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BULLETIN
TO
DESIGN AND CONSTRUCTION PROFESSIONALS

Date: December 17, 2020

Bulletin: 0005 – 2020

Section: 23 00 00 – Heating Ventilating and Air Conditioning (HVAC) Systems

Re: APS Design Guidelines and Standard Specifications Update

Item 1: This is a clarification, change or addition to the existing Atlanta Public Schools (APS) Design Guidelines and Standard Specifications dated December 1, 2010 and any previous Bulletins.

Item 2: This set of requirements and specifications should be implemented IMMEDIATELY on all projects that are in the "Construction Document" phase of the project delivery process. On projects where the "Construction" has begun, these requirements and specifications should be implemented IMMEDIATELY, WHERE PRACTICAL as to not adversely impact the schedule, budget or overall delivery of the project.

Item 3: The existing APS Design Guidelines for Division 23 00 00, Heating, Ventilating and Air Conditioning (HVAC) Systems should be replaced in entirety by the attached updated version (dated December 16, 2020). See the attached Summary of Changes, dated December 16, 2020.

Jere J. Smith III, AIA
Director of Capital Improvements

Summary of Changes
Atlanta Public Schools
HVAC Guidelines, dated March 24, 2020
December 16, 2020

Section 23 05 00 Common Work Results for HVAC -1:
1.2 General Equipment Installation Requirements, Add (B) Paragraph & Paragraph Line 2

Section 23 09 13 Instrumentation and Control Device for HVAC -1:
General Requirements Paragraph B, Line 2 & Page 2, Paragraph C, Add Line l

Section 23 50 00 Boilers:
1.2 General Boiler Requirements, Paragraph (B)

Section 23 64 00 Chillers:
1.2 General Requirements, Paragraph (A)

Section 23 73 00 Indoor Central Station Air Handling Units:
1.2 General Indoor Central Station Air Handling Unit Requirements, Line (A) and (W)

Section 23 74 00:
1.2 General Packaged Outdoor HVAC Equipment Requirements, Paragraph (A) and (Y)

Section 23 74 33:
1.2 General Dedicated Outdoor Air and Energy Recovery unit Requirements, Paragraph (A) and (Z1.a)
1.3 General Split Dedicated Outdoor Air Unit Requirements, Paragraph (A) and (S)

Section 23 81 29 Variable Refrigerant Flow Systems:
1.2 General Variable Refrigerant Flow System Requirements, Paragraph (A) and E line 3
1.5 Indoor Unit Requirement, Paragraph (J)

Section 23 81 46 Water Source Heat Pump Located in Corridors or Mezzanine:
1.2 General Water Source Heat Pump Requirements, Paragraph (A) Line 6.
1.4 Water Source Heat Pump located in Classroom, Paragraph (A) Line 3

Atlanta Public Schools

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Standards
for
HVAC Systems, Equipment and Controls

December 16, 2020

Approved by:

12-17-2020

Roderick Rayner — Date
HVAC Service Manager

Approved by:

12.17.2020

Robert Palmer — Date
Director of Operations and Maintenance

Table of Contents

SECTION 23 00 10 - MECHANICAL GENERAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Objectives
   2. HVAC General Requirements
   3. Warranties and Guarantees
   4. HVAC Training
   5. Documentation

B. Legend:
   1. APS: Atlanta Public Schools
   2. AHU: Air Handling Units
   3. BMS: Building Management System
   4. CO2: Carbon Dioxide
   5. DDC: Direct Digital Control System
   6. DOR: Designer of Record
   7. ERU: Energy Recovery Unit
   8. MEP: Mechanical, Electrical, Plumbing
   9. OA: Outside Air
   10. O&M: Operation and Maintenance
   11. P&ID: Process and Instrumentation Drawing
   12. PTAC: Packaged Terminal Air Conditioner
   13. VRF: Variable Refrigerant Flow
   14. VRFC: Variable Refrigerant Fan Coil

1.2 OBJECTIVES

A. Reliability – The systems must be designed to operate under a wide range of weather, occupancy, and building use conditions to continually provide the optimum learning and teaching environment for students and faculty. Systems must include a full complement of controls and safety devices to protect operators and the equipment. The system must operate with minimum preventive maintenance and intervention by Atlanta Public Schools personnel at the schools.

B. Maintainability – To ensure proper maintenance for systems maintained by Atlanta Public Schools mechanics, equipment must be installed so that it can be readily accessed and rapidly serviced with minimum disruption and/or interference with the teaching and learning process. Provide clearances for Air Handling Equipment to allow the removal and replacement of coils, motors, fans, valves and control devices. Equipment mounted above suspended ceiling shall be no more than two (2) feet above the grid. Match locations using reflective ceiling plans and lighting locations to be above clear tile areas for removal from ceiling spaces with minimal grid and light removal.

C. Performance – The system must be able to meet specified design parameters under actual seasonal load conditions. The HVAC system shall be commissioned by a third-party Commissioning Provider (CxP), using the guidelines for Commissioning of HVAC Systems as set forth in ASHRAE Standard 202-2018 and Guidelines 1-2005 (as revised). The Commissioning process must begin with the Pre-Design phase of construction/renovation.

D. Energy Efficiency – The system and equipment must be designed with concern for total energy consumption of all components, while still meeting the requirements for proper Indoor Air Quality, Ventilation and Humidity Control. Design must conform to guidelines contained in ASHRAE 62.1-2016 Ventilation for Acceptable Indoor Air Quality.

1.3 HVAC GENERAL REQUIREMENTS

A. Philosophy – Atlanta Public Schools is committed to providing its Education Facilities with HVAC systems that are simple; operate efficiently; are easily maintained and accessible for service; and reliably provide the proper occupant comfort to facilitate the learning and teaching process in our schools.

B. Goals:
   1. The overall goal for environmental control systems is to continually maintain environmental conditions as specified by the designed parameters of every controlled space, and do so at optimum operating, energy and maintenance cost.
   2. The overall goal for the Building Management System (BMS) is to provide the highest level of automation for the building and its HVAC systems, to provide alarm and management reporting, control monitoring adjustments, simplicity and to interface with other APS installed automation systems.

C. Code and Standards – Codes and Standards establish only the minimum requirements for the work. If the Contract Documents exceed requirements of the Codes and Standards, do not reduce the quality of the design, or eliminate future capacity/options without review and acceptance by the Atlanta Public Schools PM. Unless otherwise indicated, all mechanical work shall comply with the latest editions of the Standard Specifications, Design Guidelines and listings of the following organizations:
   1. Underwriters Laboratories, Inc. (UL).
   2. National Fire Protection Association (NFPA Gas Standards, NFPA 90A; NFPA 96).
   3. American National Standards Institute (ANSI).
   4. American Society of Heating, Refrigerating and Air Conditioning engineers (ASHRAE).
   5. ASHRAE 62.1-2016 Ventilation for Acceptable Indoor Air Quality
   6. Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
   7. AGA –Natural Fuel Gas Code and Regulations of the Gas Company.
   8. International Building Code, 2012 Edition, with Georgia Amendments (2014) (2015) (2017)
   9. International Residential Code, 2012 Edition, with Georgia Amendments (2014) (2015)
   10. International Fire Code, 2012 Edition, with Georgia Amendments (2014)
   11. International Plumbing Code, 2012 Edition, with Georgia Amendments (2014) (2015)
   12. International Mechanical Code, 2012 Edition, with Georgia Amendments (2014) (2015)
   13. International Fuel Gas Code, 2012 Edition, with Georgia Amendments (2014) (2015)
   14. National Electrical Code, 2014 Edition, with no Georgia Amendments
   15. International Energy Code, 2009 Edition, with Georgia Supplements and Amendments (2011) (2012)
   16. 2012 NFPA 101 - Life Safety Code with State Amendments (2013)
   17. All applicable federal, state, and local laws, ordinances and rulings of Government Officials having jurisdiction.

D. Space Requirements
   1. Equipment:
      a. Ensure optimum use of available space for materials and equipment installed above ceilings. Allocate space in the order of priority as listed below except as otherwise detailed. Items are listed in the order of priority, with items of equal importance listed under a single priority number.
         1) Gravity flow piping systems (no condensate pumps)
         2) Vent piping systems
         3) Recessed lighting fixtures
         4) Concealed HVAC terminals and equipment
         5) Air duct systems
         6) Sprinkler piping systems
         7) Pressurized piping systems
         8) Electrical conduit, wiring, control air tubing
         9) Refrigerant Piping for VRF systems
      b. Order of space priority does not dictate installation sequence. Installation sequence shall be as required to install all affected trades.
      c. The work of this Division 23 shall not obstruct access for installation, operation and maintenance of the work of any other Division.
      d. All major items of equipment shall be arranged to provide a minimum of 28" clear aisle space. Additional space shall be provided between and around equipment for maintenance and proper operation as shown in the equipment manufacturer's literature.

E. Coordination
   1. Coordinate all work under this Division 23 with work under all other Divisions, providing adjustment as necessary.
   2. Projects over $12,000,000 and/or 125 K sq. ft. require a MEP specialist employed by the GC/CM to coordinate MEP and Commissioning activities.
   3. Coordination of space requirements with respect to Division 26 shall be performed such that:
      a. No equipment, piping or ductwork, other than electrical, shall be installed within 42" of switchboards or panelboards.
      b. No piping or ductwork which operates at a temperature in excess of 120°F shall be installed within 3" of any electrical conductors.
   4. All items mounted in or below the ceiling, and all items penetrating the ceiling, shall be coordinated with the architectural reflected ceiling plans. If any items are not shown on these plans, or any items need to be relocated for coordination purposes, prepare a reflected ceiling plan and submit it to the Owner for approval.
   5. Mechanical Shop Drawings are a requirement on new mechanical systems. They shall be reviewed and approved by the Mechanical Engineer.

F. Code Compliance
   1. All workmanship and materials provided under this Division 23 shall comply with all laws, ordinances, codes and regulations of all Federal, State and Local Authorities having jurisdiction.
   2. All fire suppression, plumbing, heating, ventilating, and air conditioning materials and workmanship shall comply with all applicable state and local codes and standards as minimum requirement.
   3. Secure and pay all fees associated with all permits and licenses required for execution of the Contract. Arrange for all inspections required by city, county, state and other authorities having jurisdiction, and deliver certificates of approval to the Owner.

G. The code requirements are strictly a minimum and shall be met without incurring additions to the Contract. Where requirements of the drawings or specifications exceed the code requirements, the work shall be provided in accordance with these drawings or specifications. In the event of conflict or ambiguity between the various codes, the most stringent requirement shall govern.

