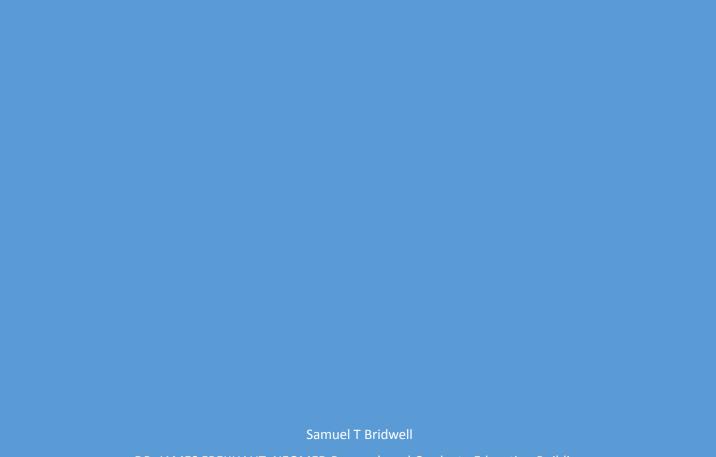
September 18, 2014

TECHNICAL REPORT ONE: ASHRAE STANDARDS 62.1 AND 90.1 EVALUATION



DR. JAMES FREIJHAUT NEOMED Research and Graduate Education Building

Table of Contents

Executive Summary	2
Building Overview	3
Mechanical Systems Overview	4
ASHRAE Standard 62.1.5-2013 Evaluation	5
ASHRAE Standard 62.1.6-2013 Evaluation	9
ASHRAE Standard 90.1-2013 Evaluation	11
References	13
Appendix	14

Executive Summary

This Report is an evaluation of the NEOMED Research and Graduate Education and Comparable Medical Unit with respect to ASHRAE Standards 62.1 and 90.1. The Project is located on the Northeast Ohio Medical University campus, at 4209 Ohio 44, Rootstown, Ohio. The facility is used for graduate-level research and education in the medical field, with laboratories, operating rooms, a vivarium, and numerous biological support spaces. The project was completed in August 2013.

Through investigation of the standards, The RGE and CMU addition are generally up to code. However, there are a number of opportunities to improve efficiency concerning ventilation rates for non-research areas and energy recovery from exhaust.

Building Overview

The project is comprised of three additions to the NEOMED campus. The main addition is the Research and Graduate Education Center, a four-story 63,000 square foot biomedical research building. The first three floors are fully built out with laboratories, support rooms, and offices, while the top floor is shelled in and will be built out as the research program grows. There is a 6,000 square foot basement to house stand-alone utilities.

The second component is a 14,500 square foot addition to the Comparable Medical Unit, which provides animal care services. Lastly, several existing laboratories in Building D were renovated.

Mechanical Systems Overview

Campus Utilities will not be utilized for this project; there is a stand-alone system of chillers, medium pressure steam generators, and hot water boilers located in the basement area of the addition. The RGE Building has two 100% outside air handling units each sized at 50,000 CFM respectively and a smaller 28,000 CFM office unit with return air. The CMU has its own 35,000 CFM 100% outdoor air unit as well.

ASHRAE Standard 62.1-2013 Evaluation

ASHRAE 62.1 Section 5: Systems and Equipment

5.1 Ventilation Air Distribution

The RGE, CMU and Building D are all in compliance with Section 5.1. The laboratories, support rooms, vivarium, and other such rooms are supplied with 100% outdoor air, therefore the airflow needed for proper conditioning easily exceeds ventilation requirements. The design documents all have appropriate information for balancing and minimum airflow allowed.

5.2 Exhaust Duct Location

Documents indicate that all exhaust duct runs are negatively pressurized relative to the supply duct runs in each room. The lab exhaust runs through two custom air handling units each at 50,000 CFM. Smaller exhaust fans are located above the office wings, and space is allotted for exhaust fans to be placed for future expansion.

5.3 Ventilation System Controls

The RGE building and the CMU addition each have an independent direct digital control systems interfaced with existing campus network. The system accomplishes all sensing and controlling via electronic actuation of all valves and dampers.

5.4 Air Stream Surfaces

All airstream surfaces are comprised of sheet metal ductwork with metal fasteners to comply with requirements for resistance to mold growth and erosion.

5.5 Outdoor Air Intakes

Outdoor air intake for office end of the RGE building is located on the east face of AHU-3. The outdoor air intake of the laboratory air handlers is located on the north face of the supply air tunnel. All outdoor air intakes are well outside of the required distances; the exhaust stacks for the lab exhaust are 25 feet high per 62.1 Table 5.5.1, giving plenty of distance for the class 4 air to discharge. In addition, each inlet is protected by a mesh screen and louvers to protect from rain, snow, and birds. All AHU's on the project are equipped with access doors for maintenance purposes.

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

TABLE 5.5.1 Air Intake Minimum Separation Distance

Note 1: This requirement applies to the distance from the outdoor air intakes for one ventilation system to the exhaust/relief outlets for any other ventilation system.

Note 2: Minimum distance listed does not apply to laboratory fume hood exhaust air outlets. Separation criteria for fume hood exhaust shall be in compliance with NFPA 45⁵ and ANSI/ AIHA Z9.5.⁶ Information on separation criteria for industrial environments can be found in the ACGIH Industrial Ventilation Manual⁷ and in ASHRAE Handbook—HVAC Applications.⁸

Note 3: Shorter separation distances shall be permitted when determined in accordance with (a) ANSI Z223.1/NFPA 54⁹ for fuel gas burning appliances and equipment, (b) NFPA 31¹⁰ for oil burning appliances and equipment, or (c) NFPA 211¹¹ for other combustion appliances and equipment.

Note 4: Distance measured to closest place that vehicle exhaust is likely to be located

Note 5: Shorter separation distance shall be permitted where outdoor surfaces are sloped more than 45 degrees from horizontal or that are less than 1 in. (30 mm) wide.

Note 6: Where snow accumulation is expected, the surface of the snow at the expected average snow depth constitutes the "other surface directly below intake."

Figure 1 (Source: ASHRAE 62.1-2013)

5.6 Local Capture of Contaminants

All areas with equipment that generate contaminates, such as labs and restrooms, have exhaust to capture contaminates and direct outdoors away from any intake openings.

5.7 Combustion Air

All laboratory spaces are equipped with fume hoods for removal of any potential combustion products.

5.8 Particulate Matter Removal

Supply air tunnels have a MERV-9 pre-filter and a MERV-14 after-filter within each air handler. Heat recovery coils within exhaust tunnels have MERV-9 pre-filters. Also, room-side replaceable "filter grilles" are used for exhaust of the animal holding room in the CMU. All of these meet the minimum ASHRAE standard of MERV-8 filtration.

5.9 Dehumidification Systems

Lab and support spaces are designed at 35% humidity in winter and 50% humidity in summer. The vivarium is designed at 30-40% winter humidity and 50% summer humidity. These are all less than the required 65% maximum. Regarding section 5.9.2, the RGE has two custom air handling units, with both supply and exhaust at 37,500 CFM for 100% outdoor air intake. The CMU addition has an 85,000 CFM supply and exhaust in a similar fashion.

5.10 Drain Pans

No mention of drain pans is given in the specifications

5.11 Finned-Tube Coils and Heat Exchangers

Plate and frame heat exchangers are utilized on this project rather than finned-tube heat exchangers

5.12 Humidifiers and Water-Spray Systems

The project utilizes Nortec NH series electrode steam humidifiers which are specified to use potable water and drain pans per ASHRAE standard.

5.13 Access for Inspection, Cleaning, and Maintenance

Sufficient access to HVAC equipment has been designed.

5.14 Building Envelope and Interior Surfaces

Architectural wall sections such as Figure 2 indicate a building envelope with rigid insulation, moisture barriers, and batt insulation between studs.

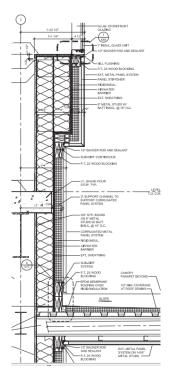


Figure 2: architectural wall section

5.15 Buildings with Attached Parking Garages

Building has no attached parking garages, therefore section 5.15 does not apply.

