III. MECHANICAL SYSTEMS

EXECUTIVE SUMMARY

The new 40,000 sq. ft Engineering Building is to be designed with similar types and quality of systems as in the Applied Research Center. Primary function of this new building is for engineering labs, teaching labs, and offices.

New mechanical systems will be served from campus chilled water on the North side of the building and mechanical equipment located in the penthouse. Majority of level 2 will be shell space with the intent to be future lab spaces.

CODE REQUIREMENTS AND SITE-SPECIFIC CONDITIONS

The following applicable Codes, Standards and Guidelines are intended to be used to determine acceptable design criteria, standard of performance, workmanship, etc.

Applicable Codes

- 2020 Florida Building Code, Building, 7th Edition
- 2020 Florida Building Code, Mechanical, 7th Edition

Applicable Standards and Guidelines

- ANSI/ASHRAE Standard 62.1-2019 Ventilation for Acceptable Indoor Quality
- NFPA 90A-2018 Standard for Installation of Air-Conditioning and Ventilating Systems
- NFPA 101-2018 Life Safety Code

BASE DESIGN CRITERIA

Outdoor Design Conditions

		Dry Bulb Temperature (°F)	Wet Bulb Temperature (°F)	Coincident Enthalpy (btu/lb)
Summer	Cooling Design(1)	97.0	82.5	46.2
	Cooling Coil/Dehumidification Design(2)	82.0	82.0	45.8
Winter	Heating Design(3)	25.0	-	-
	Humidification Design(4)	-	21.0	-

(1) Based on the maximum Dry Bulb temperature as published in Typical Meteorological Year (TMY) data sets by the National Renewable Energy Laboratory (NREL) for Lakeland Linder Regional Airport, WMO #722119.

(2) Based on the maximum Dewpoint Temperature and corresponding Humidity Ratio as published in Typical Meteorological Year (TMY) data sets by the National Renewable

Energy Laboratory (NREL) for Lakeland Linder Regional Airport, WMO #722119. Dewpoint is converted to Wet Bulb and Dry Bulb is based on 100% RH.

(3) Based on the minimum Dry Bulb temperature as published in Typical Meteorological Year (TMY) data sets by the National Renewable Energy Laboratory (NREL) for Lakeland Linder Regional Airport, WMO #722119.

(4) Based on the minimum Dewpoint Temperature and corresponding Humidity Ratio as published in Typical Meteorological Year (TMY) data sets by the National Renewable Energy Laboratory (NREL) for Lakeland Linder Regional Airport, WMO #722119. Dewpoint is converted to Wet Bulb.

System Design Conditions

System	Design Temperature [1] (°F)	Differential Temperature [1] (°F)
Chilled Water	46	16
Chilled Beam Water	58	6
Heating Hot Water	120	20

(1) Refers to circulated fluid temperature unless otherwise indicated.

Terminal Device Design Conditions

System	Design Temperature [1] (°F)	Differential Temperature [1] (°F)
Cooling Coils	44	16
Chilled Beams	58	6
Heating Coils	120	20
General Air Handling Unit Supply Air	49	N/A

(1) Refers to circulated fluid temperature unless otherwise indicated.

Indoor Design Conditions, Ventilation Rates and Pressure Relationships

Space Criteria[1]							
Room	Temperature (°F) [2]		Humidity (%RH) [3]		Minimum Ventilation (ACH) [4]		Pressure Relationship
	Min.	Max.	Min.	Max.	Occ.	Unoc.	
Office, Conference and Administrative Support Areas	72	75	(6)	50	(5)		Neutral or Positive
Breakroom	72	75	(6)	50	(5)		Negative
Laboratory/Support Space	72	75	(6)	50	6	4	Negative

Space Criteria[1]							
Room	Temperature (°F) [2]		Humidity (%RH) [3]		Minimum Ventilation (ACH) [4]		Pressure Relationship
	Min.	Max.	Min.	Max.	Occ.	Unoc.	
Toilet rooms/Janitor Closets	72	75	(6)	50	(5)		Negative
Corridors	72	75	(6)	50	(5)		Neutral or Positive
Telecommunication Rooms	72 (year round)		(6)	50	NR		Neutral
Mechanical and Electrical Rooms	60-85°F Maximum		(6)	NR	NR		Neutral
Elevator Machine Room	75 (year round)		(6)	NR	NR		Neutral
Unoccupied Spaces	65	85	(6)	NR	NR		Neutral or Positive

(1) Minimum – Winter Heating

Maximum – Summer Cooling.