H. Existing Conditions shall be documented for all work conducted in existing building. This includes HVAC equipment, accessories, and structures. Document means pictures and written description of items. If existing items need to be repaired/replaced, notify APS so repairs can be made by APS or included in current project.

I. Design and operation of Special Areas:
   1. Provide air conditioning system that should be available on a 24-hour temperature control system, occupancy schedule and designed with a varying occupant load consideration determined by APS for:
      a. Administrative Office (no voting system shall be used)
      b. Media Center
      c. Multi-Purpose or Gym
      d. Cafeteria
      e. Auditorium
      f. Special Needs Classrooms
      g. IDF/MDF rooms (shall be on a separate DX unit with 24/7 operation and under DDC control/monitoring).
   2. Dry Storage area:
      a. Location of the dry storage area shall be located adjacent to food preparation areas and convenient to receiving.
      b. Environment of the dry storage area shall be free of uninsulated steam and water pipes, water heaters, transformers, refrigeration condensing units, steam generators or other heat producing equipment. The area shall be well ventilated and maintained at 50°F (10°C) to 70°F. Humidity sensors shall be installed, and space shall be no greater than 60% RH.
   3. HVAC designs must consider the new technology heat load requirements of school classrooms, Media Center, Kitchen, and other areas which impact on electrical and HVAC systems.

4. Kitchens
    a. In most instances, school kitchens are open to the cafeteria areas and thereby influence the proper condition of the cafeteria.
    b. The kitchens shall be provided with effective heating, air conditioning and ventilation to ensure a proper working environment, while not affecting the ability to maintain proper hot food temperatures.
    c. Make-up air with gas heat shall be provided inside the hood to compensate for range hood exhaust and other vented heat producing equipment.
5. Kitchen Office
    a. Area shall be conditioned, separately from the kitchen area with a PTAC, small dx split system or VRF system.
6. Multi-Purpose Rooms/ Buildings
    a. Equipment Access – Special Conditions: Provide provisions for the access to all equipment in gyms, multi-purpose rooms, theaters and auditoriums installed 20 feet or over.
    b. All A/C equipment such as Roof Top Units, ERU, ERV should be roof or ground mounted.
7. Corridors
    a. Humidity sensors shall be installed in the corridors 8’ from the floor.
    b. Humidity sensors may be installed in return plenums.
    c. Temperature sensors shall be flat plate sensors.
    d. Equipment may use return temperature sensors in lieu of flat plate sensors.
8. Classrooms
    a. Humidity sensors may be installed in return plenums or adjacent to temperature sensors or as a wall mounted combination temperature/humidity sensor.
9. Mark ceilings with location of HVAC equipment and valves including automation repeaters and junctions.

J. Equipment Sound Levels
1. Air Conditioning Equipment Sound Levels – Within the Air Conditioning Industry, ARI Standard 270-84, “Sound Rating of Outdoor Unitary Equipment” and ARI Standard 275-84 are widely accepted procedures for sound rating of equipment and conversion of sound rating to sound pressure levels. The procedure accounts for major acoustical factors such as distance, reflecting walls and sound barriers. Several alternate locations for equipment shall be evaluated, for the impact of sound on neighbors, before actual installation of equipment. If there appears to be a problem during the planning stage, then the options still include choosing an alternate location, quieter equipment, and/or the application of several methods of noise control.
2. Comply with the “Excessive Noise” requirements, refer to Atlanta City Code Section 74-133. Exceeding ambient sound level by 10-15dB could be considered a nuisance. Non-compliance to the City Code is not acceptable to Atlanta Public Schools and an action plan is required to improve the situation.

K. Energy Efficient Mechanical Systems:
1. Design for “Average Load” – Heating and cooling equipment is most efficient when sized for the “average load” condition, not the “peak” or extreme condition. It is therefore; best to use modular unit boilers, chillers, pumps and fans in series so that the “average” operating load can be met. Cooling Towers are to be designed for maximum loads.
2. Design for “Predominant Load” – The distribution system should be designed for the predominant load, not the sum of the peak loads. The distribution system should be zoned to meet varying and different loads based on location, hours of use, and type of activity.
3. Decentralized Air Handling Units (AHU) – Decentralized air handling units have smaller trunk lines and duct losses. Dispersed AHUs located close to the end of the point-of-use can be reduced in size if hot and chilled water is piped to them.
4. No diversity factors or percentages shall be used for the classroom HVAC loads.

L. Energy Use Target:
   1. Total Energy Use Target – The total energy use target shall be between 30 and 70 BTU/SF/YR.
   2. Educational Buildings Energy Load Targets:
      a. 40% Heating Load
      b. 20% Cooling Load
      c. 30% Lighting Load
      d. 05% Fan Load
      e. 05% Other Load
      f. 100 %

M. Humidity control shall be provided for all areas except toilet rooms, janitor's closets and kitchens. Toilet room exhaust fans shall be connected to the building automation system and shown on the graphics with a representation of actual location.

N. Ducted returns preferred over open return plenums.

O. Electric heaters in toilet rooms and stairwells shall be ceiling mounted and/or out of reach of students.

P. Outside air shall be delivered and controlled by "demand ventilation" using CO2 monitoring with humidity override per occupant per ASHRAE 62.1-2010.

Q. Provide Energy Recovery Units and or Dedicated Outdoor Air Units for all OA delivery. Include factory installed automation system controls. Accepted manufacturers include: AAON, Annexair, Daikin, GreenHeck, INNOVENT, and TRANE.

R. Provide pool dehumidification units for all facilities with indoor swimming pools.

S. All roof top equipment higher than 2 feet off the roof shall have a platform for maintenance access.

T. All equipment on the roof shall be mounted on curbs or rails.

U. Freeze-proof domestic water hydrant on roof within 50 feet of equipment for cleaning HVAC coils.

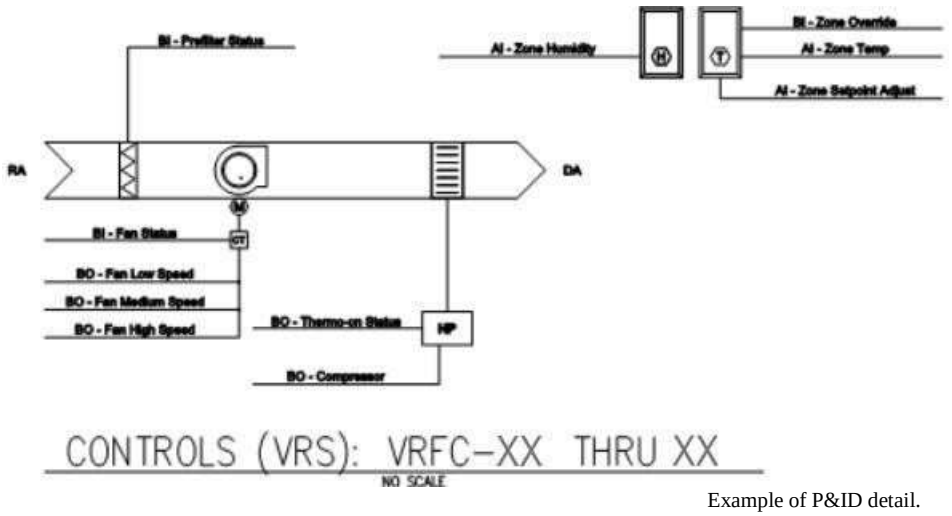
V. Design condition should meet ASHRAE 2.5% conditions.

W. Indoor design conditions:
   1. 50% RH (Adjustable / Range 50% to 60%. 60% begins dehumidification)
   2. Heating 70°F (Adjustable)
   3. Cooling 74°F (Adjustable)
   4. Room Thermostats/ sensors w/ +/- 3°F occupant adjustable range w/ unoccupied mode override (lockable from front end)
   5. CO_2 sensors

X. Additional Drawing Requirements for DOR
   1. Legends shall be included on the mechanical plans.
   2. When applicable, demolition drawings shall be provided.
   3. Provide elevation and layout plans for main mechanical rooms.
   4. Provide details of equipment connections and installation.
   5. Provide details of piping/ductwork penetrations, fire/smoke damper installations, etc.
   6. Provide sequence of operations of all equipment on mechanical drawings.
   7. Provide points list matrix for all equipment on sequence of operation sheet on mechanical drawings. See below for example
   8. Provide controls instrumentation detail (P&ID detail) for all equipment. See below for example.

VRFC-XX THRU XX	HARDWARE POINTS				SOFTWARE POINTS						
POINT NAME	AI	AO	BI	BO	AV	BV	LOOP	SCHED	TREND	ALARM	SHOW ON GRAPHIC
ZONE TEMPERATURE	X								X		X
ZONE TEMP. SETPOINT					X				X		X
ZONE SETPOINT ADJUST	X										X
ZONE OVERRIDE			X						X		X
ZONE HUMIDITY	X								X		X
ZONE HUMIDITY SETPOINT					X				X		X
ZONE W.B. TEMPERATURE	X								X		X
ZONE W.B. TEMP. SETPOINT					X				X		X
FAN STATUS				X					X		X
FAN SPEED				X					X		X
OPERATION MODE				X					X		X
COMPRESSOR STATUS			X						X		X
PRE-FILTER STATUS			X						X		X
UNIT ALARM			X						X		X
SCHEDULE								X			

Example of points list.



Example of P&ID detail.

1.4 WARRANTIES AND GUARANTEES

A. General

1. The materials of the HVAC systems shall have the Manufacturer's and/or supplier's Guarantee or Warranty put into effect by execution and filing of any and all related papers. From date of acceptance, obtain service or repair under the terms of any said Guarantee or Warranty in behalf of Atlanta Public Schools.
2. From date of beneficial occupancy, the contractor shall provide a (2) two-year warranty for parts and (1) one year labor. The Direct Digital Control system shall be warrantied for (2) two years, parts and labor.

B. Refrigeration/Air Condition Compressor Warranty

1. Each air conditioning compressor shall have a five (5) year manufacturer's guarantee against defective parts and labor after date of substantial completion.

1.5 HVAC TRAINING

A. Formal Classroom Training
   1. Classroom sessions will be scheduled to introduce the HVAC operation, maintenance and management personnel to the O & M manuals, drawings, and other documents and aids available to operate and maintain the HVAC equipment and systems.
   2. Factory specialists for major equipment (WSHP, boilers, pumps, chillers, etc.) and systems will present sessions on their specific equipment and/or systems.
   3. Automatic Temperature Controls sessions should be scheduled in conjunction with equipment items.
   4. At least three similar sessions, of 8 hours each, shall be conducted for mechanical equipment and systems. The first session shall be conducted at the time of start-up and checkout. The second session shall occur no later than the beginning of the next seasonal changeover or within four (4) months, whichever is earliest.
   5. DDC System training by manufacturer-trained personnel shall consist of a minimum of two 8-hour sessions, for three (3) operators per session.
   6. The Training syllabus shall be submitted to and approved by APS as soon as practical to allow the scheduling and designation of personnel in a timely manner. The information contained in the program shall include how the training will be conducted; when and where the sessions will be held; names and company affiliation of trainers; recommended reference materials; outside reading, etc. Atlanta Public Schools will furnish the lists of APS personnel for each training session.

