Technical Report One

ASHRAE Standard 62.1 and 90.1 Analysis

Defense Information Systems Agency Headquarters Facility

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Executive Summary

This report focuses on the Defense Information Systems Agency (DISA) Headquarters Facility's compliance with ASHRAE Standards 62.1.2007 & 90.1.2007.

The DISA HQ includes six integrated buildings organized in a campus layout. The facility is comprised of six connected buildings: Command, Operations, Acquisitions, Lab, Warehouse and Central Plant. The program contains about 70% office spaces, 7% lab spaces, and 10% common spaces.

The ASHRAE Standard 62.1 Analysis showed that the buildings are largely compliant with the requirements of Section 5, indoor air quality. Close detail has been given to the design to ensure the occupants are receiving the best air quality as possible. The buildings are largely compliant also with Section 6, Minimum Outdoor Air & Ventilation rates. All spaces analyzed complied with ASHRAE minimum ventilation requirements; some spaces greatly exceeded the required rate.

The ASHRAE Standard 90.1 Analysis showed that these buildings designers have gone above and beyond the Standard's required guidelines. The building envelope as designed is largely compliant as well as the boilers, chillers, and lighting. The Fan Power Limitation calculations were the only category in which the DISA HQ did not meet compliance. About 38% of the AHU Fans did not comply with this standard.

Overall, the DISA HQ was largely compliant with ASHRAE Standards 62.1.2007 & 90.1.2007. Supporting tables and further explanations explain the analysis.

Introduction

The overarching concept for the DISA HQ is the creation of an integrated campus environment that represents the unity of DISA in a consolidated facility. The population for the facility is currently operating at several individual sites and the ability to combine their resources into this new facility will bring operational efficiencies. The DISA HQ includes six integrated buildings organized in a campus layout.

The facility is comprised of six connected buildings: Command, Operations, Acquisitions, Lab, Warehouse and Central Plant. They are interconnected by a Concourse at Level 2 (primarily service circulation and utilities) and Level 3 (primary internal pedestrian circulation).

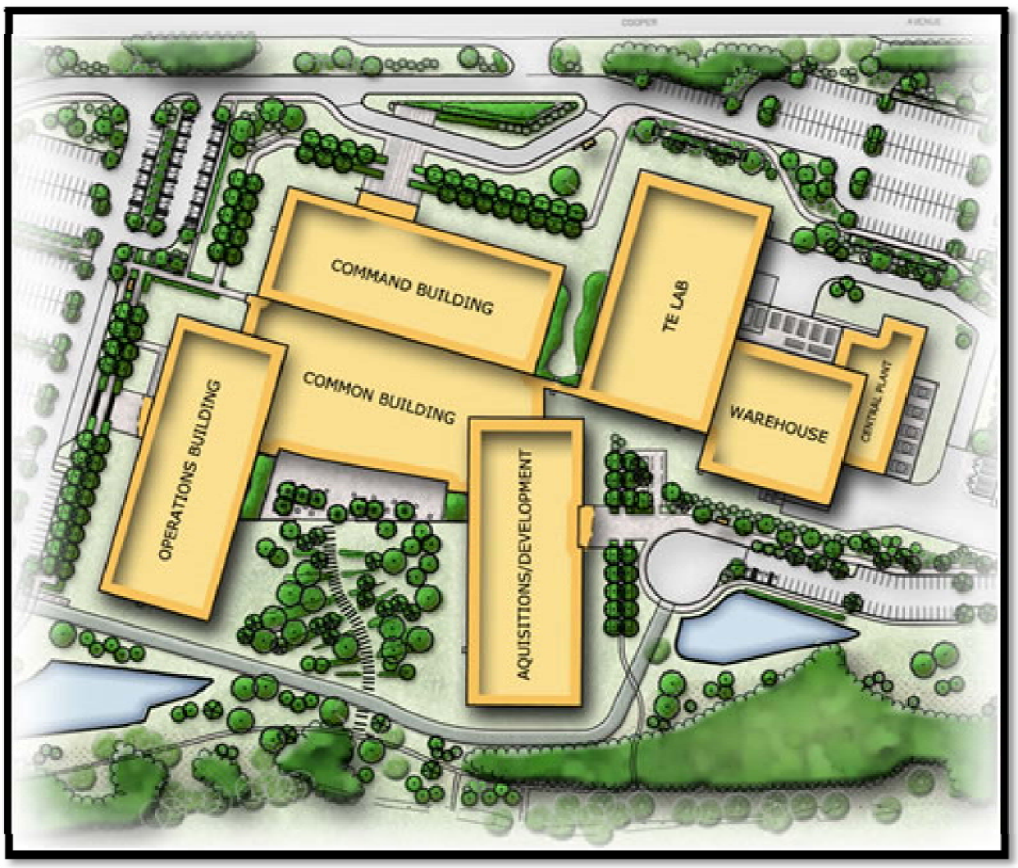


Figure 62.1.1- Campus Site Plan

The project is a complex with approximately 70% office space, 7% Lab Space, 10% Common (Multiuse) area, and 13% Special Use Spaces, based on program floor area. The Central Utility Plant (CUP) is shown attached to the Warehouse in Figure 1 above. This building contains the Boilers and Chillers which distribute Campus chilled and heating water to the entire complex. The cooling loads are extremely high for this complex, while the heating loads are minor.

The HVAC system selection for the DISA HQ was driven by the following criteria:

- **The need for flexibility to accommodate future change**
- **The project goal of 30% energy conservation compared to ASHRAE Standard 90.1 – 2004.**
- **Employee Comfort**
- **Best life cycle cost**

The air systems served by the Central Utility Plant (CUP) were selected as follows:

Office Space

An Under Floor Air Distribution (UFAD) system to make full use of the 18" raised access floor and provide individual comfort control for the building occupants, and high energy efficiency when coupled with central roof level custom air handling equipment delivering low pressure air. The decision to place the AHU equipment on the roof rather than in AHU rooms is intended to maximize usable program area in the buildings.

Lab

To serve this high load area efficiently, a system of variable volume vertical air flow, Chilled Water (CHW) AHU's designed specifically for use in data centers will be coupled with a direct injection outdoor air system to provide ventilation air at a constant dewpoint for humidity control.

This system best meets the unique needs of what is in effect a data center with high personnel occupancy. The AHU's will be enclosed in a mechanical space to one side of each floor of the lab, in contrast with CRAC units which are typically placed in the space. This will minimize the noise contribution to the space from these units.

Common (Multiuse) Area:

The lower floor contains the Cafeteria, Kitchen and Health/Wellness functions which are not suited for the use of a raised access floor. The HVAC systems for these areas are conventional overhead VAV with roof mounted AHU's. The second floor contains the Conference Center and Training functions which utilize a raised access floor. These areas are also suitable for the use of a UFAD system, to maximize the comfort and energy efficiency of these areas.

Special Use Spaces:

These are mainly high load equipment areas, some without occupancy, some with people and equipment and some with people and normal computer loads. These areas are all on raised access floors and will be handled with chilled water Computer Room Air Conditioning (CRAC) units in combination with a direct injection outside air system to provide ventilation air at a constant dewpoint for humidity control; in general, other ventilation methods are also used for some areas.

Mission Critical Spaces:

Certain spaces are Mission Critical; therefore HVAC equipment for these spaces must operate on the generator when required, together with part of the central chilled water plant and key components of the Building Automation System (BAS), to enable the Mission Critical spaces to continue uninterrupted operation. In addition some HVAC equipment is required to be redundant to increase reliability.

Part I: ASHRAE 62.1-Section 5 Analysis

5.3 Exhaust Duct Location

All exhaust ducts carrying contaminants such as smoke, toilet exhaust, and kitchen exhaust, are all negatively pressurized throughout the spaces which they pass. These systems have been designed to minimize their exposure to critical spaces, utilizing the most direct and convenient path. They have also been located sufficient distances away from intakes and other critical equipment to minimize reentry.

5.5 Airstream Surfaces

The majority of airstream surfaces are sheet metal with duct silencers for sound transmission prevention. There are short flexible duct runs to the diffusers which also are compliant with this requirement. In security-sensitive areas SCIF barriers and man bars are used to prevent any chance of sound transmission or unwanted entry.