Occ. – Occupied Air Change Rate

Unoc. – Unoccupied Air Change Rate

NR – No requirement

N/A – Not applicable.

(2) Systems will be designed to meet the indicated temperature with a ± 2°F accuracy unless otherwise noted.

(3) Systems will be designed to meet the indicated relative humidity with a ± 5% accuracy unless otherwise noted.

(4) Total air changes per hour for supply air in positive pressure or neutral rooms, or return/exhaust air in negative pressure rooms.

(5) Based on Table 6-1 of ASHRAE 62.1 Standard 2019.

(6) Mechanical humidification not planned.

Assumed Heating and Cooling Loads

Internal Load Density					
Space	Lighting Density (W/sf) [1]	Equipment Density (W/sf) [1]	Occupant		
			Occupants per 1000sf [2]	Sensible BTUH [3]	Latent BTUH [3]
Offices, Conference, and Administrative Support Areas	1.1	1.5	(2)	250	200

Internal Load Density					
Space	Lighting Density (W/sf) (1)	Equipment Density (W/sf) (1)	Occupant		
			Occupants per 1000sf (2)	Sensible BTUH (3)	Latent BTUH (3)
Teaching and Engineering Laboratories	1.4	6.0	(2)	250	200
Laboratory Support Spaces (shared Equipment Spaces)	1.4	15	(2)	250	200
Computer Rooms/MDF/IDF Rooms	1.7	To be determined by actual equipment, based on an allowance of 5,000 btu/hr per rack	-	-	-
Corridor	0.7	0	None	None	None
Storage Rooms	0.7	0	None	None	None

(1) Actual load will be used where higher than the listed value.

(2) Occupant density in each space will be based on code adopted ASHRAE Standard 62.1-2019 or the actual occupant density listed in the facility program.

(3) The occupancy heat rejection will be based on ASHRAE Handbook of Fundamentals 2021.

Infiltration

The building pressurization calculations will include an infiltration load for spaces with exterior doors.

Type	Airflow
Main Exterior Doors	100 cfm per 3’0” x 7’0” door
Roll-up Doors	5 cfm per square foot of door opening area

Building Envelope

Performance criteria for building envelope construction materials will be in accordance with the data provided by Architect.

Acoustic Criteria

Sound attenuation equipment will be provided based on standard design practice. Results are not guaranteed due to many items not under control of the design team and actual building usage.

Space Type	Initial Goals for NC Levels [1]
Laboratory with one fume hood	NC 50
Laboratory without fume hood	NC 45
Support Spaces	NC 40
Lecture Hall	NC 30
Open Office	NC 40
Private Office	NC 30
Conference Rooms	NC 30

(1) Based on 2019 ASHRAE Handbook – HVAC Applications.

(2) Measured dBA values will be approximately 5 points higher than average NC levels. A space with NC-40 will have an average sound level of 45 dBA.

(3) Sound attenuation equipment will be provided based on standard design practice and recommendations from acoustical consultant. Based on past experience, sound attenuation devices may be required for main air handling units, exhaust fans, and downstream of supply air terminals for occupied spaces and upstream of exhaust air terminals for occupied spaces.

(4) Requirements and criteria will be further evaluated as design progresses

Lab Equipment Exhaust

The exhaust air requirements for fume hoods will be based on maintaining a face velocity of 80 fpm through the open sash with the sash positioned at 18" above work surface.

Acid, combustible, or flammable storage cabinets are not vented unless otherwise noted.

Hood Description/Exhaust Requirement:
6'-0" high performance vertical sash benchtop hood: 700 cfm
4" point (snorkel) exhaust: 80 ~ 100 cfm

Snorkels

The following labs will be provided with 4" point exhaust (snorkels):

- Experiential Lab
- Mechanical Engineering (ME) Lab

HVAC PIPING SYSTEMS DESCRIPTIONS

This section includes general descriptions for HVAC systems. Refer to Pipe Distribution Criteria for more detail.