B. Hands-on Training
   1. Extensive hands-on type training will be conducted during the HVAC preliminary commissioning so that actual operation and maintenance of the HVAC equipment and systems can become their responsibility at the completion of the commissioning.
   2. The building operator and designated maintenance personnel will be required to visit the site periodically during the construction phase, particularly during equipment installation and start-up.

C. Typical HVAC Training Agenda
   1. Description of HVAC Systems:
      a. Air Side
      b. Cooling
      c. Heating
      d. Ventilation
      e. Life Safety
   2. Wet Side:
      a. Cooling
      b. Heating
      c. Water treatment
   3. Description of Equipment and Systems Installed:
      a. Chiller(s)/Refrigeration Equipment
      b. Condenser Water System (condenser maintenance frequencies)
      c. Chilled Water System
      d. Boiler(s) and Accessories (maintenance frequencies)
      e. Insulation
      f. Air Handling Units (AHUs) (maintenance of coils)
      g. Terminal Boxes
      h. Duct System
      i. Filters and Replacement Procedure
      j. Controls Equipment and Systems
      k. Programming controls and downloading software to control devices.
   4. Walk-through of building
   5. Start-up Procedure
   6. Operating Procedures
      a. Seasonal

b. Manual/Automatic (change over process)
c. Emergency Actions (stop buttons)

7. Shut-down Procedures
8. Maintenance Schedules and Requirements
9. Warranties and Call Procedures
10. Spare Parts and Sources
11. Tools/Troubleshooting (BAS and self-driven equipment screens)
12. Hands-on operation instruction of HVAC equipment and systems during HVAC preliminary commissioning.

1.6 DOCUMENTATION

A. Bid basis and substitution procedures

1. Manufacturers names, series and model numbers, as noted or specified, are for the purpose of describing type, capacity, and quality of equipment, materials and products to be used. Unless "or equal" is specifically stated, bids shall be based only on the specified "basis of design" manufacturer. The listing of a particular manufacturer as an "equal" or "acceptable substitute" manufacturer shall not be misconstrued as approving nor allowing the substitution of that manufacturer's standard product in place of the basis of design. No consideration will be given to a product which would require dimensional, spatial or aesthetic changes to the project. "Acceptable substitute" and "equal" manufacturers shall only bid those products which exactly match the size and other characteristics of the specified basis of design. Any changes to other disciplines and trades of work required by an "or equal" or "substitute" product shall be duly considered and priced accordingly prior to bidding or pricing. The decision as to whether or not a proposed substitute or "equal" product is actually equal to that specified shall rest solely with the Owner.
2. Requests to provide "equal" products in lieu of those specified shall be submitted to the Owner in writing at least five (5) days prior to final pricing and execution of the Contract. No consideration will be given to substitute products after final pricing and execution of the Contract.
3. Any "or equal" product or proposed product substitution which will cause a change in the appearance, dimensions or design of any part of the building, it structure, electrical system or any other engineered systems shall be accompanied by a scaled drawing and written description of the required change(s) for approval by the Owner. If deemed necessary by the Owner, design changes shall be signed and sealed by a registered Professional Engineer, currently licensed in this State.

B. Minimum Standards

1. Every piece of energy consuming equipment, all fire suppression products and life safety equipment shall comply with the following standards as applicable; especially in regard to prevailing codes:
   a. Factory Mutual Laboratories (FM)
   b. Industrial Risk Insurers (IRI)
   c. Underwriters Laboratories, Inc. (UL)
   d. ADC: Air Diffusion Council
   e. AGA: American Gas Association
   f. AMCA: Air Moving and Conditioning Association, Inc.
   g. ANSI: American National Standards Institute
   h. API: American Petroleum Institute
   i. ARI: American Refrigeration Institute
   j. ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers
   k. ASME: American Society of Mechanical Engineers
   l. ASTM: American Society of Testing and Materials
   m. AWWA: American Water Works Association
   n. IBR: Institute of Boiler and Radiator Manufacturers
   o. MSS: Manufacturers Standardization Society
   p. NBBP National Board of Boiler and Pressure Vessel Inspectors

q. NEMA: National Electrical Manufacturer's Association
r. OSHA: Occupational Safety & Health Administration
s. PDI: Plumbing Drainage Institute
t. PPI: Plastic Pipe Institute
u. SMACNA: Sheet Metal and Air Conditioning Contractors National Association, Inc.

C. Submittals
1. Before preparing submittals, study all Contract Drawings and specifications in detail, obtain manufacturer's recommended instructions, and have submittals prepared based on specific equipment and material proposed for installation. An officer of the contracting firm shall sign all shop drawings (certifying conformance with plans and specifications) before submitting to the Architect or releasing to the field.
2. The submittal process shall not be utilized as an avenue to substitute products after the execution of the contract. Should an unspecified or unequal product be submitted, it will be rejected. If a second attempt at substitution is made during the resubmittal of the same product, then no more reviews of that product will be performed without direct compensation to the Engineer being paid for the additional services required for the third review and any further reviews.
3. The CxP shall be provided submittals for review. The CxP shall provide the reviewed submittals to the APS Project Manager and the Engineer.
4. No more than four (4) copies of submittal data will be reviewed. Any additional copies will be returned unmarked. The responsibility of copying review comments on any additional copies will rest solely with the Contractor.
5. Submittals will not be accepted for review unless they:
a. Comply with the requirements of Division 1.
b. Include complete information pertaining to all appurtenances and accessories.
c. Include sound information of Noise/Decibels when in maximum load & speed.
1) Provide information on sound attenuation options.
d. Are submitted as complete packages which pertain to all related items in Division 23. Separate packages shall be submitted as follows:
1) All HVAC equipment and components.
2) All plumbing equipment and components.
3) The automatic controls and BMS.
4) Are properly marked with equipment, service or function identification as related to the project and are marked with pertinent specification paragraph number.
5) Submit catalog information, factory assembly drawings, field installation drawings and certifications as required for complete explanation and description of all items of equipment. The submittal data shall provide ample, unquestionable compliance with the Contract Documents.
6) Review of submittals shall not be construed as authorizing any deviations from the plans and specifications unless such deviations are clearly identified and separately submitted in the form of a letter that is enclosed with the submittals.
7) Submittals are required on all manufactured equipment, especially energy consuming equipment.

D. Record (As-Built) Drawings
1. Maintain accurate records on a set of Contract Drawings of all deviations from the drawings made during the progress of the work to be used by the engineer in preparation of the final as-built drawing. The completed set of contractor as-built drawings shall be submitted to Engineer in CAD and PDF format, on a CD/DVD, in a jewel case labeled with the project name and systems recorded, with the nature and extent of all deviations clearly shown. The Engineer shall provide the final AS-Built Drawings to the owner in in CAD and PDF format, on a CD/DVD, in a jewel case labeled with the Project Name, Year and Architectural or Engineering firm. As-Built drawings shall be submitted to CxP for Final review.

E. Coordination Drawings
   1. The sheet metal Contractor shall be responsible for the preparation of drawings (drawing to match project drawing scale) sheet metal drawings of all building levels. The Engineer and or Mechanical contractor shall not remove this requirement.

F. Operation and Maintenance (O&M) Manuals and Instructions
   1. Complete operating and maintenance manuals shall be provided to the Owner. OPERATIONAL & MAINTENANCE MANUALS (3 Copies of Each) Manuals are to be bound in three ring binders; indexed and tabbed numerically. Provide manuals on (3) CD/DVD in Jewel case labeled with project and contractor name.
   2. Operating instructions shall be provided for each mechanical system, and shall each include a brief system description, a simple schematic and a sequence of operation. Operating and maintenance instructions shall be provided for each piece of equipment. A control system wiring diagram shall be included in each operating and maintenance manual.

G. PROJECT CLOSE-OUT DOCUMENTS (3 Copies of Each)
   1. The Equipment start-up reports, warranties, system test reports, chemical test reports, test & balance reports, etc. shall be together in a separate three ring binder, tabbed and indexed and submitted to APS as the final close-out documents. Provide Close-out Documents on a CD/DVD in Jewel case labeled with project and contractor name. Provide submittals on a CD/DVD in Jewel case labeled with project and contractor name as part of the close out documents. Project close-out documentation shall be sent to CxP prior to APS for review.
      a. Documents to be included but not limited to:
         1) Test & Balance Reports
         2) Documented System Tests
         3) Duct Work Cleaning Certificate
         4) System Valve Schedule
         5) Equipment Filter Schedule
         6) Signed off permits, including copy of Certificate of Occupancy
         7) Chemical Treatment
         8) Equipment Start-Up documents
         9) Fire Alarm certification documents
         10) Warranty documents
         11) HVAC Controls Training Document
         12) HVAC Graphic Training Document
         13) HVAC Equipment Training Document
         14) As-Built Drawings
         15) Commissioning Report (Separate bidder)
   2. Prior to final acceptance or beneficial occupancy, provide the services of a competent technician for not less than three (3) days to instruct the Owner in the operation of the mechanical systems.

End of Section 23 00 10 Mechanical General

SECTION 23 01 00 – OPERATION AND MAINTENANCE OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Operation and Maintenance (O&M) Manuals and Instructions

1.2 OPERATION AND MAINTENANCE (O&M) MANUALS AND INSTRUCTIONS

A. O&M manuals shall be project specific and shall not include equipment not used on project.
B. O&M manuals shall be reviewed by general contractor/ construction manager prior to sending to the CxP.
C. O&M manuals shall be reviewed by the CxP prior to sending to APS.
D. Complete operating and maintenance manuals shall be provided to the Owner. OPERATIONAL & MAINTENANCE MANUALS (3 Copies of Each) Manuals are to be bound in three ring binders; indexed and tabbed numerically. Provide manuals on (3) CD/DVD in Jewel case with bookmarks and labeled with project and contractor name.
E. Operating instructions shall be provided for each mechanical system, and shall each include a brief system description, a simple schematic and a sequence of operation. Operating and maintenance instructions shall be provided for each piece of equipment. A control system wiring diagram shall be included in each operating and maintenance manual.