5.16 Air Classification and Recirculation

The laboratories, animal operating rooms, and various technical support spaces are all Class 2 air per Table 6.2.2.1. However, it is important to note that the airstreams from any of the fume hoods is Class 4 as stated by Table 5.16.1. All other areas such as conference rooms and offices are Class 1 air. As stated before, the laboratory and animal care areas are operating on 100% outdoor air with no recirculation. The Class 1 rooms all recirculate air via return ducts. It is also important to note that the biosafety cabinet fume hoods shall recirculate 100% back into the procedure rooms.

5.17 ETS Air

Smoking is not allowed in any part of the building; 5.17 does not apply.

Conclusion

The Buildings are in compliance with all ventilation requirements prescribed by ASHRAE Standard 62.1.5-2013. This is not surprising given the majority of zones require 100% outdoor air and sensitive humidity control due to the research activities conducted within them.

ASHRAE 62.1 Section 6: Procedures

6.1 General

The site's outdoor air has no contamination issues and is deemed acceptable for ventilation purposes. Proper ventilation rates are hereby calculated via the prescriptive Ventilation Rate Procedure and the Exhaust Rate Procedure and compared to the existing design specifications. No natural ventilation strategies are used in the design.

6.2 Ventilation Rate Procedure

A preconfigured excel spreadsheet was used to calculate ventilation needed for the offices and conference rooms to the east end of the RGE building, covered by AHU-3. In this project, this was the only air handler configuration that was not configured for 100% outdoor air intake. The breakdown from the spreadsheet calculations is located in Appendix A.

First, breathing zone outdoor air flow rates are calculated with Equation 6-1 from ASHRA 62.1-2013 for each room

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

Where R_p is outdoor airflow rate per person, P_z is zone population by occupancy class, R_a is outdoor airflow rater per area, and A_z is the area covered by the zone. Table 6-1 of ASHRAE Standard 62.1-2013 contains values for both R_p and R_a , and is referenced by the spreadsheet.

The next step is to find and factor in the zone air distribution effectiveness E_z, found in Table 6-2. In all instances examined, supply air was delivered via ceiling diffusers at cooling temperature, so E_z was 1.0 all around. These values are also referenced in the spreadsheet in Appendix A.

After entering area and airflow data from the drawings, the total supply airflow amounted to roughly 19,600 CFM. This is slightly less than the design value for AHU-3 of 28,000 CFM. Table 1 below gives a breakdown of total system ventilation.

Results						
	Ventilation System Efficiency	Ev				0.80
	Outdoor air intake required for system	Vot	cfm			1609
	Outdoor air per unit floor area	Vot/As	cfm/sf			0.17
	Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p			12.1
	Outdoor air as a % of design primary supply air	Ypd	cfm			8%

Table 1:AHU-3 Ventilation Breakdown

Also, tallying up the individual zones indicates a surplus of 1294 CFM of unneeded outdoor air and a maximum Z_p value of .26. This could present an opportunity for energy savings.

Conclusion

As a science and research facility, the RGE and CMU buildings by necessity have large turnover in airflow. The analysis shows that even in the minority of non-research zones there are moderate energy savings to be had. There are likely even greater savings to be had if one examines the heat recovery methods used for the rest of the project.

ASHRAE Standard 90.1-2013 Evaluation

Section 5: Building Envelope

5.1 General

As shown by Figure B1-1 in ASHRAE Standard 90.1-2013 Section 5.1.4, the project's location in Rootstown, Ohio places it in the 5A Climate Zone, a relatively cool, moist region.

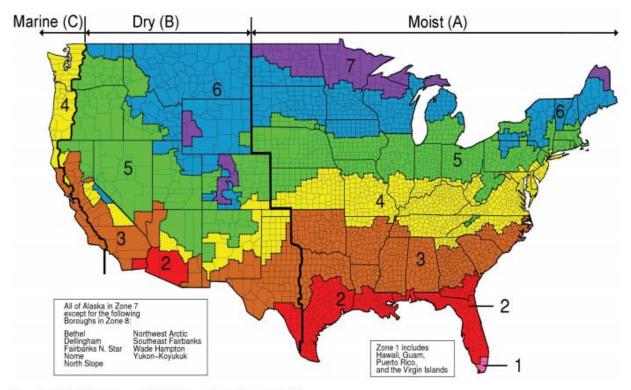


Figure B1-1 U.S. climate zone map (ASHRAE Transactions, Briggs et al., 2003).

5.2 Compliance Paths

Here we will elect to use the prescriptive evaluation for the building envelope outline in Section 5.5 of the code.

5.4 Mandatory Provisions

The building is constructed with a continuous air and water membrane throughout the entirety of the envelope. In addition, the entrances to the RGE and CMU have vestibules per section 5.4.3.4 of the code.

5.5 Prescriptive Building Envelope Option

Insulation values for the envelope are not available, making the envelope difficult to access. More information finding will be required.

Section 6: Heating, Ventilation, and Air Conditioning

6.4 Mandatory Provisions

The prescriptive path outlined in Section 6.4 of Standard 90.1-2013 shall be followed as the building project does not meet the size criteria for the simplified approach outlined in Section 6.3. All equipment meets efficiency standards outlined in the tables of Section 6.8 and load calculations were conducted in the program Chvac 7 in accordance with ASHRAE Standards. The DDC system mentioned in the Standard 62.1.5.3-2013 controls all equipment in accordance with Standard 6.4.3.

6.5 Prescriptive Path

AHU-3 is outfitted with an economizer in accordance with code Section 6.5.1. The automatic temperature control system governs the zone controls via digital sensors and actuators. Also, given the data presented in the analysis of Standard 62.1.6.2 the amount of outdoor air utilized by the office air handler is less than the amount needed to require energy recovery equipment. However, the two AHU's feeding the labs of the RGE and the AHU feeding the CMU expansion use heat pipes with refrigerant to transfer heat from the exhaust stream to the supply stream during heating season, and vice versa during the cooling season.

Section 7: Service Water Heating

Domestic water service is piped through water softeners with a duplex water system to provide adequate pressure for lab fixtures. Hot water will be provided via duplex 250 gallon condensing water heaters. This equipment is of proper efficiency per standard 7.8.

Section 8: Power

This project has a new main electrical service made up of a single ended normal power switchboard, diesel emergency generator, branch automatic transfers and an optional standby distribution system. Feeders are sized within the required voltage drop of 2% and branch circuits are sized to no more that 3% voltage drop.

Section 9: Lighting

All lighting on the project is automatically switched off via low voltage relays or occupancy sensors. Multi-level switch control is provided in perimeter areas to reduce intensity of light during daylight hours.

Section 10: Other Equipment

None of the equipment mentioned in Section 10 applies to the project.

Conclusion

The Research and Graduate Education Building and the expansion of the Comparable Medical Unit are up to energy code. This is not surprising, given the fact that the building was completed only one year ago to this report and is a very advanced technical project.