Chilled Water System

System Description

Chilled water system will consist of primary pumps, secondary pumps, distribution piping, cooling coils in air handling units, fan coil units, series fan-powered terminals and/or chilled beams.

The building's estimated cooling load will be under 200 tons, accounting for passive load control, de-coupled cooling, and for 50% effective total energy recovery for the lab system. If the energy recovery is out of service for maintenance or any type of failure, to remain under 200 tons during peak outside air cooling conditions the actual diversity in the building would have to be no greater than 75%.

Chilled water will be supplied to the building by the secondary pumps in the Central Utility Plant (CUP). Tertiary building pumps will be provided to circulate chilled water throughout this facility.

An automatic by-pass valve will be provided to by-pass the tertiary building pumps whenever there is sufficient pressure from the secondary pumps to serve the building.

Chilled water system will be variable volume system utilizing a modulating 2-way control valve at cooling coils of each cooling coil. Each tertiary distribution pump will be provided with variable frequency drive (VFD).

A differential pressure transmitter between the chilled water supply and return mains will be utilized to vary the speed of the pumps, via VFDs, to maintain a constant differential pressure between the piping mains.

An automatic bypass valve in the building be provided to maintain minimum differential pressure between supply and return pipes when one pump is operating at minimum speed.

Chilled water usage will be metered via automated BTU meter with flow rate, supply temperature and return temperature input. Data will be input to Building Automation System (BAS).

Equipment and Components

Chilled water tertiary pumps will be end suction type with a variable frequency drive.

The chilled water system will also include the following components:

- Cooling coils
- Appropriate valving and piping specialties

Subcircuits will be selected for linear control characteristics of the terminal device and control valve combination.

All major control valves will be sized by engineering calculations for linear control.

Sensible-only Cooling System

System Description

Sensible cooling coils will be piped to zone-level terminal coils throughout the facility, the extent that is appropriate without the risk of condensation.

Sensible-only cooling water will be generated by utilizing chilled water supplied from the Central Utility Plant (CUP) through blending loop.

Sensible-only cooling water system will consist of distribution pumps and piping and will be used to meet sensible cooling requirements for spaces.

Equipment and Components

Distribution pumps will be end suction type.

Subcircuits will be selected for linear control characteristics of the terminal device and control valve combination.

Heating Hot Water System

System Description

Heating hot water system will serve AHU heating coils and reheat coils.

Heating hot water system will be variable volume system utilizing a modulating 2-way control valve at each terminal heating device. Distribution pumps will each be provided with VFD.

A differential pressure transmitter between the supply and return mains will be utilized to vary the speed of the pumps, via variable frequency drives, to maintain a constant pressure differential between the piping mains.

An automatic bypass valve in the building be provided to maintain minimum differential pressure between supply and return pipes when one pump is operating at minimum speed.

Equipment and Components

Hot water boiler will be water tube type with sealed combustion with natural gas burner.

Distribution pumps will be base mounted end suction centrifugal type with VFDs.

The heating and reheat water system will also include the following components:

- Chemical pot feeder
- Air separator
- Bladder type expansion tank
- Make-up water assembly
- Heating coils
- Appropriate valving and piping specialties

Pipe Distribution Criteria

Piping Distribution Criteria			
System	**Material**	**Size Criteria**	**Pipe and Fitting Insulation**
Chilled Water and Sensible-only Cooling Water	Type L copper piping with soldered fittings for pipes 2" and smaller and ST carbon steel piping with welded fittings for pipes 2-1/2" and larger. Grooved end steel piping and fittings are optional only in mechanical rooms in lieu of welded fittings. Unions will not be provided at terminal heating devices in copper piping.	Maximum pressure drop of 4 ft of water/100 ft of pipe for piping 6" or smaller. 10 fps maximum velocity for piping 8" and larger.	Closed cell type insulation with appropriate insulation jacket.
Chilled Water (Below Ground)	Piping will be pre-manufactured insulate piping (standard weight carbon steel carrier pipe, 2" polyurethane insulation and 200 mil HDPE outer jacket) or field fabricated pipes.	Maximum pressure drop of 4 ft of water/100 ft of pipe for piping 6" or smaller. 10 fps maximum velocity for piping 8" and larger.	2" polyurethane insulation with appropriate insulation jacket
Heating Hot Water	Type L copper piping with soldered fittings for pipes 2" and smaller and ST carbon steel piping with welded fittings for pipes 2-1/2" and larger. Grooved end steel piping and fittings are optional only in mechanical rooms in lieu of welded fittings. Unions will not be provided at terminal heating devices in copper piping.	Maximum pressure drop of 4 ft of water/100 ft of pipe for piping 6" or smaller. 10 fps maximum velocity for piping 8" and larger.	Rigid glass fiber insulation with appropriate insulation jacket