End of Section 23 01 00 Operation and Maintenance of HVAC Systems

SECTION 23 05 00 – COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Equipment Installation Requirements
   2. Equipment Cleaning, Lubrication and Adjustment
   3. Ductwork Air Leakage Testing
   4. Pipe Leak Testing
   5. Painting Requirements
   6. Core Drillings
   7. Fire-Stop
   8. Excavation, Trenching, and Backfilling

B. Legend
   1. APS: Atlanta Public Schools
   2. DALT: Duct Air Leakage Test
   3. VRF: Variable Refrigerant Flow
   4. VRFC: Variable Refrigerant Fan Coil

1.2 GENERAL EQUIPMENT INSTALLATION REQUIREMENTS

A. All equipment shall be installed in strict conformance with the recommendations of the equipment manufacturer, as indicated on the Drawings and as specified.

B. Provide stand-alone unit and room sensor for the Principal's Office.

C. Provide supplementary steel framing and welded steel equipment support stands as required for proper hanging and support of the mechanical systems. Steel angles, channels and tubing utilized for such framing shall be selected for a maximum deflection of 1/360th of the span.

D. All roof curbs shall be a minimum of 12" high above the finish roof line and selected for the various roof pitches. Curbs installed on roofs having pitches of not more than 1/4" per foot may be standard curbs shimmed level with steel channels or Z's to provide suitable support and flashing surfaces.
   1. Curbs shall be insulated
   2. 6 layers of Greenboard or approved materials shall be installed inside curb for sound attenuation.
   3. Bead of caulking shall be used on curb seal to prevent curb from leaking.

E. Condenser Roof Installations: Condenser's shall be installed on equipment rails, Big foot Systems or approved stands. Condenser refrigerant piping, electrical power and control conduit for typical Split Systems and the Variable Refrigerant Flow systems shall make use of a Piping Chase for piping penetrations. The Chase penetrations shall be sealed using compression type fittings. No services shall penetrate the top of the chase.
   1. Pipe penetrations through roof shall have an insulated weather-proof chase housing with curb and seals. Alta Products, LLC Pipe Chase Housing, Alta Curb, and Exit Seals or equivalent (as approved by APS) shall be installed.
   2. Pitch Pockets shall not be used.
   3. VRF Refrigerant piping shall be neatly racked using strut channel and pipe clamps supported by equipment support stand or setting on non-penetrative stands/blocks.
      a. Pipe clamps shall be of the type that allows for insulation to be continuous through clamp.
      b. Piping shall be installed to allow for access to condensers.

F. Gas pipe and individual piping shall be supported using pipe-stand with roller-type pipe support and non-penetrative base and height adjustable.
   1. Condensate and other slope sensitive applications, shall be sloped per industry standards and code requirements to allow for proper drainage etc.

G. Ductwork on roof shall be supported using Rectorseal Bigfoot Duct Support System or equivalent approved by APS.

1.3 EQUIPMENT CLEANING, LUBRICATION AND ADJUSTMENT

A. The exterior surfaces of all mechanical equipment, piping, ductwork, conduit, etc., shall be cleaned and free of all dirt, grease, oil, paint splatter, and other construction debris.

B. Ducts, plenums, and air unit casings shall be cleaned of all debris and either vacuumed or blown free of all rubbish, dirt, and dust before installing grilles, registers or diffusers.

C. Bearings that require lubrication shall be lubricated in strict accordance with the manufacturer's recommendations.

D. All control equipment shall be adjusted to the settings required for the performance specified.

E. Fans shall be adjusted to the speed indicated by the manufacturer to meet the installed final system pressure at the airflows indicated. Any additional sheaves and belts required for final adjustments shall be provided with no increase in the Contract amount.

F. Any fans operated during construction shall have temporary filters. Temporary filters shall be changed regularly to minimize contamination of the equipment and duct systems. Permanent filters shall be installed prior to final inspection.

G. All coils shall be thoroughly cleaned and combed prior to final inspection.

1.4 DUCTWORK AIR LEAKAGE TESTING (DALT)

A. Underground, concealed and insulated ductwork and piping shall be tested for leaks in place before backfilling, concealing or covering. Tests shall be conducted in the presence of the Owner or his designated representative.

B. All low-pressure ductwork (design operating pressure of 1.0" W.C. E.S.P. or less) shall be tested by the operation of the system to which it is connected. (At the discretion of APS).

C. All medium and high-pressure ductwork (operating pressure of more than 1.0" W.C. E.S.P.) shall be tested at l.5 times the design operating pressure of the system to which it is connected, or at the total fan pressure at shutoff, whichever is greater.

D. All visible and audible air leaks from the ductwork systems shall be repaired.

1.5 PIPE LEAK TESTING

A. All gas piping shall be tested pneumatically and proved tight at a pressure of not less than 30 psi for a period of not less than two (2) hours. No loss in pressure will be permitted.

B. Refrigerant piping for Variable Refrigerant Flow systems shall be tested under vacuum, per the engineer's specifications, APS guidelines and or the manufacturer's procedures. The most stringent shall be used.

C. All leaks shall be repaired by tightening, remaking joints, or replacing pipe and fittings. The system shall be retested.

1.6 PAINTING REQUIREMENTS (should also be in painting specifications at the direction of APS)

A. All uncoated and uninsulated steel surfaces exposed to sight inside the building, such as piping, equipment hangers and supports which are not provided with factory prime coat or galvanizing, shall be cleaned and painted with one coat of rust inhibiting primer. In addition, all surfaces in finished spaces shall also be painted with two coats of finish paint in a color selected by the Owner.

B. All ductwork surfaces visible through grilles, registers and diffusers in finished areas shall be painted flat black.

C. Steel items exposed outside the building, such as equipment supports, insulated piping and hangers which are not factory painted or galvanized shall be cleaned and painted with one coat of rust inhibiting primer and two coats of asphaltic base aluminum paint. Insulated steel pipes outside the building shall be cleaned and painted with one coat of rust inhibiting primer before installing insulation.

D. Factory painted equipment that has been scratched or marred shall be repainted to match the original factory color.

E. All exterior gas piping shall be painted per the local jurisdiction requirements.

F. All exposed (uninsulated) piping welds, interior or exterior shall be painted flat black.

1.7 CORE DRILLINGS

A. Cutting of holes through concrete and masonry shall be by diamond core or concrete saw. Pneumatic hammer, impact electric and hand or manual hammer type drills will not be allowed, except as permitted by the Architect where required by limited working space. Locate holes such that they will not affect structural sections such as ribs or beams. Holes shall be laid out well in advance of the installation. These layout locations shall be approved by the Owner prior to drilling.

1.8 DIAMOND SAW CUTTING

A. Prior to sawing cutting concrete slabs and or concrete roof structures, the contractor shall X-Ray or make use of Ground Penetration Equipment to identify embedded utilities and or services, structures stress cabling and steel.

B. Masks shall be worn and water shall be used while cutting to decrease dust exposure.

C. Saw cutting shall be paused while owner/engineer/architect/commissioning are on-site.

1.9 FIRE-STOP

A. Where ductwork, piping, conduit, etc. pass through fire partitions, fire walls and floors, a firestop shall be provided that will ensure an effective barrier against the spread of fire, smoke and gases. Fire-stop material shall be packed tight and completely fill gaps between the ductwork, piping, conduit, etc. and the perimeter of their rough openings.

B. Fire-stopping material shall maintain its dimensions and integrity while preventing the passage of flame, smoke and gases under conditions of installation and use when exposed to the ASTM E119 time-temperature curve for a time period equivalent to the rating of the assembly penetrated. Fire-stopping material shall be noncombustible as defined by ASTM E136; and, for insulation materials, melt point shall be a minimum of 1700 °F for 1hour protection and 1850 °F for 2-hour protection. Fire stopping material shall be Dow-Corning RTV Foam or 3M Fire Barrier Products or Sohio Carborundum Fyre Putty or equal.

1.9 EXCAVATION, TRENCHING AND BACKFILLING

A. During excavation, the excavated material shall be piled back from the banks of the trench to avoid overloading, slides or cave-ins. Do not exceed the angle of repose unless written approval is obtained in advance from the Owner for shoring, bracing or other alternate excavation methods. All excavated material not used for backfilling shall be removed from the building and disposed of as indicated or directed by the Owner. Take measures to prevent surface water from flowing into trenches and other excavations and any water accumulating therein shall be removed by pumping. All excavation shall be made by open cut. Tunneling shall not be allowed.

B. The bottom of all trenches shall be evenly graded to provide firm support and an even bearing surface. Pipe shall be laid on firm soil, laid in straight lines and on uniform grades. Provide bell holes so that the barrel of the pipe rests evenly on the bottom of the trench along the entire length of the pipe.

C. Pipe shall be inspected and tested prior to backfilling. Trench shall be hand filled to a minimum of 12" above the top of pipe with suitable earth (free of rocks, trash, large clods and organic material) and compacted to a minimum 95% proctor. After the first layer is completed, subsequent layers shall be filled and compacted the same as the first layer. Settling the backfill with water shall not be permitted.

End of Section 23 05 00 Common Work Results for HVAC

SECTION 23 05 13 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Electrical Compliance and Interface

B. Legend
   1. APS: Atlanta Public Schools
   2. VFD: Variable Frequency Drive

1.2 ELECTRICAL COMPLIANCE AND INTERFACE

A. All electrical equipment and wiring provided under this Division 23 shall comply with the electrical system characteristics indicated on the electrical drawings and specified in Division 26.

B. Electric controls, contactors, starters, pilot lights, push buttons, etc., shall be provided complete as part of the motor, heater or other equipment which it operates. All electrical components shall be in conformance with the requirements of the National Electrical Code and Division 26. Reference Division 26 and the electrical engineering drawings for those motor starters provided under that Division 26. All starters not shown shall be provided under this Division 23. Unless specified otherwise under other individual equipment Sections, motor starters shall conform to the following minimum requirements:
   1. Starters for motors 1/3 horsepower or smaller shall be manual unless remote or automatic starting is required, in which case the starters shall be magnetic, full voltage, non -reversing, single-speed, unless otherwise indicated. All other starters shall be magnetic.
   2. Each starter for a three-phase motor shall be furnished with three (3) overload relays sized for the full load running current of the motor actually provided. Provide an external "HAND-OFF-AUTO" selector switch with red "RUNNING" light. Provide a green pilot light to indicate motor "STOPPED". Each pilot light shall have a legend plate indicating reason for signal.
   3. Each overload relay shall have a normally open alarm contact which will close only when actuated by an overload (not to be confused with N.O. or N.C. auxiliary contacts). These contacts shall be properly wired to their respective blue pilot light provided on the starter front cover and having a "TRIPPED" legend plate.
   4. Individually mounted motor starters shall be in a NEMA Type 1 general purpose enclosure in unfinished areas and shall be flush mounted in all finished areas. All starters mounted in exterior areas shall have a NEMA 3R enclosure. Each starter shall have a laminated nameplate to indicate equipment unit number, function and circuit number.
   5. All motor starters, push buttons and pilot lights shall be of the same manufacturer as the switchboard and shall be General Electric, Square D, Siemens I.T.E., or Westinghouse.