<u>References</u>

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Bard, Rao + Athanas Consulting Engineers, LLC. MEP Schematic Narratives. BR+A, Boston, MA

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TC Architects Inc. Architectural Construction Documents. TC Architects, Akron, Ohio

<u>Appendix</u>

Building:	NEOME	D Bassa	ch and Graduate Education C	ontor							
System Tag/Name:	AHU-3	D Resea	ch and Graduate Education C	enter							
Operating Condition Description:		oling Da	,								
Units (select from pull-down list)	IP	Joining Da									
Inputs for System	Name	<u>Units</u>		System							
Floor area served by system	As	sf		9671							
Population of area served by system (including diversity)	Ps	Р	100% diversity	132							
Design primary supply fan airflow rate	Vpsd	cfm		19,600							
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.06							
OA req'd per person for system area (Weighted average)	Rps	cfm/p		5.3							
nputs for Potentially Critical zones											
Zone Name	_				offices	offices	copy room	Conference	Office	IMS Director	open office reception
7	Zone tit	tle turns p	Irple italic for critical zone(s)			000	004	0.05		0.07	200
Zone Tag					362	363	364	365	366	367	369
Space type		Select fr	om pull-down list		Office space	Office space	Office space	Conference/m eeting	Office space	Office space	Reception areas
Floor Area of zone	Az	sf			426	426	155	100	142	174	155
Design population of zone	Pz	Р	(default value listed; may be ove	erridden)	2.13	2.13	0.775	5	0.71	0.87	4.65
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			675	600	275	150	375	275	225
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select fr	om pull-down list or leave blank	if N/A	ITU	ITU	ITU	ITU	ITU	ITU	ITU
Local recirc. air % representative of ave system return air	Er				75%	75%	75%	75%	75%	75%	75%
puts for Operating Condition Analyzed											
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select fr	om pull-down list		CS	CS	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep				100%	100%	100%	100%	100%	100%	100%
sults											
Ventilation System Efficiency	Ev			0.80							
Outdoor air intake required for system	Vot	cfm		1609							
Outdoor oir por unit floor area											
Outdoor air per unit floor area	Vot/As	cfm/sf		0.17							
Outdoor air per unit floor area Outdoor air per person served by system (including diversity)	Vot/As Vot/Ps			0.17 12.1							
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air	Vot/Ps	cfm/p		12.1							
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Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air tailed Calculations tial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed UncorrectedOA requirement for system Uncorrected OA requirement for system Uncorrected OA requirement for system OA rate per unit area for zone	Vot/Ps Ypd Vps Vou Xs Raz	cfm/p cfm cfm cfm cfm/sf	= Rps Ps + Ras As	12.1 8% = 19600 = 1294		5.00	5.00				
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air tailed Calculations tial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed UncorrectedOA requirement for system Uncorrected OA requi as a fraction of primary SA tial Calculations for individual zones OA rate per unit area for zone OA rate per person	Vot/Ps Ypd Vps Vou Xs Raz Rpz	cfm/p cfm cfm cfm cfm/sf cfm/p	= Rps Ps + Ras As	12.1 8% = 19600 = 1294	5.00	5.00 600	5.00 275	5.00	5.00	5.00	5.00
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air tailed Calculations tial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed UncorrectedOA requirement for system Uncorrected OA reqid as a fraction of primary SA tial Calculations for individual zones OA rate per unit area for zone OA rate per person Total supply air to zone (at condition being analyzed)	Vot/Ps Ypd Vps Vou Xs Raz Rpz Vdz	cfm/p cfm cfm cfm cfm/sf cfm/p cfm	= Rps Ps + Ras As = Vou / Vps	12.1 8% = 19600 = 1294 = 0.07	5.00 675	5.00 600	5.00 275 13.2	5.00 150	5.00 375	5.00 275	5.00 225
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air tailed Calculations tial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed UncorrectedOA requirement for system Uncorrected OA reqid as a fraction of primary SA tial Calculations for individual zones OA rate per unit area for zone OA rate per person Total supply air to zone (at condition being analyzed) Unused OA req'd to breathing zone	Vot/Ps Ypd Vou Xs Raz Rpz Vdz Vbz	cfm/p cfm cfm cfm cfm/sf cfm/p cfm cfm	 Ps Ps + Ras As Vou / Vps Rpz Pz + Raz Az 	12.1 8% = 19600 = 1294 = 0.07 =	5.00 675 36.2	5.00 600 36.2	5.00 275 13.2 13	5.00 150 31.0	5.00 375 12.1	5.00 275 14.8	5.00 225 32.6
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Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air tailed Calculations ial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed UncorrectedOA requirement for system Uncorrected OA req'd as a fraction of primary SA ial Calculations for individual zones OA rate per unit area for zone OA rate per person Total supply air to zone (at condition being analyzed) 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	Vot/Ps Ypd Vou Xs Raz Rpz Vdz Voz Voz Fa Fb	cfm/p cfm cfm cfm cfm/sf cfm/p cfm cfm	 Rps Ps + Ras As Vou / Vps = Rpz Pz + Raz Az Vbz/Ez Ep + (1-Ep)Er Ep 	12.1 8% = 19600 = 1294 = 0.07 = = = =	5.00 675 36.2 36 1.00 1.00	5.00 600 36.2 36 1.00 1.00 1.00	5.00 275 13.2 13 1.00 1.00 1.00	5.00 150 31.0 31 1.00 1.00	5.00 375 12.1 12 1.00 1.00	5.00 275 14.8 15 1.00 1.00	5.00 225 32.6 33 1.00 1.00
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air etailed Calculations itial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed Uncorrected OA requirement for system Uncorrected OA requirement for system Uncorrected OA requirement for system OA rate per unit area for zone OA rate per unit area for zone OA rate per person Total supply air to zone (at condition being analyzed) 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	Vot/Ps Ypd Vou Xs Raz Rpz Vdz Vdz Vbz Voz Fa Fb Fc Zd	cfm/p cfm cfm cfm cfm/sf cfm/p cfm cfm	 Rps Ps + Ras As Vou / Vps Rpz Pz + Raz Az Vbz/Ez Ep + (1-Ep)Er Ep 1-(1-Ez)(1-Ep)(1-Er) Voz / Vdz 	12.1 8% = 19600 = 1294 = 0.07 = = = = =	5.00 675 36.2 36 1.00 1.00 1.00 0.05	5.00 600 36.2 36 1.00 1.00 1.00	5.00 275 13.2 13 1.00 1.00 1.00 0.05	5.00 150 31.0 1.00 1.00 1.00 0.21	5.00 375 12.1 12 1.00 1.00 1.00	5.00 275 14.8 15 1.00 1.00 1.00 0.05	5.00 225 32.6 33 1.00 1.00 1.00 0.14
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air tailed Calculations tial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed Uncorrected OA requirement for system Uncorrected OA requirement for system Uncorrected OA requirement for zone OA rate per unit area for zone OA rate per person Total supply air to zone (at condition being analyzed) 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	Vot/Ps Ypd Vou Xs Raz Rpz Vdz Vdz Voz Fa Fb Fc	cfm/p cfm cfm cfm cfm/sf cfm/p cfm cfm	 = Rps Ps + Ras As = Vou / Vps = Rpz Pz + Raz Az = Vbz/Ez = Ep + (1-Ep)Er = Ep = 1-(1-Ez)(1-Ep)(1-Er) 	12.1 8% = 19600 = 1294 = 0.07 = = = = = =	5.00 675 36.2 36 1.00 1.00 1.00	5.00 600 36.2 36 1.00 1.00 1.00 0.06	5.00 275 13.2 13 1.00 1.00 1.00 0.05	5.00 150 31.0 31 1.00 1.00 1.00	5.00 375 12.1 1.00 1.00 1.00 0.03	5.00 275 14.8 15 1.00 1.00 1.00	5.00 225 32.6 33 1.00 1.00 1.00
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air stailed Calculations tital Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed UncorrectedOA requirement for system Uncorrected OA req'd as a fraction of primary SA tital Calculations for individual zones OA rate per unit area for zone OA rate per person Total supply air to zone (at condition being analyzed) Unused OA req'd to breathing zone Unused OA req'd to breathing zone Unused OA requirement for 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 Unused OA fraction required in primary air to zone Unused OA fraction required in primary air to zone	Vot/Ps Ypd Vou Xs Raz Rpz Vdz Vdz Voz Voz Fa Fb Fc Zd Zp	cfm/p cfm cfm cfm cfm/sf cfm/p cfm cfm	 Rps Ps + Ras As Vou / Vps Rpz Pz + Raz Az Vbz/Ez Ep + (1-Ep)Er Ep 1-(1-Ez)(1-Ep)(1-Er) Voz / Vdz Voz / Vpz 	12.1 8% = 19600 = 1294 = 0.07 = = = = = =	5.00 675 36.2 36 1.00 1.00 0.05 0.05	5.00 600 36.2 36 1.00 1.00 0.06 0.06	5.00 275 13.2 13 1.00 1.00 0.05 0.05	5.00 150 31.0 1.00 1.00 0.21 0.21	5.00 375 12.1 1.00 1.00 0.03 0.03	5.00 275 14.8 15 1.00 1.00 1.00 0.05 0.05	5.00 225 32.6 33 1.00 1.00 0.14 0.14
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air stailed Calculations itial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed Uncorrected OA requirement for system Uncorrected OA requirement for system Uncorrected OA reqid as a fraction of primary SA itial Calculations for individual zones OA rate per unit area for zone OA rate per person Total supply air to zone (at condition being analyzed) Unused OA requirement for zone Fraction of zone supply not directly recirc. from zone Fraction of zone supply form fully mixed primary air Fraction of zone of An tot directly recirc. from zone Unused OA fraction required in supply air to zone Unused OA fraction required in primary air to zone Unused OA fraction required in Supply air to zone Unused OA fraction required in primary air to zone Unused OA fraction required in primary air to zone Unused OA fraction required in Supply air to zone Unused OA fraction required in Supply air to zone Unused OA fraction required in primary air to zone Unused OA fraction required in Supply air to zone Unused OA fraction Prime Prime Air to zone Unused OA fraction Prime Air to zone Unused OA fraction Prime Air to zone Unused OA fraction Prime Air to zone Unused OA fracti	Vot/Ps Ypd Vps Vou Xs Raz Rpz Vdz Vdz Vdz Vbz Voz Fa Fb Fc Zd Zp Evz	cfm/p cfm cfm cfm cfm/sf cfm/p cfm cfm	 Rps Ps + Ras As Vou / Vps Rpz Pz + Raz Az Vbz/Ez Ep + (1-Ep)Er Ep 1-(1-Ez)(1-Ep)(1-Er) Voz / Vdz Voz / Vpz (Fa + FbXs - FcZ) / Fa 	12.1 8% = 19600 = 1294 = 0.07 = = = = = = = = =	5.00 675 36.2 36 1.00 1.00 1.00 0.05	5.00 600 36.2 36 1.00 1.00 1.00 0.06	5.00 275 13.2 13 1.00 1.00 1.00 0.05	5.00 150 31.0 1.00 1.00 1.00 0.21	5.00 375 12.1 1.00 1.00 1.00 0.03	5.00 275 14.8 15 1.00 1.00 1.00 0.05	5.00 225 32.6 33 1.00 1.00 1.00 0.14
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air tailed Calculations tial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed Uncorrected OA requirement for system Uncorrected OA requirement for system Uncorrected OA reqid as a fraction of primary SA tial Calculations for individual zones OA rate per unit area for zone OA rate per unit area for zone OA rate per person Total supply air to zone (at condition being analyzed) Unused OA reqid 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 supply air to zone Unused OA fraction required in primary air to zone Unused OA fraction fraction (App A Method) System Ventilation Efficiency (App A Method)	Vot/Ps Ypd Vps Vou Xs Raz Rpz Vdz Vbz Vbz Vbz Voz Fa Fb Fc Zd Zp Evz Ev	cfm/p cfm cfm cfm cfm/sf cfm/p cfm cfm	 Rps Ps + Ras As Vou / Vps Hpz Pz + Raz Az Vbz/Ez Ep + (1-Ep)Er Ep 1-(1-Ez)(1-Ep)(1-Er) Voz / Vdz Voz / Vpz (Fa + FbXs - FcZ) / Fa min (Evz) 	12.1 8% = 19600 = 1294 = 0.07 = = = = = = = = = = = = = = 0.80	5.00 675 36.2 36 1.00 1.00 0.05 0.05	5.00 600 36.2 36 1.00 1.00 0.06 0.06	5.00 275 13.2 13 1.00 1.00 0.05 0.05	5.00 150 31.0 1.00 1.00 0.21 0.21	5.00 375 12.1 1.00 1.00 0.03 0.03	5.00 275 14.8 15 1.00 1.00 1.00 0.05 0.05	5.00 225 32.6 33 1.00 1.00 0.14 0.14