HVAC AIR SYSTEMS DESCRIPTIONS

This section includes general descriptions for HVAC air systems. Refer to Duct Distribution Criteria for more detail.

Air Handling Systems

System Description

Office, Dry Laboratory and Administrative Support Areas

Factory packaged air handling units will serve the office and administrative support areas.

System will be a single duct variable air volume reheat system, providing heating and cooling to the spaces.

Air will be supplied to all appropriate spaces and a portion of this air will be returned to the air handling units or relieved to outside via return fans. The remaining portion of air not returned to the air handling units will be utilized as make-up air for the exhaust systems and for building pressurization.

Return air ceiling plenum will be used to return air from the spaces back to AHUs.

Air handling system will operate 10 hours per day, 5 days per week. Air handling system will operate with occupied, unoccupied and morning warm-up control cycles.

<u>Wet Laboratory Air Handling Systems</u>

Factory packaged air handling unit serves the wet laboratory spaces.

System will be single duct, variable air volume, reheat system, providing heating, and cooling to the spaces.

Fixed-plate heat exchangers will be provided to recover energy from lab general exhaust systems

Air supplied to all spaces will be exhausted to outdoors. No air from the laboratory or support spaces will be returned to the air handling unit.

Air handling unit will operate 24 hours per day, 365 days per year.

<u>Mechanical Room Air Handling Systems</u>

A minimum of one air handling unit will provide cooling air for each mechanical, electrical, and telecommunications room. Systems will be single duct, constant air volume with return air. No outside air will be provided.

Systems will consist of packaged fan coil units.

Systems will cycle with load.

Equipment and Components

Components(1)	AHU Systems		
	Office, Dry Laboratory and Administrative Support Areas	Wet Laboratory Air Handling Systems	Mechanical Room
Outside Air Intake Damper	X	X	N/A
Hot Water Preheating Coil		X	None
Chilled Water Cooling Coils	X	X	X
Supply Fan Arrangement	Multi-fan array(2)	Multi-fan array(2)	One DWDI Centrifugal
Supply Fan to VFD ratio	Multiple	Multiple	No VFD

Components(1)	AHU Systems		
	Office, Dry Laboratory and Administrative Support Areas	Wet Laboratory Air Handling Systems	Mechanical Room
Sound Attenuator	Duct Mounted Supply and Return Air	Duct Mounted Supply	None
MERV 7, 2" Prefilters	X	X	X
MERV 13 Cartridge Final Filters	X	X	None
UV Radiation Lights downstream of cooling coil	X	X	None
Isolation/Smoke Dampers	X	X	None
Electronic Airflow Measuring Stations	X	X	None
Return Fan Arrangement	Ducted Inline or Floor Mounted Centrifugal	None	None
Return Fan to VFD ratio	1:1	N/A	N/A
Return Air Damper	X	N/A	N/A
Relief Air Damper	X	None	None

(1) Components are not listed in airflow tunnel order.

(2) Quantity of fans dependent on size of unit. Utilize economies of scale to select the appropriate number of fans for each individual unit.

Supply fans will be plenum type with airfoil blades. Fan speed and air volume will be modulated through variable frequency drives (VFDs) controlled by supply duct static pressure controller.

Return fans will be single width single inlet centrifugal or mixed flow type with air foil blades. Fan speed and air volume will be modulated through VFDs controlled by return fan discharge static pressure controller.