5.6 Outdoor Air Intakes

The design documents show that all outdoor air intakes have been located at distances that meet or exceed the specified guidelines. Their openings are located on the roof to protect from terrorist attacks, as well as unwanted intruders.

5.7 Local Capture of Contaminants

All exhaust from Lab spaces is ducted to exhaust fans on the roof.

5.8 Combustion Air

The only sources of combustion air in the building are located in the Central Utility Plant. Combustion air louvers, positioned high and low in the boiler room exterior wall, provide combustion air and boiler room ventilation in summer. When additional airflow is required for ventilation in summer, an exhaust fan is provided that starts and stops based on the signal from a room thermostat.

5.9 Particular Matter Removal

The buildings air handlers have a flat prefilter section (MERV 8) as well as a cartridge type final filter section (MERV 13).

5.10 Dehumidification Systems

The maximum relative humidity for the spaces is 50 % as requested by the owner in the RFP.

5.11 Drain Pans

Drain pans are specified to have a minimum slope of 1/8” per foot with the outlet located at the lowest point of the slope. After reviewing the documents, all drain pains are in compliance.

5.12 Finned-Tubed Coils and Heat Exchangers

The minimum distance between coils is 18 inches which complies with the requirements.

5.13 Humidifiers and Water-Spray Systems

Water is directly from the water supply lines on site, which meets potable requirements.

5.14 Access for Inspection, Cleaning, and Maintenance

Access to each piece of equipment has been provided within regards to the specific needs of the unit. Minimum door opening size is 18" x 70". Where equipment, may require removal, the access door shall be sized to accommodate maintenance and/or replacement.

5.15 Building Envelope and Interior Spaces

The building envelope will include a vapor barrier. All piping, ductwork, and other surfaces shall be properly insulated to prevent the formation of unwanted condensation.

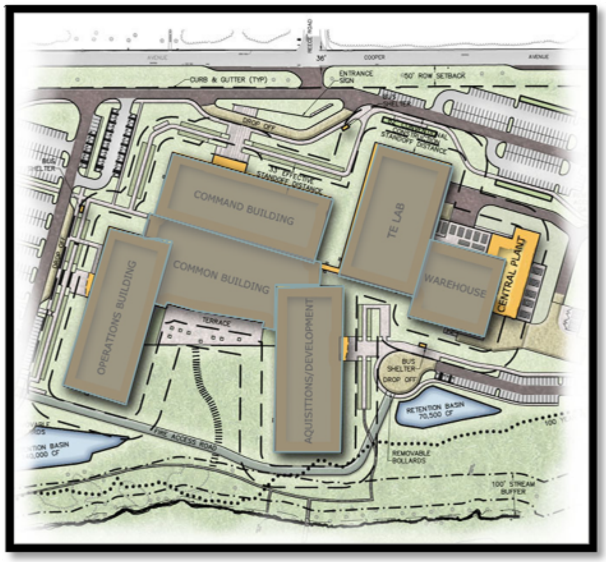


Figure 62.1.2- Central Utility Plant Location

Part II: Building Mechanical System Summary

Central Cooling Plant-

The DISA HQ Central Utility Plant (CUP) contains four (4) Centrifugal chillers with Variable Frequency Drives. The chillers are piped in (2) pairs of series/counter flow configuration and each chiller has a capacity of 950 tons. The chillers will deliver campus CHW at 42°F, with return water at 60°F to each building. The plant will meet the entire cooling needs of the facility.

The series/counter flow piping is arranged to allow a single chiller to operate at part load in each pair of chillers, with the off-duty chiller bypassed. Four (4) variable primary flow CHW end suction pumps (+ 1 for redundancy) serve the entire CHW distribution system. Each CHW pump is provided with a VFD, controlled by differential pressure in the system in conjunction with a system flow meter at the plant.

A system of supply/return piping serves the entire facility. The piping is routed through the Warehouse into the lower concourse where it runs overhead in the ceiling, with isolation branches to each major building along the route.

To serve the roof level AHU's in the office buildings, CHW supply/return risers are located in one of the return air shafts to the units. Telecommunications closet CRAC units are serves by separate risers adjacent to the CRAC units. Electrical room vertical FCU's are served also by separate risers.

Cooling Towers

Four (4) Cooling Towers, equipped with fan VFD's are located in a cooling tower yard adjacent to the cooling plant. The towers are piped to a suction header from which four (4) centrifugal end suction CW pumps are piped to a distribution header and then to the individual chiller condensers.

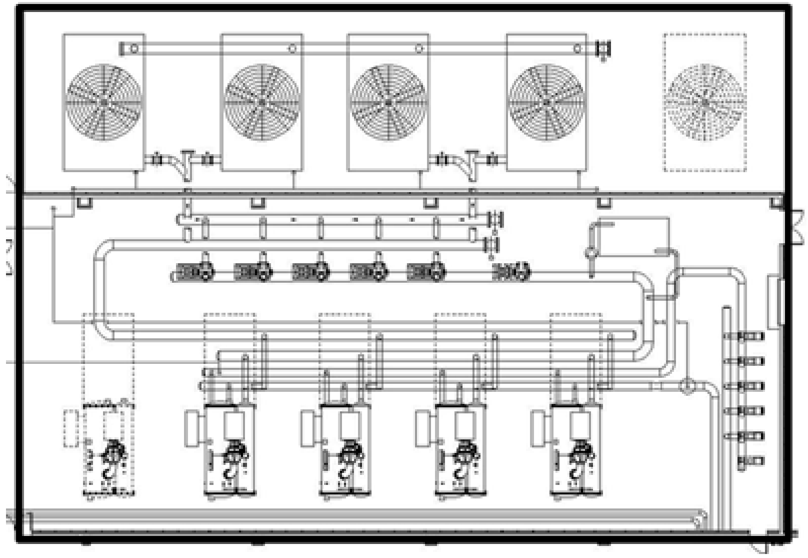


Figure 62.1.3-Central Cooling Plant in CUP

Central Heating Plant-

A heating plant is located adjacent to the cooling plant, in a separate enclosed room. The plant consists of four (4) gas-fired water tube HW boilers, three (3) of which are capable of handling the entire facility's heating capacity with one (1) as standby. The plant operates with a maximum HW supply temperature of 200°F and a return water temperature of 160°F, with reset capability down to 180°F supply temperature during mild weather. A primary loop is provided with an end suction circulating pump for each boiler.

Four (4) end suction secondary pumps, each sized at 1/3 duty serve the entire HW distribution system. A system of isolated supply/return piping serves the entire facility. The route of the HW piping is with the CHW piping.

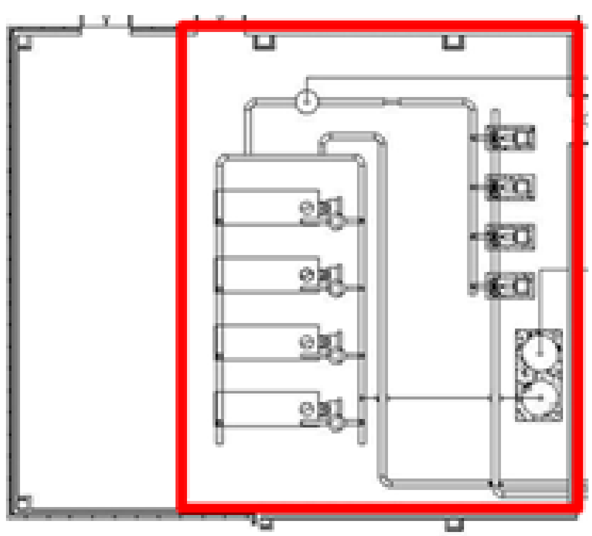
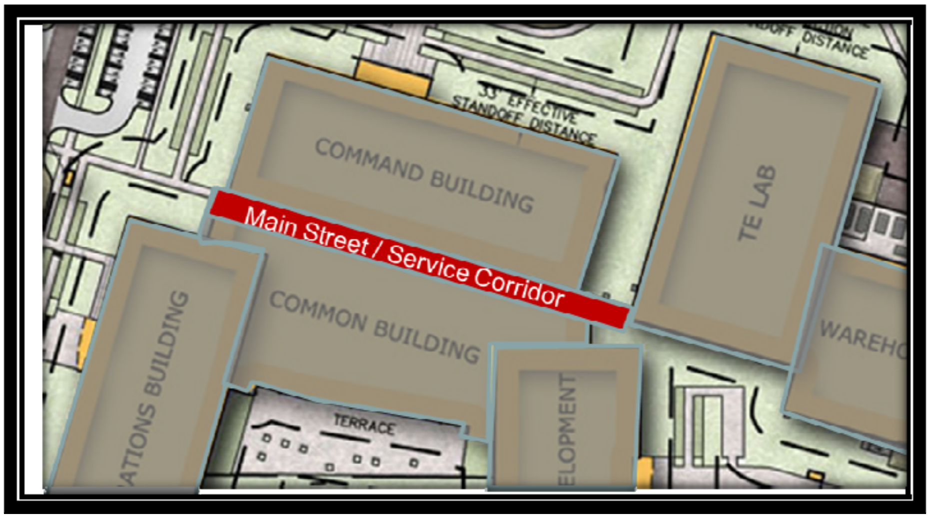