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air stailed Calculations tial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed Uncorrected OA requirement for system Uncorrected OA reqd as a fraction of primary SA tial Calculations for individual zones OA rate per unit area for zone OA rate per person 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 not directly recirc. from zone Unused OA fraction required in supply air to zone Unused OA fraction required in supply air to zone Unused OA fraction required in primary air to zone vestem Ventilation Efficiency (App A Method) System Ventilation Efficiency (Table 6.3 Method)	Vot/Ps Ypd Vps Vou Xs Raz Rpz Vdz Vdz Vdz Vbz Voz Fa Fb Fc Zd Zp Evz	cfm/p cfm cfm cfm cfm/sf cfm/p cfm cfm	 = Rps Ps + Ras As = Vou / Vps = Rpz Pz + Raz Az = Vbz/Ez = Ep + (1-Ep)Er = Ep = 1-(1-Ez)(1-Ep)(1-Er) = Voz / Vdz = Voz / Vpz = (Fa + FbXs - FcZ) / Fa = min (Evz) 	12.1 8% = 19600 = 1294 = 0.07 = = = = = = = = = = = = = 0.80	5.00 675 36.2 36 1.00 1.00 0.05 0.05	5.00 600 36.2 36 1.00 1.00 0.06 0.06	5.00 275 13.2 13 1.00 1.00 0.05 0.05	5.00 150 31.0 1.00 1.00 0.21 0.21	5.00 375 12.1 1.00 1.00 0.03 0.03	5.00 275 14.8 15 1.00 1.00 1.00 0.05 0.05	5.00 225 32.6 33 1.00 1.00 0.14 0.14
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air tailed Calculations tial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed Uncorrected OA requirement for system Uncorrected OA reqid as a fraction of primary SA tial Calculations for individual zones OA rate per unit area for zone OA rate per person Total supply air to zone (at condition being analyzed) Unused OA reqid to breathing zone Unused OA reqid to breathing zone Unused OA requirement for zone Fraction of zone supply from fully mixed primary air Fraction of zone of anot directly recirc. from zone 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 Unused OA fraction tefficiency (App A Method) System Ventilation Efficiency (App A Method) Ventilation System Efficiency (Table 6.3 Method) inmum outdoor air intake airflow	Vot/Ps Ypd Vou Xs Raz Rpz Vdz Vdz Vdz Vdz Voz Fa Fb Fc Zd Zp Evz Ev	cfm/p cfm cfm cfm/sf cfm/p cfm cfm cfm cfm	 = Rps Ps + Ras As = Vou / Vps = Npz Pz + Raz Az = Vbz/Ez = Ep + (1-Ep)Er = Ep = 1-(1-Ez)(1-Ep)(1-Er) = Voz / Vdz = Voz / Vpz = (Fa + FbXs - FcZ) / Fa = min (Evz) = Value from Table 6.3 	12.1 8% = 19600 1294 = 0.07 = = = = = = = = = = = = = 0.80 = 0.89	5.00 675 36.2 36 1.00 1.00 0.05 0.05	5.00 600 36.2 36 1.00 1.00 0.06 0.06	5.00 275 13.2 13 1.00 1.00 0.05 0.05	5.00 150 31.0 1.00 1.00 0.21 0.21	5.00 375 12.1 1.00 1.00 0.03 0.03	5.00 275 14.8 15 1.00 1.00 1.00 0.05 0.05	5.00 225 32.6 33 1.00 1.00 0.14 0.14
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air tailed Calculations tial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed Uncorrected OA requirement for system Uncorrected OA reqid as a fraction of primary SA tial Calculations for individual zones OA rate per unit area for zone OA rate per person Total supply air to zone (at condition being analyzed) Unused OA reqid to breathing zone Unused OA requirement for zone Fraction of zone supply not directly recirc. from zone Fraction of zone of unit directly recirc. from zone Unused OA fraction required in supply air to zone Unused OA fraction required in primary air Fraction of Zone Ventilation required in primary air to zone Unused OA fraction required in primary air to zone Unused OA fraction required in Supply air to zone Unused OA fraction Efficiency (App A Method) System Ventilation Efficiency (App A Method) Ventilation System Efficiency (Table 6.3 Method) intume outdoor air intake airflow Outdoor Air Intake Flow required to System	Vot/Ps Ypd Vps Vou Xs Raz Rpz Vdz Vdz Vbz Voz Fa Fb Fc Zd Zp Evz Ev Ev Ev	cfm/p cfm cfm cfm cfm/sf cfm/p cfm cfm	 = Rps Ps + Ras As = Vou / Vps = Rpz Pz + Raz Az = Vbz/Ez = Ep + (1-Ep)Er = Ep = 1-(1-Ez)(1-Ep)(1-Er) = Voz / Vpz = (Fa + FbXs - FcZ) / Fa = min (Evz) = Value from Table 6.3 = Vou / Ev 	12.1 8% = 19600 = 1294 = 0.07 = = = = = = = = = = = = = = = = = = =	5.00 675 36.2 36 1.00 1.00 0.05 0.05	5.00 600 36.2 36 1.00 1.00 0.06 0.06	5.00 275 13.2 13 1.00 1.00 0.05 0.05	5.00 150 31.0 1.00 1.00 0.21 0.21	5.00 375 12.1 1.00 1.00 0.03 0.03	5.00 275 14.8 15 1.00 1.00 1.00 0.05 0.05	5.00 225 32.6 33 1.00 1.00 0.14 0.14
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air tailed Calculations tial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed Uncorrected OA requirement for system Uncorrected OA requirement for system Uncorrected OA requirement for system OA rate per unit area for zone OA rate per unit area for zone OA rate per person Total supply air to zone (at condition being analyzed) Unused OA requirement for zone Fraction of zone supply not directly recirc. from zone Fraction of zone supply forn fully mixed primary air Fraction of zone Supply forn 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 Unused OA fraction required in primary air to zone Unused OA fraction Efficiency (App A Method) System Ventilation Efficiency (App A Method) Ventilation System Efficiency (Table 6.3 Method) Outdoor Air Intake A Flow required to System OA intake req'd as a fraction of primary SA	Vot/Ps Ypd Vps Vou Xs Raz Rpz Vdz Vbz Vbz Vbz Vbz Vbz Vbz Vbz Vbz Vbz Vb	cfm/p cfm cfm cfm/sf cfm/yp cfm cfm cfm cfm	 Rps Ps + Ras As Vou / Vps Rpz Pz + Raz Az Vbz/Ez Ep + (1-Ep)Er Ep 1-(1-Ez)(1-Ep)(1-Er) Voz / Vdz Voz / Vpz (Fa + FbXs - FcZ) / Fa min (Evz) Value from Table 6.3 Vou / Ev Vot / Vps 	12.1 8% = 19600 = 1294 = 0.07 = = = = = = = = = = = = =	5.00 675 36.2 36 1.00 1.00 0.05 0.05 1.01	5.00 600 36.2 36 1.00 1.00 0.06 0.06	5.00 275 13.2 13 1.00 1.00 0.05 0.05	5.00 150 31.0 1.00 1.00 0.21 0.21	5.00 375 12.1 1.00 1.00 0.03 0.03	5.00 275 14.8 15 1.00 1.00 1.00 0.05 0.05	5.00 225 32.6 33 1.00 1.00 0.14 0.14
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air etailed Calculations itial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed Uncorrected OA requirement for system Uncorrected OA requ'a sa fraction of primary SA itial Calculations for individual zones OA rate per unit area for zone OA rate per person Total supply air to zone (at condition being analyzed) Unused OA requ'a 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 supply air to zone Unused OA fraction required in primary air to zone vetem Ventilation Efficiency (App A Method) System Ventilation Efficiency (App A Method) Ventilation System Efficiency (Table 6.3 Method) Unudoor Air Intake Flow required to System OA intake req'd as a fraction of primary SA Outdoor Air Intake Flow required to System (A intake req'd as a fraction of primary SA	Vot/Ps Ypd Vps Vou Xs Raz Rpz Vdz Vdz Vdz Vdz Vdz Vdz Vdz Vdz Vdz Vd	cfm/p cfm cfm cfm/sf cfm/p cfm cfm cfm cfm	= $Rps Ps + Ras As$ = Vou / Vps = $Rpz Pz + Raz Az$ = Vbz/Ez = $Ep + (1-Ep)Er$ = Ep = $1-(1-Ez)(1-Ep)(1-Er)$ = Voz / Vdz = Voz / Vdz = $(Fa + FbXs - FcZ) / Fa$ = min (Evz) = Value from Table 6.3 = Vou / Ev = Vou / Ev	12.1 8% = 19600 = 1294 = 0.07 = = = = = = = = = = = = = = = = = = =	5.00 675 36.2 36 1.00 1.00 0.05 0.05 1.01 1.01	5.00 600 36.2 36 1.00 1.00 0.06 0.06	5.00 275 13.2 13 1.00 1.00 0.05 0.05	5.00 150 31.0 1.00 1.00 0.21 0.21	5.00 375 12.1 1.00 1.00 0.03 0.03	5.00 275 14.8 15 1.00 1.00 1.00 0.05 0.05	5.00 225 32.6 33 1.00 1.00 0.14 0.14
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air etailed Calculations itial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed UncorrectedOA requirement for system Uncorrected OA req'd as a fraction of primary SA itial Calculations for individual zones OA rate per unit area for zone OA rate per unit area for zone OA rate per person Total supply air to zone (at condition being analyzed) Unused OA req'd to breathing zone Unused OA req'd to breathing zone Unused OA requirement for zone Fraction of zone supply from fully mixed primary air 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 Unused OA fraction (App A Method) System Ventilation Efficiency (App A Method) Ventilation System Efficiency (Table 6.3 Method) Outdoor Air Intake Flow required to System OA intake req'd as a fraction of primary SA Outdoor Air Intake Flow required to System (Table 6.3 Method) OA intake req'd as a fraction of primary SA	Vot/Ps Ypd Vps Vou Xs Raz Rpz Vdz Vbz Vbz Vbz Vbz Vbz Vbz Vbz Vbz Vbz Vb	cfm/p cfm cfm cfm/sf cfm/yp cfm cfm cfm cfm	 Rps Ps + Ras As Vou / Vps Rpz Pz + Raz Az Vbz/Ez Ep + (1-Ep)Er Ep 1-(1-Ez)(1-Ep)(1-Er) Voz / Vdz Voz / Vpz (Fa + FbXs - FcZ) / Fa min (Evz) Value from Table 6.3 Vou / Ev Vot / Vps 	12.1 8% = 19600 = 1294 = 0.07 = = = = = = = = = = = = =	5.00 675 36.2 36 1.00 1.00 0.05 0.05 1.01	5.00 600 36.2 36 1.00 1.00 0.06 0.06	5.00 275 13.2 13 1.00 1.00 0.05 0.05	5.00 150 31.0 1.00 1.00 0.21 0.21	5.00 375 12.1 1.00 1.00 0.03 0.03	5.00 275 14.8 15 1.00 1.00 1.00 0.05 0.05	5.00 225 32.6 33 1.00 1.00 0.14 0.14
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air etailed Calculations itial Calculations for the System as a whole Primary supply air flow to system at conditioned analyzed Uncorrected OA requirement for system Uncorrected OA reqid as a fraction of primary SA itial Calculations for individual zones OA rate per unit area for zone OA rate per person Total supply air to zone (at condition being analyzed) Unused OA reqid to breathing zone Unused OA requirement for zone Fraction of zone supply not directly recirc. from zone Fraction of zone of undirectly recirc. from zone Unused OA fraction required in supply air to zone Unused OA fraction required in supply air to zone Ventilation Efficiency Zone Ventilation Efficiency (App A Method) System Ventilation Efficiency (Table 6.3 Method) Unutdoor Air Intake Flow required to System OA intake reqid as a fraction of primary SA Outdoor Air Intake Flow required to System (A intake required as a fraction of primary SA	Vot/Ps Ypd Vps Vou Xs Raz Rpz Vdz Vdz Vdz Vdz Vdz Vdz Vdz Vdz Vdz Vd	cfm/p cfm cfm cfm/sf cfm/yp cfm cfm cfm cfm	= $Rps Ps + Ras As$ = Vou / Vps = $Rpz Pz + Raz Az$ = Vbz/Ez = $Ep + (1-Ep)Er$ = Ep = $1-(1-Ez)(1-Ep)(1-Er)$ = Voz / Vdz = Voz / Vdz = $(Fa + FbXs - FcZ) / Fa$ = min (Evz) = Value from Table 6.3 = Vou / Ev = Vou / Ev	12.1 8% = 19600 = 1294 = 0.07 = = = = = = = = = = = 0.80 = 0.88 = 1609 = 0.88 = 1457 = 0.07	5.00 675 36.2 36 1.00 1.00 0.05 0.05 1.01 1.01	5.00 600 36.2 36 1.00 1.00 0.06 0.06	5.00 275 13.2 13 1.00 1.00 0.05 0.05	5.00 150 31.0 1.00 1.00 0.21 0.21	5.00 375 12.1 1.00 1.00 0.03 0.03	5.00 275 14.8 15 1.00 1.00 1.00 0.05 0.05	5.00 225 32.6 33 1.00 1.00 0.14 0.14