Design Criteria

Air Handling Unit Maximum allowable nominal face velocities at Maximum airflow	
Air Intake Louvers	400 fpm through free area of louver
Intake Hoods	400 fpm through free area of louver
Relief Hoods	800 fpm through free area of louver
Hot Water Heating Coils	650 fpm
Chilled Water Cooling Coils	450 fpm
Pre-filters	500 fpm
Final-filters	500 fpm
Sound Attenuating Devices	Located in AHU: 500 fpm Located in ductwork: Maximum 1,200 fpm or maximum 0.25" w.g.

Laboratory Exhaust Systems

System Description

<u>Laboratory General Exhaust System</u>

Laboratories will be served by a central exhaust air system. The system will combine snorkels and canopy hood exhaust used to capture heat with general room exhaust. Exhaust from steam sterilizer rooms will also be served by the lab general exhaust system.

Laboratory exhaust system will be variable air volume. Fan speed and air volume will be modulated through VFDs controlled to in response to supply and flow rates to maintain space pressurization.

System will operate 24 hours per day, 365 days per year.

<u>Fume Hood Exhaust System</u>

Laboratory fume hoods will be served by a central exhaust air system. The system will combine fume hoods with biosafety cabinet exhaust. Exhaust from gas cylinder storage rooms will also be served by the fume hood exhaust system.

System will consist of exhaust fans connected to a common exhaust fan inlet plenum and will be located on the roof. The fans are intended to operate in parallel and will each be sized for a fraction of the design load.

Laboratory exhaust system will be variable air volume. While the system is variable air volume the exhaust fans operate at constant volume to maintain a constant stack discharge velocity. A static pressure sensor in the exhaust fan inlet plenum modulates an outside air bypass damper, introducing the required outside air into the plenum to maintain a constant flow rate through the fans.

System will operate 24 hours per day, 365 days per year.

Equipment and Components

Components	Laboratory General Exhaust System	Fume Hood Exhaust System
Common exhaust fan intake plenum		X
Sound attenuating device.	X	X
Isolation damper at each fan inlet.	X	X
Roof mounted downblast centrifugal fan	X	
SWSI Centrifugal fans		X
Exhaust stack for each fan discharge.		X
Outside air bypass with sound attenuating rain hood and control damper.		X

Exhaust fans will be of AMCA Class "B" or "C" spark-resistant construction with bearings and motors out of the air stream, with final determination made during the detailed design phase.

Fans will have corrosion resistant coating on surfaces in contact with air stream

Induced flow exhaust fans will be used to dilute contaminated air at the stack outlet and increase outlet air volume.

Fans will have packless type sound attenuating devices on the exhaust main.

Air Terminal Devices

Individual spaces up to two spaces having a common exterior exposure or a common interior space, and common occupancy, will be served by one supply air terminal (AT) device.

One air terminal device will be provided where individual space temperature control is required.

Air terminal devices will be utilized for fume hoods, snorkel exhausts, and general exhaust.

Air Terminal Devices			
Spaces and System	Service	Type	Sound Attenuation

General	Supply	Galvanized steel single blade damper ATs will have internal liner with airflow measuring ring. [1]	(2), (3)
	Return and Exhaust	Galvanized Steel single blade damper ATs will have internal liner with airflow measuring ring. [1]	(2), (3)
General Lab	Supply and Exhaust	Pressure independent ATs will have characterized plunger and fast acting 24V actuator. Supply air terminal devices will have sensible-only cooling devices where sensible cooling would otherwise drive airflow requirements.	(3)
Specialty Lab Exhaust	Fume Hood Exhaust	316 stainless steel, variable volume pressure independent ATs will have characterized plunger and fast acting 24V actuator.	(3)
Secondary Sensible-only Cooling	Supply	Fan Coil Units with Supply and Return Ducts OR Active Chilled Beams with 1-Way, 2-Way, or 4-Way Throw OR Series Fan-Powered Terminal Units with Supply and Return Ducts	(2), (3)

(1) ATs will be provided with system pressure independent DDC controllers with 24 V electric actuators.

(2) Ductwork will not be lined. Sound attenuating flexible duct up to 6 ft in total length, will be provided at the diffusers and grilles to control noise. Sound attenuators at the discharge of supply and inlet of exhaust/return air terminal devices will be provided to meet noise criteria.