Figure 62.1.4-Central Heating Plant in CUP

Main Street/Service Corridor:

Main Street is a two story connecting circulation for all buildings and occurs at Level 1. This area doubles as the main circulation spine on the top level for all occupants, and as a service corridor on the level below. All CHW/HW distribution from the CUP in the Warehouse runs through this corridor and branches into the other buildings. (Shown Below in Figure 62.1.5)



AHU	MANUFACT.	LOCATION	SERVICE	# OF FANS	FAN AIRFLOW CFM	UNIT AIRFLOW CFM	OUTSIDE AIRFLOW CFM	SA TEMP (°F)
C-AHU-1	BUFFALO	COMMAND ROOF	5 LEFT	1	27,000	27,000	4,995	62
C-AHU-2	BUFFALO	COMMAND ROOF	5 CENTER	1	32,500	32,500	6,015	62
C-AHU-3	BUFFALO	COMMAND ROOF	5 RIGHT	1	27,500	27,500	5,090	62
4R	BUFFALO	COMMAND ROOF	LEFT CORE	1	13,750	13,750	2,545	62
5R	BUFFALO	COMMAND ROOF	CENTER	1	13,750	13,750	2,545	62
6R	BUFFALO	COMMAND ROOF	RIGHT CORE	1	13,750	13,750	2,545	62
8, -9	NOT USED	-	-	-	-	-	-	-
C-AHU-10	CARRIER 39 M	C-LVL 4 MECH. RM.	LOBBY	1	4,000	4,000	4,000	55
11A, -11R	CARRIER 39 M	C-LVL 2 MECH. RM.	ELECT. RMS.	1	11,650	11,650	-	55
L-OHU-1	CARRIER 39 M	LAB	SYSTEM	1	10,500	10,500	10,500	52
10)	RACAN	LAB MECH. RM.	HOTELS	1	34,000	34,000	-	65
20)	RACAN	LAB MECH. RM.	HOTELS	1	32,000	32,000	-	65
L-AHU-21	CARRIER 39 M	LAB ROOF	LAB ADMIN	1	7,900	7,900	2,150	55
W-AHU-1	CARRIER 39 M	WAREHOUSE ROOF	MAIL ROOM	1	1,500	1,500	300	55
W-AHU-2	CARRIER 39 M	WAREHOUSE ROOF	CE	1	7,600	7,600	6,600	55
M-AHU-1	CARRIER 39 M	COMMON ROOF	WELLNESS	1	3,000	3,000	800	55
M-AHU-2	CARRIER 39 M	COMMON ROOF	FITNESS	1	8,000	8,000	3,000	50
M-AHU-3	CARRIER 39 M	COMMON ROOF	DINING	1	24,680	24,680	21,000	50
M-AHU-4	CARRIER 39 M	COMMON ROOF	CENTER	1	8,500	8,500	2,175	62
M-AHU-5	CARRIER 39 M	COMMON ROOF	CE CENTER	1	21,500	21,500	7,250	62
M-AHU-6	CARRIER 39 M	COMMON ROOF	TV STUDIO	1	5,500	5,500	500	55
M-AHU-7	CARRIER 39 M	COMMON ROOF	AV STUDIO	1	8,200	8,200	1,200	55
M-OHU-1	CARRIER 39 M	COMMON ROOF	SYSTEM	1	1,900	1,900	1,900	52
O-AHU-1	BUFFALO	OPERATIONS ROOF	UFAD LEFT	1	38,000	38,000	7,030	62
O-AHU-2	BUFFALO	OPERATIONS ROOF	UFAD	2	25,250	50,500	9,345	62
O-AHU-3	BUFFALO	OPERATIONS ROOF	UFAD RIGHT	2	22,500	45,000	8,325	62
A-AHU-1	BUFFALO	ACQUISITIONS ROOF	UFAD LEFT	2	27,250	54,500	10,085	62
A-AHU-2	BUFFALO	ACQUISITIONS ROOF	UFAD	2	31,000	62,000	11,470	62
A-AHU-3	BUFFALO	ACQUISITIONS ROOF	UFAD RIGHT	2	24,250	48,500	8,975	62

Figure 62.1.6- DISA HQ AHU Schedule

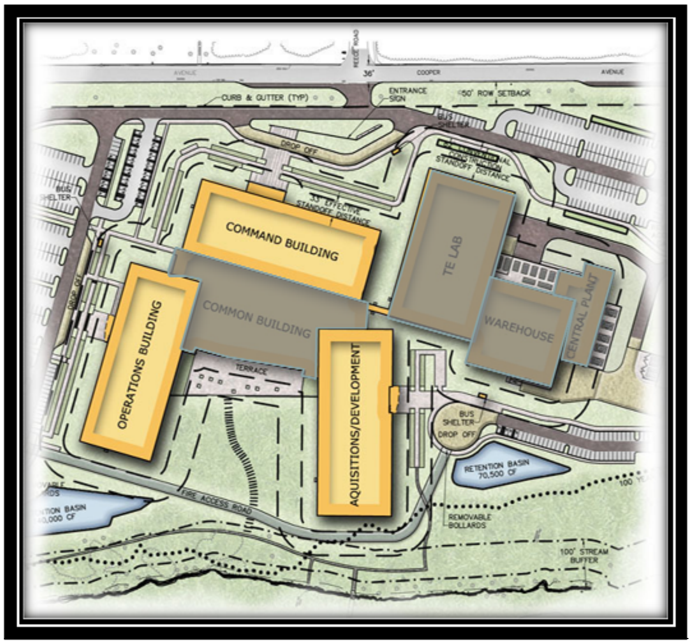


Figure 62.1.7-General Office Locations

General Office Spaces:

UFAD systems serve all typical office spaces located in the Command, Acquisitions, and Operations buildings along with Level 3 of the Common building via an 18" RAF. The UFAD system pressurized the under floor plenum using supply air at a temperature between 62 °F and 68 °F. Central roof level AHU's using CHW from the Central Plant deliver a variable volume of supply air maintained at a constant temperature within the range above, dictated by the BAS.

The perimeter is treated as a "skin" system, meaning a narrow exterior zone within which only the exterior envelope heat gains and losses will be handled. Perimeter UFT's will be provided, with a system of insulated flexible supply air ducts connected to a linear bar type floor diffuser under windows. By controlling the perimeter as a skin system, a large cooling only interior zone is thus created for the rest of the air handling zone.

Each office floor is divided into three (3) air handling zones served by supply air risers, located in the core of the office buildings. Sheet metal zone dividers below the floor allow the maintenance of a constant under floor plenum pressure for each zone.