Building:	NEOM		rch and Graduate Education C	`onto								
Svstem Tag/Name:	AHU-3	ED Resea	rch and Graduate Education C	ente	r							
Operating Condition Description:		ooling Da	A A A A A A A A A A A A A A A A A A A									
Units (select from pull-down list)	IP		y									
				_								
Inputs for System	Name	Units		;	System							
Floor area served by system	As	sf			9671							
Population of area served by system (including diversity)	Ps	P	100% diversity		132							
Design primary supply fan airflow rate	Vpsd	cfm			19,600							
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf			0.06							
OA req'd per person for system area (Weighted average)	Rps	cfm/p			5.3							
Inputs for Potentially Critical zones						Office	Office	Due als (Mar a three		- (1)		
Zone Name						Office	Office	Break/Meeting	offices	offices	copy workroom	conference
Zono numo	Zone ti	tle turns p	urple italic for critical zone(s)								workioom	
Zone Tag						370	371	373	260	261	262	263
Space type						Office space	Office space	Break rooms	Office space	Office space	Office space	Conference/m
			om pull-down list									eeting
Floor Area of zone	Az	sf				142	142	381	426	426	155	100
Design population of zone	Pz	P	(default value listed; may be over	erridd	den)	0.71	0.71	9.525	2.13	2.13	0.775	
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm				300	725	1225	675	600	275	250
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?	_	Select fr	om pull-down list or leave blank	If N/A	۹	ITU	ITU	ITU	ITU	ITU	ITU	ITU
Local recirc. air % representative of ave system return air	Er					75%	75%	75%	75%	75%	75%	75%
Inputs for Operating Condition Analyzed	D-	0/		_	40001	1000-1	10001	10001	1000	1000	1000	1000
Percent of total design airflow rate at conditioned analyzed	Ds	% Salaat fi	ana multi davva list		100%	100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed	-	Select fr	om pull-down list			CS	CS	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez					1.00 100%	1.00 100%	1.00 100%	1.00 100%	1.00 100%	1.00 100%	1.00
Primary air fraction of supply air at conditioned analyzed	Ep					100%	100%	100%	100%	100%	100%	100%
Results	Ev				0.80							
Ventilation System Efficiency Outdoor air intake required for system	Ev Vot	cfm			1609							
Outdoor air make required for system	Vot/As	cfm/sf			0.17							
Outdoor air per unit noor area Outdoor air per person served by system (including diversity)	Vot/As Vot/Ps	cfm/p			12.1							
Outdoor air per person served by system (including diversity) Outdoor air as a % of design primary supply air	Ypd	cfm			8%							
Detailed Calculations												
Initial Calculations for the System as a whole	Van	a f	VadDa		19600							
Primary supply air flow to system at conditioned analyzed UncorrectedOA requirement for system	Vps Vou	cfm cfm	= VpdDs	=	19600							
Uncorrected OA regulation of primary SA	Xs	cim	= Rps Ps + Ras As = Vou / Vps	=	0.07							
	AS		= vou / vps	=	0.07							
Initial Calculations for individual zones OA rate per unit area for zone	Raz	cfm/sf				0.06	0.06	0.06	0.06	0.06	0.06	0.06
						5.00			5.00		5.00	
OA rate per person Total supply air to zone (at condition being analyzed)	Rpz Vdz	cfm/p cfm				300			5.00 675		275	
Unused OA reg'd to breathing zone	Vaz Vbz	cfm	= Rpz Pz + Raz Az	=		300 12.1	125		36.2		275	
Unused OA requirement for zone	Voz	cfm	= Rpz Pz + Raz Az = Vbz/Ez	=		12.1			36.2		13.2	
•	voz Fa	CIIII		=		12			36 1.00		1.00	
Fraction of zone supply not directly recirc. from zone	га Fb		= Ep + (1-Ep)Er			1.00			1.00		1.00	
Fraction of zone supply from fully mixed primary air	FD FC		= Ep = 1_(1_Ez)(1_Ep)(1_Er)	=		1.00			1.00		1.00	
Fraction of zone OA not directly recirc. from zone	Zd		= 1-(1-Ez)(1-Ep)(1-Er) = Voz / Vdz	=		0.04			0.05		0.05	
Unused OA fraction required in supply air to zone	Za Zp		= Voz / Vaz = Voz / Vpz	=		0.04	0.02		0.05		0.05	
Unused OA fraction required in primary air to zone System Ventilation Efficiency	zμ		- v0z/vpz	-		0.04	0.02	0.06	0.05	0.06	0.05	0.12
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	=		1.03	1.05	1.01	1.01	1.01	1.02	0.94
System Ventilation Efficiency (App A Method)	Evz		= (ra + rb xs - rcz) / ra = min (Evz)	=	0.80	1.03	1.05	1.01	1.01	1.01	1.02	0.94
Ventilation System Efficiency (App A Method)	Ev		= Value from Table 6.3	-	0.80							
Minimum outdoor air intake airflow	LV			-	0.09							
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	_	1609							
OA intake regid as a fraction of primary SA	Y	CIIII	= Vot / Vps	=	0.08							
Outdoor Air Intake Flow required to System (Table 6.3 Method)		cfm	= Vot / vps = Vou / Ev	-	1457							
Outdoor All make Flow required to System (Table 6.3 Method) OA intake reg'd as a fraction of primary SA (Table 6.3 Method)		CIIII	= Vou / Ev = Vot / Vps	1	0.07							
OA Temp at which Min OA provides all cooling	1		_ vot/vps	-	0.07							
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTrf	=	-135							
		Dogi		_	- 100							