C. Motor starters for the following equipment shall be provided under this Division 23 by the manufacturer of the equipment:
   1. Packaged air conditioning equipment.
   2. Other equipment hereinafter specified in other Sections to be provided with integral starters.

D. Unless otherwise noted or specified in individual Sections, all 3 phase motors shall be standard NEMA continuous duty "B" type, with Class B insulation, open drip-proof frame for indoor service, TEFC for outdoor service and a service factor of 1.15. All motors 5 HP and larger shall be U.S. Motors Hi-Efficiency Model or Reliance XE Hi-Efficiency Model. (VFD compatible.)

E. All power wiring and final connections to equipment shall be provided under Division 26.

F. Control components, all interlocks (motor-operated dampers, fire alarm motors, etc.) and control wiring (120 volt, single phase and less) shall be provided under this Division 23 as required to achieve the specified control sequences.

G. All control wiring over 30 volts shall be installed by a Licensed Electrician working under this Division 23.

End of Section 23 05 13 Common Work Results for HVAC

SECTION 23 05 17 – SLEEVES, SEALS AND ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Sleeves, Seals and Escutcheons

1.2 SLEEVES, SEALS AND ESCUTCHEONS

A. Sleeves shall be provided through all pipe penetrations of concrete or masonry walls, elevated floors and roofs, except those plumbing piping penetrations for fixtures, vents, etc.

B. Sleeves shall be fabricated from Schedule 40 steel pipe through 10" and Standard Wall steel pipe for sleeve sizes 12" and larger. All sleeves penetrating exterior walls, underground walls, pit or vault walls shall be provided with a 3" x 3/8" thick water stop ring welded completely to the midpoint of the sleeve.

C. All sleeves penetrating exterior walls, underground walls, pit or vault walls and elevated floors shall be packed and sealed watertight.

D. Pipe penetrations through roof shall have an insulated weather-proof chase housing with curb and seals. Alta Products, LLC Pipe Chase Housing, Alta Curb, and Exit Seals or equivalent (as approved by APS) shall be installed.

E. Sleeves through walls shall be cut and finished flush with each surface of the wall in which they are installed.

F. Sleeves shall be sized to provide a minimum of 1/2" clearance between the inside surface of the sleeve and the outside finished surface of the pipe plus any insulation specified.

G. Fire-stops shall be provided as specified herein. All annular spaces between piping and sleeves which do not require fire stops shall be packed with mineral wool and caulked.

H. Provide round, chrome-plated escutcheons on all exposed piping penetrations passing through walls, floors, partitions and ceilings.

End of Section 23 05 17 Sleeves, Seals and Escutcheons for HVAC Piping

SECTION 23 05 29 – HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Refrigerant Piping Hangers and Supports Requirements
   2. General Chilled and Condenser Water Piping Hangers and Supports Requirements
   3. General Condensate Piping Hangers and Supports Requirements
   4. General Hot Water Piping Hangers and Supports Requirements
   5. General Equipment Hangers and Supports Requirements

B. Legend:
   1. APS: Atlanta Public Schools
   2. VRF: Variable Refrigerant Flow

1.2 GENERAL REFRIGERANT PIPING HANGERS AND SUPPORTS REQUIREMENTS

A. Exterior VRF Refrigerant piping shall be neatly racked using strut channel and pipe clamps supported by equipment support stand or setting on non-penetrative stands/blocks.
   1. Pipe clamps shall be of the type that allows for insulation to be continuous through clamp.

B. Refrigerant pipe shall be supported every 6 feet including vertical runs. There shall be no sagging in refrigerant pipe.

C. Piping shall be sleeved where pipe penetrates walls, floors, or ceilings.
   1. Sleeves where piping penetrates walls, floors, or ceiling, do not count as support.

D. Walls shall not be used as piping support.

E. Pipe shall be supported within 12-20” (inches) of a change in direction.

F. In no case shall multiple refrigerant piping be installed in a single clevis type hanger.

G. Supports for vertical runs of refrigerant pipe shall be of the clamp type that allows for continuous insulation throughout clamp.

H. Length requirements, fitting requirements, trap requirements, expansion requirements, and accessory requirements shall be provided by manufacturer’s requirements.

I. Supports shall have saddles at each location.

J. Supports and saddles shall not compress insulation.

K. Saddles shall be the type that can be affixed to clevis and/or trapeze hangers.
   1. Snap n’ Shield or equivalent as approved by APS.
   2. Alternative to saddles include items equivalent to Armacell’s Armafix Insulation Pipe Hanger.

1.3 GENERAL CHILLED AND CONDENSER WATER PIPING HANGERS AND SUPPORTS REQUIREMENTS

A. Pipe shall be supported every 8 feet including vertical runs.

B. Pipe shall be sleeved when penetrating walls, ceilings, and floors.
   1. Sleeves where piping penetrates walls, floors, or ceiling, do not count as support.

C. Walls shall not be used as piping support.

D. Saddles shall be provided where supported to prevent insulation from becoming compressed.

E. Piping over 2.5” shall have blocking in insulation at hangers.

1.4 GENERAL CONDENSATE PIPING HANGERS AND SUPPORTS REQUIREMENTS

A. Condensate pipe shall be supported every 6 feet including vertical runs. There shall be no sagging in condensate pipe.

B. Supports shall be installed in such a way to provide required slope (1/8” per foot) for proper drainage.

C. Supports for vertical runs of refrigerant pipe shall be of the clamp type that allows for continuous insulation throughout clamp.

D. Saddles shall be located where condensate pipe is supported to prevent compression of insulation.

E. Supports and saddles shall not compress insulation.

F. Saddles shall be the type that can be affixed to clevis and/or trapeze hangers.
   1. Snap n' Shield or equivalent as approved by APS.
   2. Alternative to saddles include items equivalent to Armacell's Armafix Insulation Pipe Hanger.
G. At no time (including temporarily) should there be anything hung from or supported from condensate piping.
H. Piping shall be sleeved where pipe penetrates walls, floors, or ceilings.
   1. Sleeves where piping penetrates walls, floors, or ceiling, do not count as support.
I. Walls shall not be used as piping support.
J. Condensate pipe located outdoors shall be supported using pipe-stand with roller-type pipe support and non-penetrative base and height adjustable.
K. Piping over 2.5" shall have blocking in insulation at hangers.

1.5 GENERAL HOT WATER PIPING HANGERS AND SUPPORTS REQUIREMENTS

A. HW pipe shall be supported every 8 feet including vertical runs.
B. Split ring or clevis hangers acceptable for hot water piping.
   1. If copper piping is used, copper plate hanger shall be used.
C. Piping shall be sleeved where pipe penetrates walls, floors, or ceilings.
   1. Sleeves where piping penetrates walls, floors, or ceiling, do not count as support.
D. Walls shall not be used as piping support.
E. Piping over 2.5" shall have blocking in insulation at hangers.

1.6 GENERAL EQUIPMENT HANGERS AND SUPPORTS REQUIREMENTS

A. Equipment shall be hung/supported using threaded rod or strapping as directed by APS and DOR.
B. Bigfoot system or equal shall be used for equipment support where applicable on roof and grade.
C. Structural steel can be an alternative to big foot system.
   1. Maintenance platform shall be erected if equipment service doors or panels not accessible.

End of Section 23 05 29 Hangers and Supports for HVAC Piping and Equipment

SECTION 23 05 33 – HEAT TRACING FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Heat Tracing Requirements
   2. Heat Tracing Installation
   3. Testing

1.2 GENERAL HEAT TAPE/TRACING REQUIREMENTS

A. Heat trace/tape shall be covered by a dielectric jacket.
B. Heat tracing shall be sized to maintain a minimum water temperature of 40°F at an ambient temperature of -10°F.
C. Heat tape/trace shall be self-regulating type that varies heat output in response to temperature along its length.
   1. Constant wattage heater shall not be installed.
D. Heat trace shall have thermostatic control.

1.3 HEAT TRACING INSTALLATION

A. Heat tape/tracing shall be installed on all exterior make-up and condenser water piping above grade.
   1. Tape/trace shall not be installed on plastic piping.
B. Heat tape can be monitored by the BMS but shall be independently controlled by traditional methods.
C. Heat tape/tracing and control system shall be installed in strict accordance with the manufacturers' recommendations.
D. Piping with heat tape/trace shall have signs reading "Electric Heat Traced" outside of pipe insulation.

1.4 TESTING

A. Heat tape/trace shall be tested both before and after installing associated pipe insulation.

End of Section 23 05 33 Heat Tracing for HVAC Piping

SECTION 23 05 48 – VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Vibration Controls Requirements

B. Legend:
   1. APS: Atlanta Public Schools
   2. EOR: Engineer of Record

1.2 VIBRATION CONTROLS REQUIREMENTS

A. All equipment with the possibility of vibration shall have vibration controls.

B. Isolation selection shall be based on mechanical equipment to be installed.

C. Installation of vibration controls shall not cause any change in position of equipment, piping, or ductwork resulting in stresses or misalignment.

D. The following types of isolation are acceptable:
   1. Elastomeric isolation pads.
   2. Elastomeric isolation mounts
   3. Restrained elastomeric isolation mounts
   4. Open-spring isolators
   5. Housed spring isolators
   6. Restrained-spring isolators
   7. House-restrained spring isolators
   8. Pipe-riser resilient support
      a. All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum 0.5 inch thick neoprene
   9. Resilient pipe guides
      a. Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum 0.5 inch thick neoprene
   10. Elastomeric Hangers
      a. Elastomeric mount in a steel frame with upper and lower steel hanger rods.
   11. Spring Hangers
      a. Combination coil-spring and elastomeric insert hander with spring and insert in compression.

End of Section 23 05 48 Vibration Controls for HVAC

SECTION 23 05 53 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Identification Requirements
   2. Equipment Identification Requirements
   3. Ductwork Identification Requirements
   4. Pipe Identification Requirements
   5. Valve identification Requirements

B. Legend:
   1. APS: Atlanta Public Schools

1.2 GENERAL IDENTIFICATION REQUIREMENTS

A. All HVAC equipment shall be labeled per contract documents.
B. All ductwork shall be labeled per contract documents.
C. All piping and valves shall be labeled per contract documents.
D. Labels shall be located where accessible and visible.