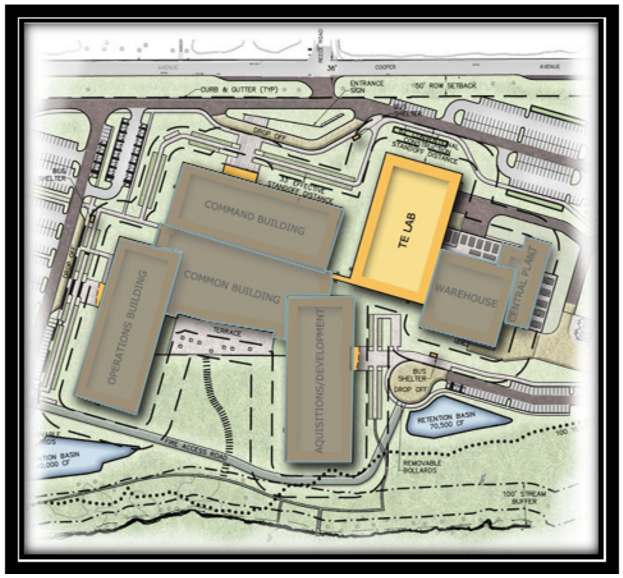


Figure 62.1.8- TE Lab Spaces

<u>TE Lab Spaces:</u>

The TE Lab HVAC load requirements are 30% of the total cooling load for the entire DISA HQ, even though it is only 7% of the total programmable area. Vertical air flow, Chilled Water (CW) AHU's designed specifically for use in data centers will be coupled with direct injection outdoor air systems to provide ventilation and humidity control for the unique needs of what is in effect a data center with high personnel occupancy. The units will be located in two (2) secure, stacked equipment rooms along the south edge of the space to serve both levels of the TE Lab.

From the two (2) 100% OA constant volume AHU's, located in the same equipment rooms as the vertical AHU's a system of medium pressure supply air ductwork in the ceiling will distribute the air to the TE Lab space and to the individual "hotel" rooms via Constant Air Volume (CAV) terminal units with downstream low pressure ductwork and ceiling diffusers.

Because the elevated supply air temperature used for the Lab only provides sensible cooling, a separate dehumidification system is provided, in the form of a Dedicated Outdoor Air System (DOAS). This is a 100% OA system supplying the ventilation requirements of the space, with all the air being cooled to a 50°F dewpoint. The only dehumidification requirements in the space are due to people latent heat gains, when 20 cfm/person or greater of ventilation air is supplied at 50°F dewpoint; the resulting humidity level is less than 50%RH. The required ventilation rate per ASHRAE Std 62.1-2004 is greater than 20 cfm/person at the surge occupancy of 120 people per Main Lab Floor, thus this system can handle all the dehumidification requirements of the space. The DOAS AHU (L-OHU-1) is located on the roof of the Lab building above the Admin office area.

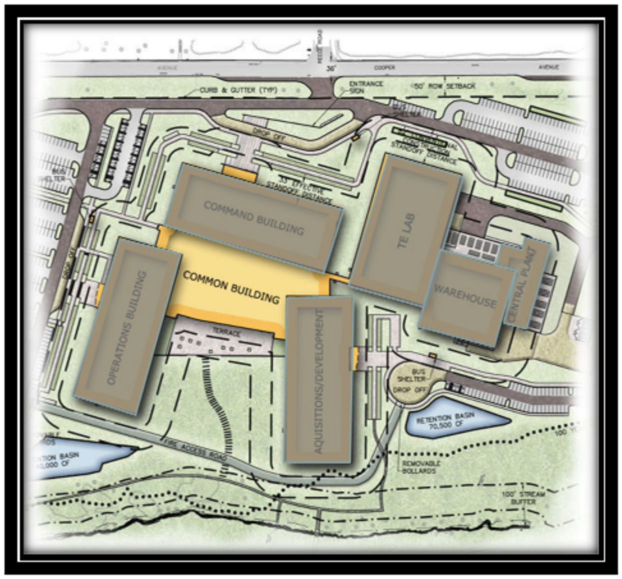


Figure 62.1.9- Common Building

<u>Common Building Mixed-Used Spaces:</u>

The Common Building provides central employee amenities and therefore has a diverse program. The Common Building upper level will be serviced by UFAD via RAF. The lower level will be serviced by overhead VAV systems to accommodate dining, kitchen, fitness and locker room functions. This building also includes a Conference Center, Academic Training, A/V Center and A/V Control Room.

Part III: ASHRAE 62.1- Section 6 Analysis

In section 2 above actual ventilation outdoor air flow rates have been determined from the design documents, this value must then be compared to a calculated flow rate. The outdoor air flow rates have been determined using the Ventilation Rate Procedure found in ASHRAE Standard 62.1.2007. A step by step guide can be found in Appendix A of this report. The calculations will focus on the AHU's that serve the UFAD office buildings, the AHU's that serves the Lab Spaces, and the AHU's that feed VAV boxes for overhead distribution of specialty spaces such as kitchen, fitness center, locker rooms, wellness center, ect. Since the complex is so large and contains many AHU's, one AHU will be examined for each of these different space types to ensure compliance with the standard. All population assumptions for these calculations were provided by DISA, therefore they should be accurate.

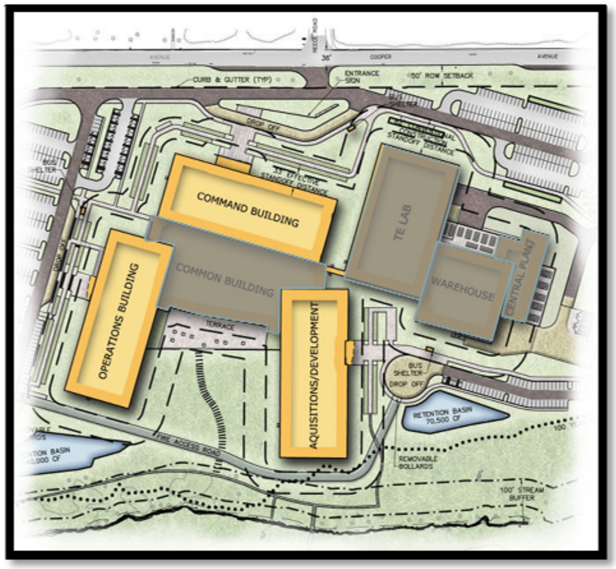


Figure 62.1.10- General Office Spaces

General Office Spaces:

In order to determine the OA requirements for the AHUs serving the UFAD system in the office buildings, a typical floor was analyzed using the ASHRAE 62.1-2007. Since the floor plan and space types in each of the office buildings, the "critical zone" for each AHU system will be the same. The center core of the 3rd floor of Command building was analyzed with the calculations shown below.

-This calculation applies to C-AHU-(1-9), A-AHU-(1-3) and O-AHU-(1-3)

-The core examined is a worst case scenario due to (7) conference rooms being located on the floor. Therefore 85% diversity factor was taken on the system population to account for some of the conference rooms being occupied by workers located on the same floor.

Figure 62.1.11- Typical Zone Breakdown for Office Buildings- Center Zone Calculated

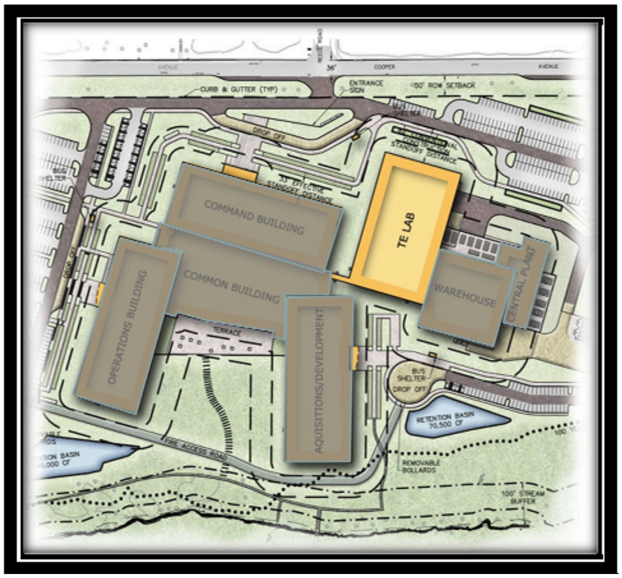


Figure 62.1.12- TE Lab

TE Lab:

The technical spaces in the Lab Building are served by a system of multiple CHW custom AHU's (L-AHU-(1-20) located in a Mechanical Room in the lab building. These AHU's can be located below in Figure 62.1.12, shaded in purple. These (20) AHU's handle all of the Sensible Loads for this space. A Dedicated Outdoor Air System (DOAS) (L-OHU-1) located on the roof will handle all Ventilation required by ASHRAE 62.1 as well as provide the dehumidification for the space. Since the lab AHU's (L-AHU-(1-20) are similar, I have provided the ASHRAE 62.1 calculation for L-AHU-1. This minimum ventilation air will be provided by L-OHU-1 located on the roof.