Deallation	NEON	D D			1						
Building:		D Resea	rch and Graduate Education Ce	enter							
System Tag/Name: Operating Condition Description:	AHU-3	oling Day									
Units (select from pull-down list)	IP	boling Day	y		-						
Inputs for System	Name	<u>Units</u>		System	7						
Floor area served by system	As	sf		967	1						
Population of area served by system (including diversity)	Ps	Р	100% diversity	13	2						
Design primary supply fan airflow rate	Vpsd	cfm		19,60	D						
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.0							
OA req'd per person for system area (Weighted average)	Rps	cfm/p		5.	3						
Inputs for Potentially Critical zones					_			,	ritical Zones		
					Office space	unassig	open office	Office space	Office space	break meeting	-
Zone Name	-		a second second second			director	reception			room	bridge
	∠one tri	le turns pi	urple italic for critical zone(s)							074	100
Zone Tag					264	265	266	267	269	271	1 & 2
Space type		0.1	and world damage line		Office space	Office space	Reception	Office space	Office space	Office space	Corridors
Floor Area of zone	Az	Select fr	om pull-down list		142	! 174	areas 155	142	142	388	884
	Az Pz		(default value listed; may be ove	rriddon)	0.71	0.87	4.65	0.71	0.71	388	884
Design population of zone	P2 Vdzd	P cfm	(uciauli value listeu, may be ove	muuen)	375	0.87	4.65	300	325	1.94	2825
Design total supply to zone (primary plus local recirculated)	vuzu		om pull-down list or leave blank i	f NI/A	ITU	ITU	ITU 275	ITU 300	ITU 325	ITU	ITU
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan? Local recirc. air % representative of ave system return air	Er	Select II	on puil-down list of leave blank I	i in/A	75%	75%	75%	75%	75%	75%	75%
Inputs for Operating Condition Analyzed					/5%	/3%	/5%	/5%	15%	15%	15%
Percent of total design airflow rate at conditioned analyzed	Ds	%		1009	6 100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed	05		om pull-down list	100,	CS	CS	CS	CS	CS	CS	CS
Zone air distribution type at conditioned analyzed	Ez	Selectin	om puil-down list		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep				100%	1.00	100%	100%	100%	100%	100%
Results	цþ				10078	10078	10078	10078	10078	10078	10070
Ventilation System Efficiency	Ev			0.80							
Outdoor air intake required for system	Vot	cfm		1609							
Outdoor air make required for system	Vot/As	cfm/sf		0.17							
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		12.1							
Outdoor air as a % of design primary supply air	Ypd	cfm		89							
	•										
Detailed Calculations											
Initial Calculations for the System as a whole		,		4000	-						
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	= 1960							
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	= 129							
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	= 0.0	/						
Initial Calculations for individual zones	D				0.00	0.00	0.00	0.00	0.00	0.00	0.00
OA rate per unit area for zone	Raz	cfm/sf			0.06						
OA rate per person	Rpz	cfm/p			5.00						
Total supply air to zone (at condition being analyzed)	Vdz	cfm	Des De : Des As		375			300			
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=	12.1			12.1			
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	=	12						
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	=	1.00			1.00			
Fraction of zone supply from fully mixed primary air	Fb		= Ep	=	1.00			1.00			
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	=	1.00			1.00			
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	=	0.03						
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	=	0.03	0.05	0.12	0.04	0.04	0.04	0.02
System Ventilation Efficiency	Eve				1.03	4.04	0.95	1.03	4.02	1.02	1.05
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	= 0.90		1.01	0.95	1.03	1.03	1.02	1.0
System Ventilation Efficiency (App A Method)	Ev Ev		min (Evz)Value from Table 6.3	= 0.80 = 0.89							
Ventilation System Efficiency (Table 6.3 Method) Minimum outdoor air intake airflow	Ev		- value nom rable 6.3	- 0.89							
	Vot	ofm		= 160	•						
Outdoor Air Intake Flow required to System	Y	cfm	= Vou / Ev								
OA intake req'd as a fraction of primary SA		ofm	= Vot / Vps	= 0.0							
Outdoor Air Intake Flow required to System (Table 6.3 Method) OA intake reg'd as a fraction of primary SA (Table 6.3 Method)		cfm	= Vou / Ev	= 145							
OA Intake req d as a fraction of primary SA (Table 6.3 Method) OA Temp at which Min OA provides all cooling	T I		= Vot / Vps	= 0.0							
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTrf	= -13	5						
OAT DELOW WHICH OA ITTAKE HOW IS W HITHIIIIUIT		Degi		-13							