1.3 EQUIPMENT IDENTIFICATION REQUIREMENTS

A. All HVAC equipment shall have plastic labels with equipment designation as per drawings.
B. Letter color shall be white with black background.
C. Label shall have predrilled holes for attachment.
D. Labels shall be attached to equipment using stainless steel rivets or self-tapping screws.
E. Labels shall be able to withstand a minimum of 160 °F.

1.4 DUCTWORK IDENTIFICATION REQUIREMENTS

A. All ductwork shall have plastic labels with predrilled holes for attachment or adhesive.
B. Letter color shall be white with blue or green background depending on service.
C. Labels shall be able to withstand a minimum of 160 °F.
D. Labels shall be attached to equipment using stainless steel rivets or self-tapping screws or adhesive.
E. Labels shall include duct service and direction.
F. Labels shall be located near where ducts penetrate floors, ceilings, walls, and concealed spaces and at a maximum of every 20 feet.

1.5 PIPE IDENTIFICATION REQUIREMENTS

A. All pipe shall have labels that are pre-tensioned semi-rigid plastic formed to cover full circumference of pipe that does not need adhesive or printed plastic with adhesive.
B. Letter color shall be white with blue or green background depending on service.
C. Labels shall be able to withstand a minimum of 160 °F.
D. Labels shall be attached to equipment using stainless steel rivets or self-tapping screws or adhesive.
E. Labels shall include pipe service, size and direction.
F. Pipe shall be labeled where exposed, above accessible ceilings, machine rooms, accessible maintenance spaces and exterior exposed locations. These locations include:
   1. Near each valve and control device
   2. Near each branch connection.
   3. Near wall, floor, ceilings and inaccessible penetrations.
   4. At access doors, manholes, and other forms of access points
   5. Near major equipment and other points of origin and termination.
   6. Spaced at max of 15 feet along each run.

1.6 VALVE IDENTIFICATION REQUIREMENTS

A. All valves shall have valve tags.
B. Valve tags shall be stamped or engraved brass with predrilled or stamped holes for attachments.
C. Valve tags shall be hung using brass wire ink or beaded chain or s-hook.
D. Valve schedule shall be included in O&M manual and include valve number, piping system, system abbreviated, location of valve, normal operating position, and variations for identification.
    1. Specialty service, such as emergency shut off, shall be notated.
E. Check valves, valves with-in factory fabricated equipment, faucets, shutoff valves do not need to a valve tag.

End of Section 23 05 53 Identification for HVAC Piping and Equipment

SECTION 23 05 93 – TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Test and Balance Requirements
   2. Minimum Test and Balance Requirements
   3. Scope
   4. Submittals
   5. Execution

B. Legend:
   1. AHU: Air Handling Unit
   2. APS: Atlanta Public Schools
   3. BMS: Building Management System
   4. DDC: Direct Digital Control System
   5. DOAS: Dedicated Outdoor Air System
   6. ERU: Energy Recovery Unit
   7. OA: Outside Air
   8. RTU: Roof Top Unit
   9. VRF: Variable Refrigerant Flow
   10. VRFC: Variable Refrigerant Fan Coil

1.2 GENERAL TEST AND BALANCE REQUIREMENTS

A. The Test & Balance Company shall be contracted directly to the ***owner (APS) or the Commissioning Provider.***

B. Testing and balancing shall be performed by a fully certified Independent, Test and Balance Agency, approved by the design engineer acting for the Atlanta Public Schools. Certification shall be from AABC or NEBB. Final test and balance shall be determined by a "real time" full load of occupancy.

C. Test and Balancing shall be performed in accordance with the AABC national Standards, 6th Edition or latest version.

D. Field technicians shall also be certified through the company they work for by a certifying agency.

E. Specifications shall be clearly written to require Contractors and Construction Managers to provide the Testing, Adjusting and Balancing of Mechanical Systems by a firm certified by the National Environmental Balancing Bureau (NEBB) or the Associated Air Balance Council (AABC) in testing and balancing disciplines for the subject type of project.

F. Submit the names of three (3) qualified firms as described above to the APS Project manager for selection.

G. The firms proposed shall not be associated in any way with any other work on this project.

H. Perform laser shaft alignment on all base mounted pumps.

I. Perform laser pulley and sheave alignment on all central AHU's.

J. Perform a Duct Air Leakage Test (DALT) on all medium and high-pressure ductwork.
   1. All medium and high-pressure ductwork (operating pressure of more than 1.0" W.C. E.S.P.) shall be tested at l.5 times the design operating pressure of the system to which it is connected, or at the total fan pressure at shutoff, whichever is greater.
   2. DALT shall be witnessed by the CxP and/or the Mechanical Engineer.

K. Balance all air moving HVAC equipment except for VRFC system cassettes (suspended or ceiling grid type).
   1. VRFCs with ducted OA or ductwork for air distribution shall be balanced.

L. Balance OA for DOAS/ERUs/AHUs/RTUs to +5% only. i.e. outside air shall not be less than design.

M. Unless otherwise directed by APS, all HVAC equipment, except as stated in paragraph "K", shall be balance with +/- 10% of design.

N. Return air grilles and registers shall also be measured for air volume.

1.3 MINIMUM TEST AND BALANCE REQUIREMENTS

A. Examine installed new work and conditions to ensure that work has been completed, cleaned and is operable. Review the Commissioning reports/documents for outstanding issues. Submit a detailed report documenting deficiencies of systems and controls that prevent complete testing, adjusting and balancing. NOTE: Do not proceed with adjusting and balancing work until unsatisfactory conditions have been corrected.

B. Initial Test and Balance – This test shall be performed immediately after equipment has been started and before the building is occupied.

C. Re-Balance and Re-Test – This test shall be performed after the building has been occupied for a period not to exceed 30 days to rebalance the system to meet required space temperatures based on actual occupied conditions.

D. Seasonal Adjustments – Following the final testing and Test and Balance Agency shall be required to schedule two additional visits to make seasonal adjustments as necessary. One visit each shall be scheduled for the following summer/winter. The seasonal testing months shall be determined by APS & CxP.

E. Final Approval – The installation shall not be considered complete until a final report has been submitted by the Test and Balance Agency and approved by the design engineer. Refer to "Start-up and Commissioning" section of this guideline for other requirements.

1.4 SCOPE

A. Upon the completion of the T&B work, the Agency shall submit four copies of the complete HVAC Test and Balance Report directly to the Architect and APS. Test and balance report shall identify unit manufacturer, model number, serial number and location of the equipment. A DVD, in jewel case, with project name and company or type shall be provided. Report shall include equipment list in Adobe and Excel formats.

B. The Agency shall plainly mark and record the settings of all valves, dampers and other adjustable devices. If a balancing device is provided with a memory stop, it shall be set, locked and marked.

C. These systems include, but are not limited to, the following:
   1. Supply distribution systems
   2. Return and exhaust air systems
   3. Heating, ventilating and air conditioning equipment (all scheduled equipment)

1.5 SUBMITTALS

A. The name and certification of the Agency, along with the name and certification of the Certified Test and Balance Engineer, shall be submitted to the Architect for review within 30 days after the award of the general contract. The Test & Balance Company Vendor certification shall be included with the submittal.

B. The selected Agency shall submit to the Owner:
   1. Procedural Manual
   2. Report Forms
   3. AABC or NEBB Performance Guaranty
   4. Instrument List and Calibration Dates
   5. Schedule

C. A reviewed copy of each of the above shall be returned to the Agency before the HVAC Test and Balance begin.

1.6 EXECUTION

A. The Contractor shall start-up and maintain the HVAC systems and shall continue the operation of the HVAC systems during each day of testing and balancing. Start-up and operation shall include, as a minimum, the following:
   1. All equipment operable and in safe condition.
   2. Temperature control system complete.

3. Proper thermal overload protection in place for electrical equipment.
4. Ductwork leakage rates not exceeding those specified and all duct systems clean of debris.
5. Air transfer systems shall have:
    a. Correct fan rotation and RPM.
    b. Coils fins cleaned and combed.
    c. Filters clean and in place.
    d. Access doors closed.
    e. All dampers in place and open.
    f. All grilles, registers and diffusers installed.

End of Section 23 05 93 Testing, Adjusting and Balancing for HVAC

SECTION 23 07 13 – DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Duct Insulation Requirements
   2. External Duct Insulation Requirements
   3. Mastics, Seals and Adhesive Requirements

B. Legend:
   1. APS: Atlanta Public Schools
   2. DOR: Designer of Record
   3. OA: Outside Air

1.2 GENERAL DUCT INSULATION REQUIREMENTS

A. Ductwork used for supply air (including OA) shall be insulated.
B. Exhaust ductwork does not have to be insulated unless directed by APS or DOR.
C. Duct liner for thermal insulation is not acceptable.
D. Insulation on duct larger than 24” shall be pinned or wired on bottom of duct to prevent sagging.
E. Insulation shall not be pulled tight around corners.
F. Insulation shall not be compressed.
   1. In areas where there is limited space, duct board shall be used.
G. Duct insulation shall be sealed where duct strap hangers penetrates insulation.
H. If trapeze hanger penetrates insulation, fill in angular spacing of hanger support.
I. Duct insulation at fire dampers shall be sealed at wall.
J. Duct insulation shall be continuous through wall, ceiling, and floor penetrations.
K. Torn or ripped insulation shall be taped/repaired.
L. Exposed duct insulation, not located in mechanical rooms, shall be duct board.

1.3 EXTERNAL DUCT INSULATION REQUIREMENTS

A. Exterior ductwork shall be externally insulated.
B. External ductwork shall be elastomeric insulation or rigid duct board.
C. Insulation shall be sloped to prevent ponding.
D. Insulation shall have aluminum/metal clad jacketing.