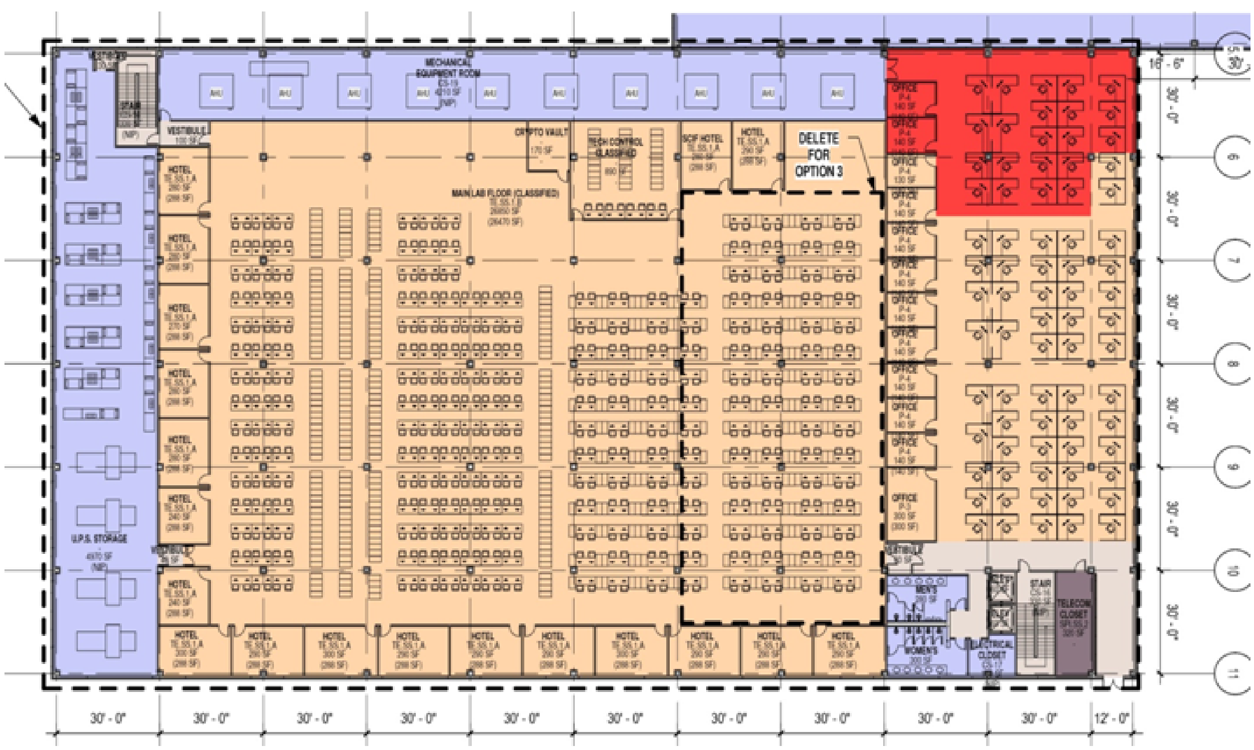


Figure 62.1.13- Lab Floor Plan

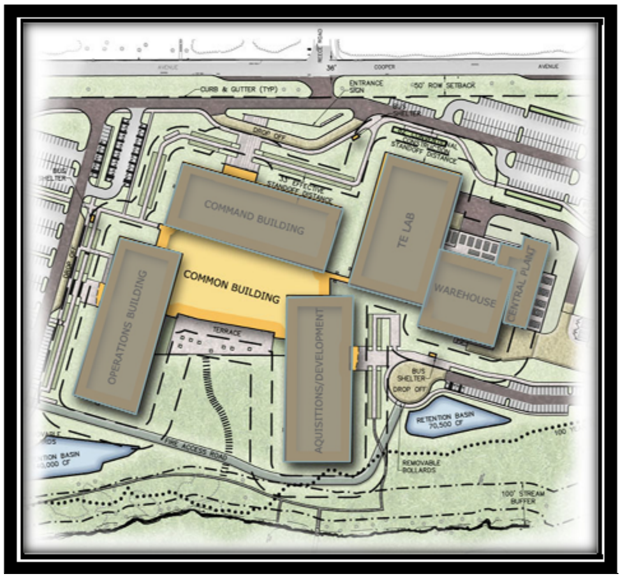


Figure 62.1.14- Common Building

A VAV system, with an AHU (M-AHU-2) on the roof of the Common Building, supplies 50°F air via a medium pressure overhead ducted system to series fan powered terminal units (SFTs), with HW heating coils and low pressure distribution ducting. The interior zones use linear slot diffusers in the ceiling. The perimeter zones use downblow linear slot diffusers above the windows. I have focused this buildings OA Requirement calculation on the Wellness Area fed by M-AHU-2.

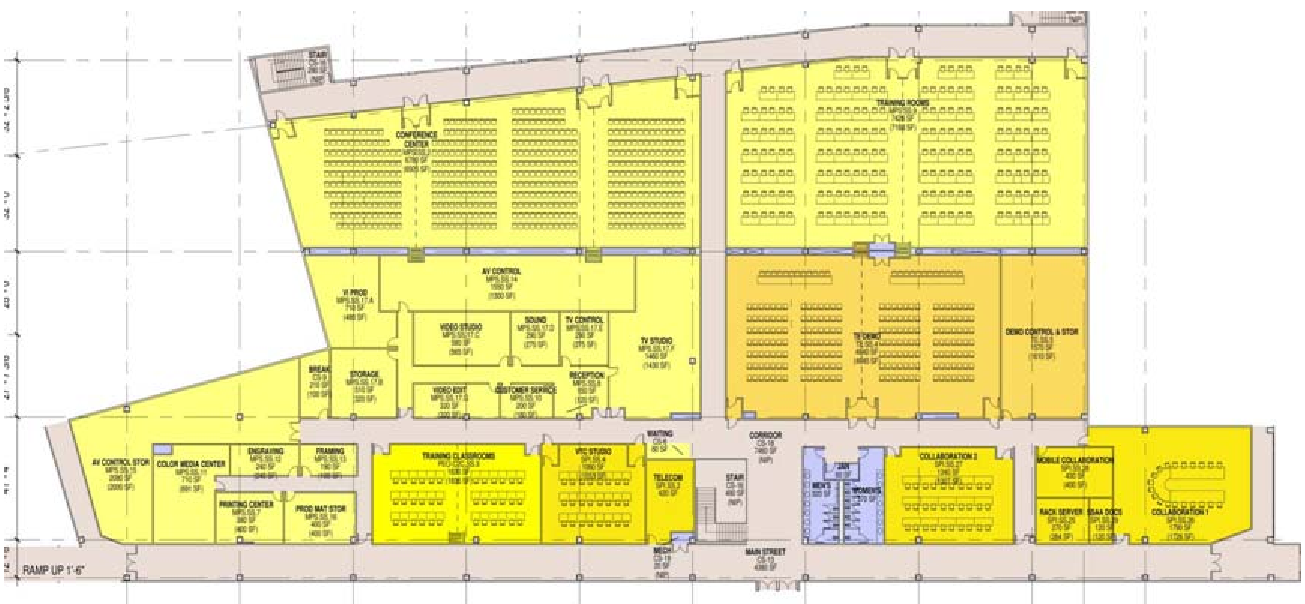


Figure 62.1.15- Common Building Floor Plan

ASHRAE 62.1 Minimum Outside Air Requirements Conclusions:

The results for the minimum OA calculations can be seen below. All of the AHU's calculated were in compliance with Standard 62.1.2007. The Lab OA requirements are handled by L-OHU-1, a DOAS system.