Building:	NEOME	D Resear	ch and Graduate Education	Center								
ystem Tag/Name:	AHU-3											
perating Condition Description:	Max Co	oling Day	1									
nits (select from pull-down list)	IP											
puts for System	Name	Units		Sy	/stem							
Floor area served by system	As	sf			9671							
Population of area served by system (including diversity)	Ps	Р	100% diversity		132							
Design primary supply fan airflow rate	Vpsd	cfm			19,600							
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf			0.06							
OA req'd per person for system area (Weighted average)	Rps	cfm/p			5.3							
outs for Potentially Critical zones												
Zone Name						open office reception	service closets	lobby	offices	offices	AV Room	conference/ seminar
	Zone tit	le turns pi	Irple italic for critical zone(s)			reception	0103013					Seriina
Zone Tag						153	152	151	154	155	156	165 & 163
Space type						Reception	Telephone	Main entry	Office space	Office space	Storage	Conference/m
	A –		om pull-down list		-	areas	closets	lobbies	100	100	rooms	eeting
Floor Area of zone	Az	sf P		امام اسم		221	200	877	426	426	50	762
Design population of zone	Pz Vdzd	P cfm	(default value listed; may be o	vennaaer	"	6.63 250	0	8.77 500	2.13 725	2.13	<u> </u>	38.1
Design total supply to zone (primary plus local recirculated)	vuza		m pull-down list or loove blan	L if NI/A	ŀ	ITU 250	150 ITU	500 ITU	ITU 725	600 ITU	50 ITU	1800 ITU
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?	Er	Select If	om pull-down list or leave blan	K II IN/A	ŀ		75%					
Local recirc. air % representative of ave system return air outs for Operating Condition Analyzed	EI					75%	/5%	75%	75%	75%	75%	75%
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed	05		om pull-down list		100%	100% CS	100% CS	100% CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez	Selecting	Jin puil-down list		F	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep				F	100%	100%	1.00	1.00	1.00%	100%	100%
sults	ЦР					10070	10070	10070	10070	10070	10070	10070
Ventilation System Efficiency	Ev				0.80							
Outdoor air intake required for system	Vot	cfm			1609							
Outdoor air per unit floor area	Vot/As				0.17							
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p			12.1							
Outdoor air as a % of design primary supply air	Ypd	cfm			8%							
etailed Calculations itial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	=	19600							
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	_	1294							
Uncorrected OA reg'd as a fraction of primary SA	Xs	onn	= Vou / Vps	_	0.07							
tial Calculations for individual zones	7.0		- 100,100		0.07							
OA rate per unit area for zone	Raz	cfm/sf				0.06	0.00	0.06	0.06	0.06	0.12	0.06
OA rate per person	Rpz	cfm/p				5.00	0.00	5.00			0.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm				250	150	500		600	50	1800
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=		46.4	0.0	96.5		36.2	6.0	236.2
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	_		40.4	0.0	96.5		36	6.0	230.2
Fraction of zone supply not directly recirc. from zone	Fa	Jim	= VD2/E2 = Ep + (1-Ep)Er	=		1.00	1.00	1.00		1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep + (1-Ep)El	_		1.00	1.00	1.00		1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	FD		= Ep = 1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00		1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	=		0.19	0.00	0.19	0.05	0.06	0.12	0.13
	Zp		= V02 / V02 = Voz / Vpz	=		0.19	0.00	0.19	0.05	0.06	0.12	0.13
Unused OA fraction required in primary air to zone stem Ventilation Efficiency	zμ		_ voz / vpz	-		0.19	0.00	0.19	0.05	0.06	0.12	0.13
	Evz		= (Fa + FbXs - FcZ) / Fa	=		0.88	1.07	0.87	1.02	1.01	0.95	0.93
Zone Ventilation Efficiency (App A Method)	Evz Ev		· · · · ·		0.00	0.88	1.07	0.87	1.02	1.01	0.95	0.93
System Ventilation Efficiency (App A Method)	EV Ev		= min (Evz) - Value from Table 6.3	=	0.80 0.89							
Ventilation System Efficiency (Table 6.3 Method)	EV		= Value from Table 6.3	=	0.89							
nimum outdoor air intake airflow	1/-1	- (4000							
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	=	1609							
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	=	0.08							
Outdoor Air Intake Flow required to System (Table 6.3 Method)		cfm	= Vou / Ev	=	1457							
OA intake req'd as a fraction of primary SA (Table 6.3 Method) A Temp at which Min OA provides all cooling	Y		= Vot / Vps	=	0.07							
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTrf	=	-135							
			((p =) () (in our in									