(3) Sound attenuating flexible duct up to 6 ft in total length, will be provided at diffusers and grilles to control noise. Sound attenuators at the discharge of supply and inlet of exhaust/return air terminal devices will be provided to meet noise criteria.

General Exhaust Systems

System Description

General Exhaust System

The system will service toilet rooms, janitor's closets, etc.

System will consist of multiple exhaust fans that will be controlled via occupied/unoccupied control.

System will consist of exhaust fans located on the roof.

The exhaust system will be constant volume.

Equipment and Components

Exhaust Components	General Exhaust Systems
Inline or Roof-mounted downblast centrifugal fan	X
Fan Inlet Side Sound Attenuator	X
Automatic damper	X

Ductwork Systems

Ductwork will be constructed in accordance with SMACNA Standards for appropriate pressure class. Ductwork will be sealed to meet SMACNA Seal Class A as a minimum and to limit ductwork leakage not exceeding 1% of the design flow rate for high pressure ductwork and 2% for low pressure ductwork.

Supply and Return/Exhaust System with Air Terminals

Description	Construction	Design Criteria	Insulation
Air Handling Unit to Air terminal (AT) Device	Galvanized Steel +6" Pressure Class	(1)	Fiberglass insulation
AT Device to Supply Diffuser	Galvanized Steel +2" Pressure class Ductwork will be lined for 5 ft downstream of air terminal devices	(2)	Fiberglass insulation
Return/Exhaust Fan to AT Device	Galvanized Steel (-4)" Pressure class	(1)	None
AT Device to Return/Exhaust Grille	Galvanized Steel (-2)" Pressure class	(2)	None

(1) Maximum pressure drop of 0.15"/100 ft when ≤ 10,000 cfm

Maximum velocity of 2,000 fpm when > 10,000 cfm

Maximum velocity of 2,500 fpm when > 10,000 cfm in mechanical room, risers in shafts, and where space constraints dictate quantity of fans dependent on size of unit. Utilize economies of scale to select the appropriate number of fans for each individual unit.

(2) Maximum pressure drop of 0.1"/100 ft when ≤ 8,000 cfm

Maximum velocity of 1,600 fpm when > 8,000 cfm

Lab Exhaust

System	Construction	Design Criteria	Insulation
From Equipment, Grille, etc. to Air Terminal Device	(-2)" Pressure class 316 stainless steel, all welded construction	(1)	None
Exhaust Fan Stack Discharge Velocity	+10" Pressure class 316 stainless steel, all welded construction	(3)	None

(1) Maximum pressure drop of 0.1"/100 ft when ≤ 8,000 cfm

(2) Maximum pressure drop of 0.15"/100 ft when ≤ 10,000 cfm

Maximum velocity of 2,000 fpm when > 10,000 cfm

(3) Nozzle velocity 3000 - 3500 fpm

Miscellaneous Systems

Technology Space Cooling

Intermediate Distribution Framework (IDF) Rooms that require cooling will be provided with self-contained fan-coil units to maintain required space temperature.

Unit to include supply fan driven, filters, and DX cooling coil.

Energy Conservation Measures

Life Cycle Cost Analysis

Energy conservation measures will be evaluated using a life cycle cost analysis based on a whole-building energy simulation tool in accordance with Appendix G of ASHRAE 90.1-2019. The following energy conservation schemes will be included in the design based on the results of this analysis:

Demand-Controlled Ventilation

Active Chilled Beams

Outside Air Preconditioning with Energy Recovery

Office, Dry Laboratory and Administrative Support Areas

1). Conditioning of ventilation air will be de-coupled from space conditioning using secondary sensible-only cooling at the terminal devices such as fan coil units, series fan-powered terminal units or active chilled beams.

2). Demand control ventilation and variable air volume control will be implemented.

Wet Laboratory Air Handling Systems

1). Fixed plate energy recovery will be provided to precondition outside air with laboratory general exhaust air.

2). Conditioning of ventilation air will be de-coupled from space conditioning using secondary cooling at the terminal devices such as fan coil units, series fan-powered terminal units or active chilled beams.

3). Variable air volume control will be implemented.

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