AHU	LOCATION SERVED	LOCATION	CFM	V_{BZ}	V_{OZ}	E	DESIGN MIN. OA	CALC. MIN. OA	COMPLIANCE
C-AHU-2	UFAD LVL. 3-5- CENTER CORE	COMMAND CENTER ROOF	32,500	3,252	32,500	1	6015	3,252	YES
M-AHU-1	COMMON-WELLNESS CNTR.	COMMON BLDG. ROOF	3,000	670.3	3,000	1	800	670.3	YES
L-AHU-1	LAB	LAB MECH. ROOM	32,000	0	0	1	0	4,285	-
L-OHU-1	LAB	LAB ROOF	10,500	10,500	-	-	10,500	4,285	YES

Figure 62.1.16- Compliance Report

SECTION 3

ASHRAE 90.1.2007 COMPLIANCE

ASHRAE 90.1 Analysis

ASHRAE Standard 90.1 is mainly concerned with the energy efficiency measures taken in designing the building. It focused on building envelope, HVAC systems, and lighting/electrical design.

Section 5-Building Envelope

This section specifies envelope glazing percentages and façade material minimum R-values.

Figure 90.1-1: East Elevation- Main DISA Entrance

Figure 90.1-2: Detail of Exterior Wall Precast

Figure 90.1-3: North Elevation

ASHRAE 90.1 Proposed Building, and as designed:

'U' Values (Btu/hr-ft²-°F)

- Roof 0.034 (R-30 equivalent)
- Walls 0.08 (R-19 equivalent)
- Glass 0.46 (Double glazed)

Glass Solar Heat Gain Coefficient (SHGC) 0.25

Equivalent Shading Coefficient ($SC = \frac{SHGC}{0.87}$) 0.29

ASHRAE 90.1 Compliance Baseline Building:

'U' Values (Btu/hr-ft²-°F)

- Roof 0.063 (R-15 equivalent)
- Walls 0.124 (R-13 equivalent)
- Glass 0.57 (Double glazed)

Glass Solar Heat Gain Coefficient (SHGC) 0.39

Equivalent Shading Coefficient ($SC = \frac{SHGC}{0.87}$) 0.45

Building Envelope Conclusion:

In conclusion, the proposed building as designed is not only in compliance with ASHRAE 90.1.2007 it goes above and beyond the baseline building as shown in the above data.

ASHRAE 90.1- Section 6- HVAC System

Economizers-

Section 6.5.1 of ASHRAE 90.1.2007 states that cooling systems with a fan must meet the specification listed in Table 6.5.1. According to this table, all systems that have an output of 65,000 BTU/Hr or greater must have an economizer. All of the systems in the DISA HQ which meet this requirement have economizers incorporate in the design; therefore this is in compliance with ASHRAE 90.1.2007

Fan Power Limitation-

Section 6.5.3.1 of ASHRAE 90.1.2007 lists guidelines for fan power limitations and shows the calculation procedure for these limitations. The results of the calculations can be found below in Table 90.1.1.

ID TAG	SERVICE	FAN AIRFLOW (cfm)	SFSIZE (hp)	ALLOWABLE (hp)	COMPLIANCE
C-AHU-1	UFAD LVL. 3-5 LEFT CORE	27,000	25	29.7	No
C-AHU-2	UFAD LVL. 3-5 CENTER CORE	32,500	30	35.75	No
C-AHU-3	UFAD LVL. 3-5 RIGHT CORE	27,500	25	30.25	No
C-AHU-4A, -4R	UFAD LVL. 6 LEFT CORE	13,750	15	15.125	No
C-AHU-5A, -5R	UFAD LVL. 6 CENTER CORE	13,750	15	15.125	No
C-AHU-6A, -6R	UFAD LVL. 6 RIGHT CORE	13,750	15	15.125	No
C-AHU-10	COMMAND LOBBY	4,000	7.5	4.4	Yes
C-AHU-11A, -11R	C-LVL 2 ELECT. RMS.	11,650	15	12.815	Yes
L-OHU-1	DOAS SYSTEM	10,500	15	11.55	Yes
L-AHU-(1-10)	LAB MLFS & HOTELS	34,000	20	37.4	No
L-AHU-(11-20)	LAB MLFS & HOTELS	32,000	20	35.2	No
L-AHU-21	LAB ADMIN	7,900	10	8.69	Yes
W-AHU-1	MAIL ROOM	1,500	2	1.65	No
W-AHU-2	MAINTENANCE	7,600	10	8.36	Yes
M-AHU-1	WELLNESS	3,000	7.5	3.3	Yes
M-AHU-2	FITNESS	8,000	10	8.8	Yes
M-AHU-3	DINING	24,680	30	27.148	Yes
M-AHU-4	TRAINING CENTER	8,500	15	9.35	Yes
M-AHU-5	CONFERENCE CENTER	21,500	25	23.65	Yes
M-AHU-6	TV STUDIO	5,500	7.5	6.05	Yes
M-AHU-7	AV STUDIO	8,200	10	9.02	Yes
M-OHU-1	DOAS SYSTEM	1,900	5	2.09	Yes
O-AHU-1	OFFICE UFAD LEFT CORE	38,000	40	41.8	No
O-AHU-2	OFFICE UFAD CENTER CORE	25,250	2 @ 20	27.775	Yes
O-AHU-3	OFFICE UFAD RIGHT CORE	22,500	2 @ 20	24.75	Yes
A-AHU-1	OFFICE UFAD LEFT CORE	27,250	2 @ 25	29.975	Yes
A-AHU-2	OFFICE UFAD CENTER CORE	31,000	2 @ 25	34.1	Yes
A-AHU-3	OFFICE UFAD RIGHT CORE	24,250	2 @ 20	26.675	Yes

Table 90.1.1: Fan Power Compliance

Fan Power Limitation Conclusion: According to these calculations, most but not all AHU fans meet ASHRAE 90.1.2007 Fan Power Limitation Compliance.

Kitchen Exhaust Hood:

There are a total of (5) Exhaust hoods in the Kitchen and Servery all of which are connected to one exhaust system with up blow discharge exhaust fans located on the roof of the Common Building. Make up-air is provided via 2'x2' perforated panels in the Kitchen ceiling allowing transfer air from the Dining area. The exhaust fans are provided with speed control via VFDs. The hoods are an advanced design, minimizing exhaust and therefore make-up air requirements to contribute to the energy savings strategy of the project. "Capture jet" fans (supplied with the hoods) are located above the ceiling, drawing air from the ceiling plenum to discharge across the face of the hoods. In addition sensors in the cooking area of the hoods vary the exhaust fan speed via the VFDs. The exhaust system is interlocked to the OA dampers on M-AHU-3 to maintain balance between the exhaust and make-up air requirements. Area CO_2 sensors in the Dining Area monitor occupancy levels and can override the make-up air control.

Kitchen Exhaust Hood Conclusion:

These energy-efficient exhaust hoods meet and exceed all compliances discussed in ASHRAE standard 90.1.2007.

Chillers:

The Central Cooling Plant consisting of four (4) Centrifugal chillers ((CHLR-(1-4)),each of 950 tons capacity which will deliver CHW at 42°F, with return water at 60°F. The refrigerant is R-134a (HFC). The chiller selection is for the lowest optimum input power, with particular emphasis on part load conditions. The chiller schedule can be found below in Table 90.1.2.