Building:	NEOME	ED Resea	rch and Graduate Education	Center								
ystem Tag/Name:	AHU-3											
perating Condition Description:	Max Co	oling Day	/									
nits (select from pull-down list)	IP											
puts for System	Name	Units		Sys	stem							
Floor area served by system	As	sf			9671							
Population of area served by system (including diversity)	Ps	Р	100% diversity		132							
Design primary supply fan airflow rate	Vpsd	cfm		1	9,600							
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf			0.06							
OA req'd per person for system area (Weighted average)	Rps	cfm/p			5.3							
outs for Potentially Critical zones									~ ///			
Zone Name	_					kitchen	copy room	Office space	Office space	conference room	Office space	Office space
Zone Tag	Zone ti	tle turns p	Irple italic for critical zone(s)			162	157	158	159	160	161	166
•						Cafeteria/fast-	Office space	Office space	Office space	Conference/m	Office space	Office space
Space type		Select fr	om pull-down list			food dining	onice space	ennee space	onice space	eeting	onice space	onice space
Floor Area of zone	Az	sf				162	130	142	142	130	142	142
Design population of zone	Pz	Р	(default value listed; may be ov	verridden)	16.2	0.65	0.71	0.71	6.5	0.71	0.71
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm				575	275	475	275	250	300	400
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select fr	om pull-down list or leave blank	k if N/A		ITU	ITU	ITU	ITU	ITU	ITU	ITU
Local recirc. air % representative of ave system return air	Er					75%	75%	75%	75%	75%	75%	75%
outs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%			100%	100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select fr	om pull-down list			CS	CS	CS	CS	CS	CS	CS
Zone air distribution effectiveness at conditioned analyzed	Ez					1.00	1.00	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep					100%	100%	100%	100%	100%	100%	100%
sults												
Ventilation System Efficiency	Ev				0.80							
Outdoor air intake required for system	Vot	cfm			1609							
Outdoor air per unit floor area	Vot/As				0.17							
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p			12.1							
Outdoor air as a % of design primary supply air	Ypd	cfm			8%							
etailed Calculations												
itial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs	= "	19600							
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As	=	1294							
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps	=	0.07							
ial Calculations for individual zones												
OA rate per unit area for zone	Raz	cfm/sf				0.18	0.06	0.06	0.06	0.06		0.06
OA rate per person	Rpz	cfm/p				7.50	5.00	5.00	5.00			5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm				575	275	475	275	250	300	400
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az	=		150.7	11.1	12.1	12.1	40.3	12.1	12.1
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez	=		151	11	12	12	40	12	12
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone supply from fully mixed primary air	Fb		= Ep	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fraction of zone OA not directly recirc. from zone	Fc		= 1-(1-Ez)(1-Ep)(1-Er)	=		1.00	1.00	1.00	1.00	1.00	1.00	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz	=		0.26	0.04	0.03	0.04	0.16	0.04	0.03
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz	=		0.26	0.04	0.03	0.04	0.16	0.04	0.03
stem Ventilation Efficiency												
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa	=		0.80	1.03	1.04	1.02	0.90	1.03	1.04
System Ventilation Efficiency (App A Method)	Ev		= min (Evz)	=	0.80							
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3	=	0.89							
nimum outdoor air intake airflow												
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev	=	1609							
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps	_	0.08							
Outdoor Air Intake Flow required to System (Table 6.3 Method)	-	cfm	= Vou / Ev	-	1457							
OA intake req'd as a fraction of primary SA (Table 6.3 Method)		Cini	= Vot / Vps	=	0.07							
A Temp at which Min OA provides all cooling		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTrf									
OAT below which OA Intake flow is @ minimum					-135							

Building			D Resea	rcha	and Graduate Education C	enter		
	Tag/Name: Ig Condition Description:	AHU-3 Max Co						
	elect from pull-down list)	IP						
Innuts fo	or System	Name	Units			Sve	stem	
inputs io	Floor area served by system	As	sf			Jys	9671	
	Population of area served by system (including diversity)	Ps	P		100% diversity		132	
	Design primary supply fan airflow rate	Vpsd	cfm			1	9,600	
	OA req'd per unit area for system (Weighted average)	Ras	cfm/sf				0.06	
	OA req'd per person for system area (Weighted average)	Rps	cfm/p				5.3	
nputs fo	or Potentially Critical zones							
	Zone Name							offices
	Zone Tag	Zone ti	tle turns p	urple	e italic for critical zone(s)			168
								Office space
	Space type			om p	oull-down list			
	Floor Area of zone	Az	sf					342
	Design population of zone	Pz	P	(def	ault value listed; may be over	erridden)	1.71
	Design total supply to zone (primary plus local recirculated)	Vdzd	cfm Calent fr		الحجاء معاممين المناه	:4 NI/A		1200 ITU
	Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan? Local recirc. air % representative of ave system return air	Er	Select fr	om p	oull-down list or leave blank	II N/A		75%
nnuts fo	br Operating Condition Analyzed							15%
	Percent of total design airflow rate at conditioned analyzed	Ds	%				100%	100%
	Air distribution type at conditioned analyzed	20		om r	oull-down list			CS
	Zone air distribution effectiveness at conditioned analyzed	Ez						1.00
	Primary air fraction of supply air at conditioned analyzed	Ep						100%
Results								
	Ventilation System Efficiency	Ev					0.80	
	Outdoor air intake required for system	Vot	cfm				1609	
	Outdoor air per unit floor area	Vot/As					0.17	
	Outdoor air per person served by system (including diversity)	Vot/Ps					12.1 8%	
	Outdoor air as a % of design primary supply air	Ypd	cfm				070	
	Calculations							
Initial Ca	Ilculations for the System as a whole	1/1						
	Primary supply air flow to system at conditioned analyzed	Vps	cfm	=	VpdDs		19600 1294	
	UncorrectedOA requirement for system Uncorrected OA req'd as a fraction of primary SA	Vou Xs	cfm	=	Rps Ps + Ras As Vou / Vps	=	0.07	
Initial Ca	Inculations for individual zones	A5		=	vou / vps	=	0.07	
	OA rate per unit area for zone	Raz	cfm/sf					0.06
	OA rate per person	Rpz	cfm/p					5.00
	Total supply air to zone (at condition being analyzed)	Vdz	cfm					1200
	Unused OA req'd to breathing zone	Vbz	cfm	=	Rpz Pz + Raz Az	=		29.1
	Unused OA requirement for zone	Voz	cfm	=	Vbz/Ez	=		29
	Fraction of zone supply not directly recirc. from zone	Fa		=	Ep + (1-Ep)Er	=		1.00
	Fraction of zone supply from fully mixed primary air	Fb		=	Ep	=		1.00
	Fraction of zone OA not directly recirc. from zone	Fc		=	1-(1-Ez)(1-Ep)(1-Er)	=		1.00
	Unused OA fraction required in supply air to zone	Zd		=	Voz / Vdz	=		0.02
O	Unused OA fraction required in primary air to zone	Zp		=	Voz / Vpz	=		0.02
System \	Zene Ventilation Efficiency (App & Method)	Evz			(Ea + EbYs - EoZ) / Ec	_		1.04
	Zone Ventilation Efficiency (App A Method) System Ventilation Efficiency (App A Method)	Evz Ev		=	(Fa + FbXs - FcZ) / Fa min (Evz)	=	0.80	1.04
	Ventilation System Efficiency (Table 6.3 Method)	EV Ev		=	Min (Evz) Value from Table 6.3	_	0.80	
Minimum	n outdoor air intake airflow	2.					0.00	
an	Outdoor Air Intake Flow required to System	Vot	cfm	=	Vou / Ev	=	1609	
	OA intake reg'd as a fraction of primary SA	Y		=	Vot / Vps	=	0.08	
	Outdoor Air Intake Flow required to System (Table 6.3 Method)	Vot	cfm	=	Vou / Ev	=	1457	
	Outdoor Air Intake Flow required to System (Table 6.5 Method)							
	OA intake req'd as a fraction of primary SA (Table 6.3 Method)	Y		=	Vot / Vps	=	0.07	
OA Tem			Deg F		Vot / Vps {(Tp-dTsf)-(1-Y)*(Tr+dTrf		0.07	