1.4 MASTICS, SEALS AND ADHESIVE REQUIREMENTS

A. Mastics, seals and adhesives shall be low VOC.

End of Section 23 07 13 Duct Insulation

SECTION 23 07 19 – HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Refrigerant Pipe Insulation Requirements
   2. Chilled and Condenser Water Pipe Insulation Requirements
   3. Hot Water Pipe Insulation Requirements
   4. Condensate Pipe Insulation Requirements
   5. Adhesive, Sealant, and Tape Requirements

B. Legend:
   1. APS: Atlanta Public Schools
   2. CHW: Chilled Water
   3. HW: Hot Water
   4. CW: Condenser Water

1.2 REFRIGERANT PIPE INSULATION REQUIREMENTS

A. All piping shall be insulated with elastomeric insulation tubing.
B. Insulation shall not be compressed.
C. Saddles shall be located where refrigerant pipe is supported to prevent compression of insulation.
D. Supports and saddles shall not compress insulation.
E. Insulation at elbows and fittings shall be mitered or preformed except at isolation valves. Installation installed at isolation valves shall be pre-formed.
F. Insulation shall be continuous through walls, floors, and ceilings.
G. Refrigerant pipes shall not be affixed together included but not limited to zip tied together as this can compress insulation.
H. All piping shall be labeled. The insulation shall be labeled to indicate service. The service shall not be referred to or have in the description as simply “Gas”.
I. Refrigerant pipe and insulation located outside shall have aluminum or metal jacketing.
J. The insulation at the butt joints shall have matching insulation tape wrapped around joint to prevent separation.

1.3 CHILLLED AND CONDENSER WATER PIPE INSULATION REQUIREMENTS

A. All piping shall be insulated with fiberglass insulation with a jacket that is fire retardant.
B. Insulation shall never be compressed. Provide inserts between the support and piping.
C. Saddles shall be provided where supported to prevent insulation from becoming compressed.
D. Insulation at elbows and fittings shall be mitered or pre-formed.
E. Insulation shall be continuous through walls, floors, and ceilings.
F. All joints and seams shall be vapor tight.
G. All piping shall be labeled.
H. Hydronic pipe insulation locate outside shall have aluminum or metal jacketing.
I. Heat trace shall be installed where water in pipe has the potential for freezing.
J. Where Automatic air vents and or Manual air vents are installed at high points (required) in mechanical rooms, the valves below the air vent shall be wrapped.

1.4 HOT WATER PIPE INSULATION REQUIREMENTS

A. All piping shall be insulated with fiberglass insulation with a jacket that is fire retardant.
B. Insulation shall never be compressed.
C. Insulation at elbows and fittings shall be mitered or pre-formed.
D. Insulation shall be continuous through walls, floors, and ceilings.
E. All joints and seams shall be vapor tight.
F. All piping shall be labeled.

G. Hydronic pipe insulation locate outside shall have aluminum or metal jacketing.
H. Heat trace shall be installed where water in pipe has the potential for freezing.
I. Where Automatic air vents and or Manual air vents are installed at high points (required) in mechanical rooms, the valves below the air vent shall be wrapped.

1.5 CONDENSATE PIPE INSULATION REQUIREMENTS

A. All interior piping shall be insulated with elastomeric insulation tubing.
B. Insulation shall not be compressed.
C. Saddles shall be located where condensate pipe is supported to prevent compression of insulation.
D. Insulation at elbows and fittings shall be mitered or preformed. Insulation installed at isolation valves shall be pre-formed.
E. Cleanouts shall have removable insulation plugs.
F. P-traps, floor drains, and roof drains receiving condensate shall be insulated.
G. Insulation shall be continuous through walls, floors, and ceilings.
H. Condensate pipes shall not be affixed together included but not limited to zip tied together as this can compress insulation.
I. All piping shall be labeled. The insulation shall be labeled to indicate service.
J. Condensate pipe located outdoors does not need to be insulated.

1.6 ADHESIVE, SEALANTS, AND TAPE REQUIREMENTS

A. Adhesives, tapes, and sealants shall be low VOC.

End of Section 23 07 19 HVAC Piping Insulation

SECTION 23 08 00 - MECHANICAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Description of Work
   2. Definitions
   3. General
   4. Commissioning and Start-Up
   5. CxP Activities
   6. CxP Schedule of Activities
   7. Contractor Responsibilities

1.2 DESCRIPTION OF WORK

A. This Section includes work related to start-up procedures and the commissioning procedures related to systems installation and start-up. This section also includes a description of the duties of the Commissioning Agent (CxP) and contractor as theyrelate to start-up as well as other phases of the HVAC, fire protection and electrical work.

B. The activities called for in this Section apply to:
   1. HVAC work called for by Division 23.

C. Refer to other Division 23 Sections of the Specifications for start-up procedures for any other building systems included in this scope.

D. The CxP has been contracted directly for all of the duties and responsibilities required herein.

E. The Contractor shall include the commissioning activities in the master construction schedule of work.

1.3 DEFINITIONS

A. APS Design Guidelines: A document that details the functional requirements of a project and the expectations of how it will be used and operated. These include Project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, commissioning, training, documentation, and supporting information.

B. Basis of Design (BOD): A document that records concepts, calculations, system selection decisions, and product selections used to meet the APS Design Guidelines and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.

C. Commissioning: The systematic process of assuring by verification and documentation, from the design phase through occupancy that all facilities perform interactively in accordance with the design documentation and intent, and in accordance with the owner's operational needs, including preparation of operational personnel.

D. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process. This is an overall plan that provides the structure, schedule, and coordination planning for commissioning. As construction progresses, the CxP will update the plan, which includes details of:
   1. Commissioning scope.
   2. Systems to be commissioned.
   3. Rigor of commissioning.
   4. Team contact information.
   5. Roles and responsibilities of all parties.
   6. Communication and reporting protocols.
   7. Commissioning overview and details of submittal activities.
   8. Construction observation, checklists, and start-up activities.
   9. Process for dealing with deficiencies.
   10. Test procedure development and execution.
   11. Description of summary report, progress and reporting logs.

E. CxP: Commissioning Provider. The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process. The CxP has been engaged under a separate contract.

F. Construction Start-up: The initial activation or energizing of equipment or systems for the purpose of demonstrating completeness of installation, utility connections, performance, system operations, and ability to perform for its specified purpose.

G. Functional Performance Test (FPT) Procedures: This written protocol defines methods, personnel, and expectations for test conducted on components, equipment, assemblies, systems, and interfaces among systems. Tests clearly described the test prerequisites, required test conditions, individual systematic test procedures, expected system response and acceptance criteria for each procedure, actual response or findings, and any pertinent discussion. Test procedures differ from testing requirements found in the specifications, which describe what modes and features are to be tested and verified and under what conditions. Test procedures describe the step-by-step method of how to test. Simple checklists may be appropriate for testing simple components, but dynamic testing of interfacing components requires more detailed procedures and forms.

H. HVAC: The Heating, Ventilating and Air Conditioning system called for by the Contract Documents.

I. Issues Log: The purpose of this log is to provide a method for tracking and resolution of deficiencies discovered as a result of the commissioning process. This list also includes the current disposition of issues and the date of final resolution as confirmed by the Commissioning Provider. Deficiencies are defined as those issues where products, execution or performance do not satisfy the Specifications and/or the design intent. The Issues Log will be created and managed by the commissioning Provider.

J. Pre-functional Checklists: Pre-functional checklists are forms developed by the contractor, equipment manufacturer, or CxP as applicable and used by the contractor to verify that specified systems and components are complete and correctly installed, ready for start-up and functional testing. These Checklists are supplemental to the equipment manufacturer's standard installation instructions and pre-start up forms. The Completed Checklists along with the equipment manufacturer's pre-start-up forms must be submitted by the contractor PRIOR to startup of the equipment. Equipment specified to have factory start-up performed must have the applicable Checklist filled out by the vendor and submitted by the contractor. After the Checklists have been approved and start-up has occurred, the contractor can begin their pre-checkout of the functional operations of the equipment and systems prior to validation by the CxP during the Functional Testing.

K. Pre-functional Testing: The process of starting the equipment and systems utilizing vendor/contractor startup and installation pre-functional checklists in coordination with the CxP's pre-functional documentation to ensure systems are operating in compliance with the contract documents, specifications and building automation system sequences, prior to functional validation by the CxP

L. Start Up: The initial activation or energizing of equipment or systems for the purpose of demonstrating completeness of installation, utility connections, performance, system operations, and ability to perform for its specified purpose.

M. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

PART 2 – PRODUCTS (Not Applicable)

PART 3 – EXECUTION

3.1 GENERAL

A. Except for the activities to be performed by the CxP called for herein, all component and system installation work required by the Division 23 specifications including specific contractor furnished items indicated by this Section shall be provided by the Contractor.

1. The Contractor shall provide all necessary manpower to assist the CxP in activities to access all equipment and components including providing ladders with personnel to remove and re-install ceiling tiles under equipment to be commissioned and providing door keys to access rooms throughout the buildings

2. Contractor shall perform the following:

a. Contractor "in-house" preliminary commissioning and start-up based on equipment manufacturer's submitted procedures and the pre-functional CxP document to the CxP for review to assure the systems, equipment, and components are ready to be commissioned and inform the CxP that the commissioning start-up activities can begin.

b. The Contractor shall perform detailed "point to point" controls system check outs to verify that all DDC and life safety system wiring and any associated hard wired interlocks are correct PRIOR to the commissioning acceptance testing activities by the CxP. Upon this completion by the

Contractor, the Contractor shall work through the Controls Sequence of Operation with the CxP to verify that it meets the intent of the specifications. If sequences are found to require minor modifications based on actual field conditions, the Contractor and CxP shall jointly prepare recommendations and submit to the Owner and Engineer of Record for his approval of the modifications.

c. The contractor shall perform a pre-functional checkout of the building automation system to verify functional sequences are complete prior to commencing the functional systems validation by the CxP. After completion of the pre-functional checkout, demonstrate to the CxP that the systems operate as specified and complete. If the sequences are found to require minor modifications, based on actual field conditions, the contractor and CxP shall jointly prepare recommendations and submit to the Owner/Engineer of Record for approval, prior to modifications.

3.2 COMMISSIONING and START-UP

A. Place each item of equipment and each system into full operation.

B. Prior to start-Up:

1. The Commissioning Agent (CxP) shall verify that equipment and systems are complete, correctly connected to utilities, and tested. The CxP will submit to the Contractor and Architect/Engineer Commissioning Site Reports indicating any deficiencies in the installation relating to equipment and component connections (controls, piping, ductwork, etc.), insulation installation, maintenance clearances for servicing components and removal/replacement of equipment, code required clearances, hanger suspension of equipment and components, etc. A detailed "Deficiency Log and Resolution Report" will be maintained throughout the construction process and updated on a timely basis for the team. The contractor shall respond to the CxP for each Deficiency Log within two (2) days of receipt with comments indicating scheduled completion dates and actual date of the completed work.
2. The CxP will witness a sample of the Contractor's flushing and cleaning of piping systems, and calibration of the automatic temperature controls. A Testing Record Log will be maintained though the construction process by the Contractor and submitted to the CxP for review.
3. Comply with requirements of manufacturers.
4. Perform all pre-start inspections and tests as called for in Division 23 including all equipment and as may be necessary to ensure that work is installed as specified and to determine suitability for energizing.
5. The Contractor shall provide power for start-up and testing as may be required by the CxP.
6. The Contractor shall arrange for a change over from temporary to permanent utility sources.
7. The Contractor shall re-adjust and lubricate operating components to ensure smooth and unhindered operation.
    a. The Contractor shall check drive rotations, belt tension, control sequences, and other features which might cause damage if not adjusted. The CxP shall re-confirm drive rotations.
8. When specified or when required by manufacturer, have manufacturer's representative perform start-up and supervise their activities.