ID TAG	MANUFACTURER/ MODEL	TYPE	LOCATION	SERVICE	NOMINAL CAPACITY (Tons)	DRIVE TYPE	kW / TON AT DESIGN (ARI)	REFRIG TYPE	REFRIG QUANTITY (lbs)	NPLV
CHLR-1	CARRIER 19XRV	WATER COOLED HERMETIC CENTRIFUGAL	CHILLER RM.	HVAC CHILLED WATER	975	VFD	0.521	R-134A	2,450	0.297
CHLR-2	CARRIER 19XRV	WATER COOLED HERMETIC CENTRIFUGAL	CHILLER RM.	HVAC CHILLED WATER	925	VFD	0.551	R-134A	2,450	0.353
CHLR-3	CARRIER 19XRV	WATER COOLED HERMETIC CENTRIFUGAL	CHILLER RM.	HVAC CHILLED WATER	975	VFD	0.521	R-134A	2,450	0.297
CHLR-4	CARRIER 19XRV	WATER COOLED HERMETIC CENTRIFUGAL	CHILLER RM.	HVAC CHILLED WATER	925	VFD	0.551	R-134A	2,450	0.353

Table 90.1.2: Chiller Schedule

Chiller Conclusion:

ASHRAE Standard 90.1.2007 Table 6.8.1C states that the minimum efficiency for a water cooled, centrifugal chiller over 300 tons must be have a COP of at least 6.10. CHLR-1 & 3 have a COP of 6.74 and CHLR-2&4 have a COP of 6.38, therefore the chillers in DISA HQ are compliant.

Boilers:

The central heating plant consists of four (4) gas-fired water tube HW boilers. The plant operates at a maximum HW supply temperature of 200°F and a return water temperature of 160°F, with reset capability down to 180°F supply temperature during mild weather. The boiler schedule can be found below in table 90.1.3.

ID TAG	TURER/	MODEL	LOCATION	SERVICE	CAPACITY		(gpm)	EWT (°F)	LWT (°F)	PRIMARY FUEL		
					INPUT	OUTPUT				TYPE	MAX.	MIN. INLET
BLR-1	BRYAN RV RV SERIES	RV800-W	BOILER	HEATING HOT HOT WATER	8,000	6,720	310	160	200	NATURAL GAS	1.0	0.87
BLR-2	BRYAN RV	RV800-W	BOILER	HEATING HOT HOT WATER	8,000	6,720	310	160	200	NATURAL GAS	1.0	0.87
BLR-3	BRYAN RV RV SERIES	RV800-W	BOILER	HEATING HOT HOT WATER	8,000	6,720	310	160	200	NATURAL GAS	1.0	0.87
BLR-4	BRYAN RV RV SERIES	RV800-W	BOILER	HEATING HOT HOT WATER	8,000	6,720	310	160	200	NATURAL GAS	1.0	0.87

Table 90.1.3: Boiler Schedule

Boiler Conclusion:

ASHRAE 90.1.2007 Table 6.8.1F gives minimum efficiency requirements for gas-fired boilers. For gas-fired hot water boilers over 2,500,000 BUT/hr, efficiency must be at least 80%. The DISA HQ boilers are 84% efficient; therefore they are all compliant with ASHRAE 90.1.2007

Section 7- Service Water Heating

Electric tank type water heaters shall be used for stacked toilet areas, warehouse locker rooms, break rooms and janitor closets to serve hot water to sinks, showers and lavatories. High efficiency (90% or greater) gas water heaters shall be used in the common building to provide hot water needs to the gym locker room area and kitchen.

All Water Heaters in DISA HQ are greater than the 80% efficiency required in this section of ASHRAE 90.1-2007, therefore they are compliant.

Section 9- Lighting

The lighting was carefully design for the DISA HQ to promote energy efficiency, meet ASHRAE 90.1-2007 and earn L.E.E.D credits.

-The office buildings were arranged in order to maximize day lighting, to enhance the work environment for the occupants. The benefits of natural day lighting and views are therefore available to the general open office cubicles as well as private offices. The Building Automation System will harvest the natural light to conserve energy. These strategies will ensure the maximum LEED points are obtained for the use of day lighting.

-Circuiting of exterior light fixtures have been coordinated with the Building Automation System controls, to maximize use of day lighting as much as possible

-The use of occupancy sensors in all private offices, conference rooms, and other intermittent use spaces. Timed on/off control for all general lighting, not already controlled by occupancy sensors will be used as well.

-According to Table 9.5.1 office space must have a lighting power density of 1.0 W/ft^2. The office spaces in the DISA HQ has lighting power density of 0.7 W/ft^2.

Lighting Conclusion:

The lighting design for the DISA HQ not only meets, but exceeds ASHRAE 90.1-2007 compliance standards.

Appendix A: Calculations

Section 6.2.2.1

- $Vb_Z = R_P P_z + R_A A_z$
    - Vb_Z = Breating Zone Outdoor Air Flow (CFM)
    - R_P = Outdoor Air Flow Rate Required Per Person (CFM/PERSON)
    - P_z= Zone Population (PERSON)
    - R_A = Outdoor Airflow Rate Per Unit Area (CFM/ft^2)
    - A_z = Zone Floor Area (ft^2)

- $V_{oZ} = Vb_Z / E_z$
    - V_{oZ} = Zone Outdoor Airflow (CFM)
    - E_z= System Ventilation Efficiency

Section 6.2.2.1

- $COP_{CHILLER}=MBH_{TOTAL}/KW$

APPENDIX B: LIST OF FIGURES

ASHRAE 62.1 Ventilation Rate Spreadsheets:

Command Building-C-AHU-2

Building:	Delete Zone	Command, Acquisitions, Operations
System Tag/Name:		Built-Up UFAD System Areas
Operating Condition Description:	Add Zone	Center Core - 3rd Flr - Command Building
Units (select from pull-down list)		IP

Item	Name	Units	Notes	System	CO-3-C-Off	CO-3-C-Copy	*CO-3-C-Conf-1*	CO-3-C-Break	Check Figures / Totals/averages		
Inputs for System	**Name**	**Units**		**System**					**Check Figures**		
Floor area served by system	As	sf		20510							
Population of area served by system (including diversity)	Ps	P	85% diversity	239					11.7	P/1000 sf	
Design primary supply fan airflow rate	Vpsd	cfm		14,124					0.69	cfm/sf	
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.06					0.06	ave cfm/sf	
OA req'd per person for system area (Weighted average)	Rps	cfm/p		5.0					5.00	ave cfm/p	
Inputs for Potentially Critical zones					**Potentially Critical Zones**						
Zone Name			*Zone title turns purple italic for critical zone(s)*		CO-3-C-Off	CO-3-C-Copy	*CO-3-C-Conf-1*	CO-3-C-Break	**Totals/averages**		
Zone Tag			Show Values per Zone		enter tag	enter tag	New zone	New zone			
Space type			Select from pull-down list		Office space	Office space	Conference/meeting	Break rooms			
Floor Area of zone	Az	sf			13,790	150	230	400	14570	total sf	
Design population of zone	Pz	P	(default value listed; may be overridden)		68.95	0.75	11.5	10	91.2	total P	
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			8,682	175	255	645	9757	total cfm	
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?			Select from pull-down list or leave blank if N/A								
Local recirc. air % representative of ave system return air	Er								1.00	average	
Inputs for Operating Condition Analyzed											
Percent of total design airflow rate at conditioned analyzed	Ds	%		69%	100%	100%	100%	100%	100%	average	
Air distribution type at conditioned analyzed			Select from pull-down list		FSCR	FSCR	FSCR	FSCR			
Zone air distribution effectiveness at conditioned analyzed	Ez		Show codes for Ez		1.00	1.00	1.00	1.00	100%	average	Primary airflow rate to zones
Primary air fraction of supply air at conditioned analyzed	Ep								1.00	average	9757 cfm
Results											
Ventilation System Efficiency	Ev			**0.97**							
Outdoor air intake required for system	Vot	cfm		**2503**							
Outdoor air per unit floor area	Vot/As	cfm/sf		**0.12**							
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		**10.5**							
Outdoor air as a % of design primary supply air	Ypd	cfm		**18%**							

