KD-1	9	41	369
KD-D	5	62	310
KE	2	33	66
KI	17	29	493
KL	1	36	36
KL-D	4	36	144
KP	7	33	231
KQ	6	20	120
KR	5	62	310
KR-1	4	41	164
KS-D	5	62	310
K2	13	9	117
K3	11	9	99
A	11	32	352
B	6	32	192
C	1	32	32
F	3	32	96
		Total watts:	9011
		Total SF:	15772
		WATTS/SF:	0.5713