Item	Name	Units	Formula	System	CO-3-C-Off	CO-3-C-Copy	CO-3-C-Conf-1	CO-3-C-Break	Check	
Detailed Calculations										
Initial Calculations for the System as a whole										
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	9757					91.2	System population without diversity
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	2426					2.62	System population diversity, D
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.25						
Initial Calculations for individual zones										
OA rate per unit area for zone	Raz	cfm/sf			0.06	0.06	0.06	0.06		
OA rate per person	Rpz	cfm/p			5.00	5.00	5.00	5.00		
Total supply air to zone (at condition being analyzed)	Vdz	cfm			8682	175	255	645	9757	
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		1172.2	12.8	71.3	74.0	1330	
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		1172	13	71	74	1330	
Fraction of zone supply not directly recirc. from zone	Fa		= Ep + (1-Ep)Er =		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		
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		
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.14	0.07	0.28	0.11	0.28	Maximum Zd
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.14	0.07	0.28	0.11	0.28	Maximum Zp
System Ventilation Efficiency										
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		1.11	1.18	0.97	1.13		
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.97**						
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	0.87						
Minimum outdoor air intake airflow										
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**2503**						
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.26**						
Outdoor Air Intake Flow required to System (Table 6.3 Metho	Vot	cfm	= Vou / Ev =	2787						
OA intake req'd as a fraction of primary SA (Table 6.3 Method	Y		= Vot / Vps =	0.29						
OA Temp at which Min OA provides all cooling										
OAT below which OA Intake flow is @ minimum		Deg F	= [(Tp-dTsf)-(1-Y)*(Tr+dTr =	6						

Common Building Wellness Center- M-AHU-1

A / B	C	D	E–H	I	J	K	L	M	N	O	P	Q
Building: (Delete Zone)	**Common Building**											
System Tag/Name:	**Wellness Area - M-AHU-1**											
Operating Condition Description: (Add Zone)												
Units (select from pull-down list)	**IP**											
Floor Area of zone	Az	sf			263	148	73	162	162	230	260	256
Design population of zone	Pz	P	(default value listed; may be overridden)		3	1	1	2	2	2	0	2
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			140	80	80	100	100	120	100	140
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A										
Local recirc. air % representative of ave system return air	Er											
Inputs for Operating Condition Analyzed												
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%	100%	100%	100%	100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list	Show codes for Ez		FSCR	FSCR	FSCR	FSCR	FSCR	FSCR	FSCR	FSCR
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep											
Results												
Ventilation System Efficiency	Ev			**0.85**								
Outdoor air intake required for system	Vot	cfm		**799**								
Outdoor air per unit floor area	Vot/As	cfm/sf		**0.12**								
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		**22.2**								
Outdoor air as a % of design primary supply air	Ypd	cfm		**29%**								
Detailed Calculations												
Initial Calculations for the System as a whole												
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	2780								
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	682								
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.25								
Initial Calculations for individual zones												
OA rate per unit area for zone	Raz	cfm/sf			0.06	0.06	0.18	0.18	0.18	0.06	0.12	0.06
OA rate per person	Rpz	cfm/p			5.00	5.00	5.00	5.00	5.00	5.00	0.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			140	80	80	100	100	120	100	140
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		30.8	13.9	18.1	39.2	39.2	23.8	31.2	25.4
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		31	14	18	39	39	24	31	25
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	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	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	1.00
Unused OA fraction required in supply air to zone	Zd		= Voz / Vdz =		0.22	0.17	0.23	0.39	0.39	0.20	0.31	0.18
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.22	0.17	0.23	0.39	0.39	0.20	0.31	0.18
System Ventilation Efficiency												
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		1.03	1.07	1.02	0.85	0.85	1.05	0.93	1.06
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**0.85**								
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	0.76								
Minimum outdoor air intake airflow												
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**799**								
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.29**								
Outdoor Air Intake Flow required to System (Table 6.3 Metho	Vot	cfm	= Vou / Ev =	899								
OA intake req'd as a fraction of primary SA (Table 6.3 Method	Y		= Vot / Vps =	0.32								
OA Temp at which Min OA provides all cooling												
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTı =	13								

TE LAB- L-AHU-1

	Name	Units		System	Potentially Critical Zones	
Building: (Delete Zone)	**Lab Building**					
System Tag/Name:	**L-AHU- (1-20) - Lab Area Served with AHUs**					
Operating Condition Description: (Add Zone)						
Units (select from pull-down list)	**IP**					
Inputs for System	**Name**	**Units**		**System**		
Floor area served by system	As	sf		33500		
Population of area served by system (including diversity)	Ps	P	100% diversity	120		
Design primary supply fan airflow rate	Vpsd	cfm		307,300		
OA req'd per unit area for system (Weighted average)	Ras	cfm/sf		0.11		
OA req'd per person for system area (Weighted average)	Rps	cfm/p		5.0		
Does system have Outdoor Air Economizer		Select from pull-down list		No		
Inputs for Potentially Critical zones					**Potentially Critical Zones**	
Zone Name		*Zone title turns purple italic for critical zone(s)*			**Main Lab**	***Hotel***
Zone Tag (Show Values per Zone)					**enter tag**	**New zone**
Space type		Select from pull-down list			**Computer (not**	**Computer (not**
Floor Area of zone	Az	sf			26,310	290
Design population of zone	Pz	P	(default value listed; may be overridden)		105.24	1.16
Design total supply to zone (primary plus local recirculated)	Vdzd	cfm			230,100	2320
Induction Terminal Unit, Dual Fan Dual Duct or Transfer Fan?		Select from pull-down list or leave blank if N/A				
Local recirc. air % representative of ave system return air	Er					
Inputs for Operating Condition Analyzed						
Percent of total design airflow rate at conditioned analyzed	Ds	%		100%	100%	100%
Air distribution type at conditioned analyzed		Select from pull-down list	Show codes for Ez		FSCR	FSCR
Zone air distribution effectiveness at conditioned analyzed	Ez				1.00	1.00
Primary air fraction of supply air at conditioned analyzed	Ep					
Results						
Ventilation System Efficiency	Ev			**1.00**		
Outdoor air intake required for system	Vot	cfm		**4268**		
Outdoor air per unit floor area	Vot/As	cfm/sf		**0.13**		
Outdoor air per person served by system (including diversity)	Vot/Ps	cfm/p		**35.6**		
Outdoor air as a % of design primary supply air	Ypd	cfm		**1%**		
Detailed Calculations						
Initial Calculations for the System as a whole						
Primary supply air flow to system at conditioned analyzed	Vps	cfm	= VpdDs =	307300		
UncorrectedOA requirement for system	Vou	cfm	= Rps Ps + Ras As =	4285		
Uncorrected OA req'd as a fraction of primary SA	Xs		= Vou / Vps =	0.01		
Initial Calculations for individual zones						
OA rate per unit area for zone	Raz	cfm/sf			0.06	0.06
OA rate per person	Rpz	cfm/p			5.00	5.00
Total supply air to zone (at condition being analyzed)	Vdz	cfm			230100	2320
Unused OA req'd to breathing zone	Vbz	cfm	= Rpz Pz + Raz Az =		2104.8	23.2
Unused OA requirement for zone	Voz	cfm	= Vbz/Ez =		2105	23
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 =		0.01	0.01
Unused OA fraction required in primary air to zone	Zp		= Voz / Vpz =		0.01	0.01
System Ventilation Efficiency						
Zone Ventilation Efficiency (App A Method)	Evz		= (Fa + FbXs - FcZ) / Fa =		1.00	1.00
System Ventilation Efficiency (App A Method)	Ev		= min (Evz) =	**1.00**		
Ventilation System Efficiency (Table 6.3 Method)	Ev		= Value from Table 6.3 =	1.14		
Minimum outdoor air intake airflow						
Outdoor Air Intake Flow required to System	Vot	cfm	= Vou / Ev =	**4268**		
OA intake req'd as a fraction of primary SA	Y		= Vot / Vps =	**0.01**		
Outdoor Air Intake Flow required to System (Table 6.3 Metho	Vot	cfm	= Vou / Ev =	3759	**509.39**	
OA intake req'd as a fraction of primary SA (Table 6.3 Method	Y		= Vot / Vps =	0.01	**0.12**	
OA Temp at which Min OA provides all cooling						
OAT below which OA Intake flow is @ minimum		Deg F	= {(Tp-dTsf)-(1-Y)*(Tr+dTı =	-1152		

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