C. Notify the CxP / Architect / Engineer a minimum of three (3) days prior to start-up of each item and system.

D. The CxP's witnessing of start-up and testing of major system equipment and components specified herein and in Division 23, shall take place with the assistance of the Contractor as required.

E. Execute start-up under supervision of qualified contractor and equipment manufacturer personnel and in accordance with the manufacturer's instruction.

1. The CxP shall review the equipment manufacturer's pre-functional checklist for completion. The CxP may add to this checklist any requirements that go beyond the startup and installation checklists, which must be acknowledged before demonstration of the functional tests occur.
2. When specified or when required by manufacturer, have manufacturer's representative perform start-up witnessed by the CxP.
3. Review the manufacturer's representative written report of start-up operation and include in the Commissioning Report.

F. After start-up, the CxP shall notify the Contractor of any deficiency items requiring correction such as adjustments to components and equipment, any systems operation, equipment clearances for maintenance and code compliance, connections for: piping, power, ductwork, controls, etc.

G. The CxP shall perform with the Contractor assistance and manpower support component and system testing checking through every function and control sequence/cycle to ensure that it operates as designed and specified by conducting field observations for verification of the status of operation.
H. The CxP shall confirm the operation of equipment and systems documenting the results in the Commissioning Report and submit this to the Owner/Architect/Engineer for review.
   1. The Contractor shall have the final version of the Operating and Maintenance manuals specified in Division 23 available during testing and demonstration for components and systems.

3.3 CxP ACTIVITIES

A. Assist the Architect / Engineer in verifying and documenting compliance with the contract documents.
B. Oversee the performance of the start-up and functional tests of equipment, systems and components working with the Contractor for the controls' sequences of operation.
C. Observe installed HVAC ductwork, piping systems, controls, and equipment prior to covering or ceiling and partition installation.
D. Make periodic site visits during equipment and system "rough-in" to review their installation with particular attention paid to proper access for maintenance, code required clearances, equipment testing, balancing, replacement, etc. Document these findings in Commissioning Site Reports and Deficiency and Resolution Log Reports as "punch-list" items requiring correction by the Contractor.
E. Coordinate with the Contractor's construction schedule for implementation of the Commissioning Activities after reviewing the overall general construction schedule. Coordinate updates to the Commissioning Activities with the Contractor throughout the construction of the project.
F. Witness all design and performance tests called for by Division 23. Initiate and witness additional system and equipment tests as required to verify compliance and performance.
G. Monitor the installation of all major HVAC equipment and plumbing (water heating equipment only)
H. Attend site observations for substantial and final completion and assist in listing (punch list) the incomplete or corrective work called for.
I. Review all changes in scope that affect the systems to be installed related to the work of Division 23 and adjust the Commissioning Plan as required.
J. Field verify accuracy and completeness of the Test and Balance reports submitted under Division 23 by witnessing critical system balancing by the Test and Balance agent. Review the Test and Balance Report prior to project turnover to the Owner and forward comments to the Architect/Engineer and Owner.
K. Review the Contractor's installed piping and equipment identification and labeling for conformance to the specifications.
L. Coordinate the start-up with the Owner so that their staff can be present during the commissioning start-up and system testing activities.
M. Prepare and submit the Commissioning Report prior to project acceptance by the Owner. The report shall contain the Commissioning Plan consisting of the following:
   1. Equipment and systems testing procedures
   2. Commissioning Site Reports of punch list items
   3. Completed Equipment Pre-functional Checklist Forms
   4. Manufacturer Start-up Reports
   5. Deficiency and Resolution Log reports
   6. Testing Log reports

3.4 CxP - SCHEDULE OF ACTIVITIES

A. Within a timely fashion after the Notice to proceed, the CxP shall submit to the Contractor a schedule of the construction activities related to the work of Division 23, as called for by the Contract Documents, which the CxP will be inspecting, monitoring or performing, including the name of the person who will be performing the Activities. Periodic updates will be submitted during the course of the project to keep the Contractor current with any modifications to Contractor's construction schedule and the Schedule of Activities.

B. Prior to the beginning of any HVAC and plumbing systems field work, the CxP will forward to the Owner / Architect / Engineer and the Contractor copies of the applicable Pre-functional Checklist forms to be executed by the CxP with the assistance of the Contractor's field personnel.

C. The CxP shall prepare and distribute functional test procedures for completion by the CxP. These documents will be used during completion of the Functional Performance tests and during the CxP validation process to confirm systems are complete and operational.

3.5 CONTRACTOR RESPONSIBILITIES - CxP ACTVITIES

A. Contractor shall accommodate the duties and tasks of the CxP, including, but not limited to, by:

1. Allowing the CxP access to the site during normal working hours.
2. Working with the CxP to coordinate commissioning activities with construction activities and include these activities in the master construction schedule. This master construction schedule shall include a minimum of two (2) weeks of schedule time for the commissioning activities PRIOR to project turnover to the Owner for "final" building systems acceptance.
3. Making allowance in the overall project schedule for the integration of those commissioning activities which are dependent upon the activities and progress of the project. Allow a minimum of five (5) days from the start-up of the last unit in the system until the completion of the Commissioning process. Notify the CxP directly with a copy to the Architect, of any procedure, test, covering, installation, or start-up of equipment, which are on the Schedule of Activities.
5. Contractor shall inform the CxP of the schedule of his performance for Test and Balancing of the air systems, including flushing and cleaning of domestic hot water piping systems, and calibration of the automatic temperature controls.
6. The Controls contractor shall perform their own "Point-to-point" wiring and communications detailed field testing to assure all Controls systems are functioning properly PRIOR to the CxP's HVAC Functional Performance Testing activities. The Controls contractor shall assist the CxP in the field providing labor as required to operate the Control system computer software and hardware components during the Functional Performance Testing of all HVAC and plumbing (hot water system only) equipment, components and systems.
7. The Contractor shall respond in writing within seven (7) days of receipt to the Commissioning Site Reports and Deficiency and Resolution Log Reports with dates of completion of the associated punch list items noted by the CxP.
8. The Contractor shall provide power and fuel for start-up and testing as may be required by the CxP and other sections of the specifications.
9. The Contractor shall arrange for a change over from temporary to permanent utility sources.
10. The Contractor shall re-adjust and lubricate operating components to ensure smooth and unhindered operation.
11. The Contractor shall check drive rotations, belt tension, control sequences, and other features which might cause damage if not adjusted.
12. Where specified or when required by manufacturer, the Contractor shall have the manufacturer's representative perform start-up to be supervised by the CxP for their activities.
13. Trend logs required in the testing requirements will be set up and executed by the Contractor and provided to and analyzed by the CxP. Monitoring using data loggers will be conducted by the CxP as needed. Trend logs shall be compiled and transmitted to the CxP in a CSV or Excel format. PDF's and graphs are not acceptable. Trend logs and monitoring are conducted after manual testing and subsequent trouble-shooting are complete and systems are in normal operation without frequent service shutdowns, etc.

B. The contractor's schedule shall be the basis for the coordination of the CxP's activities. Input from the CxP shall not be used or construed to dictate the progress, timing or planning of any of the Contractor's work activities except as necessary to coordinate the CxP's scheduled activities.

C. Contractor shall provide a minimum of five (5) days written notice in advance of any test, cover-up, installation, or scheduled commissioning activity. Failure to provide this notice may result in the Contractor uncovering, re-testing or re-starting these systems at the Contractor's expense.

D. The Contractor shall, at all times and upon demand, make available to the CxP for inspection, the Record Drawings maintained in the field called for by the General Conditions, all currently approved Shop Drawings, and the current version of the Operation and Maintenance manuals.

E. The Contractor shall coordinate and make arrangements for a collaborative effort between the CxP and the HVAC subcontractor's Automatic Temperature Controls sub-subcontractor to perform functional performance tests on each item, sub-system and entire control system witnessed by the CxP. Additional systems as noted herein will require the Contractor's assistance in field personnel along with providing access to ceiling plenums and rooms (providing labor to remove/reinstall ceiling tiles, ladders, etc.).

F. The Contractor shall schedule the Work taking into account the activities to be performed by the CxP. No claim for delay or request for an extension of Contract Time will be allowed as the result of the scheduled activities of the CxP.

G. The Contractor shall take into account the activities of the CxP in submitting their Bid for the Work. No additional compensation or changes in the Contract Sum will be approved if the basis of the proposed change is a result of the prescribed activities of the CxP.

End of Section 23 08 00 Commissioning - Mechanical

SECTION 23 09 13 – INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. General Requirements
2. Scope Definition
3. Design requirements
4. BMS Requirements
5. Other Requirements
6. BMS Supplemental Requirements
7. Minimum System Points list

B. Legend:
1. AHU: Air Handling Unit
2. APS: Atlanta Public Schools
3. BMS: Building Management System
4. DDC: Direct Digital Control System
5. DOAS: Dedicated Outdoor Air System
6. EF: Exhaust Fan
7. EMS: Energy Management System
8. ERU: Energy Recovery Unit
9. LCT: Leaving Coil Temperature
10. MAU: Make-up Air Unit
11. NSB: Night Set-Back
12. PIU: Powered Induction Unit
13. RTU: Roof Top Unit
14. VAV: Variable Air Volume
15. VRF: Variable Refrigerant Flow
16. VRFC: Variable Refrigerant Fan Coil
17. WSHP: Water Source Heat Pump

1.2 GENERAL REQUIREMENTS

A. Atlanta Public Schools (APS) has Building Management Systems (BMS) installed in all school facilities for the purpose of controlling and monitoring HVAC systems and for energy conservation and utility recording. Standalone panels at BMS schools, communicate with PC workstations at the APS Central Utilities Office via Internet connections. The goal of APS is upgrade all schools on BMS (Building Management Systems).

B. New and/or renovated school facilities shall be designed with an EMS/ BMS including the appropriate sensors, actuators, panels, and software as a standalone system with the ability to interface with the APS central office for remote controlling and monitoring energy using equipment and systems. When a school is to be renovated that contains an active BMS (for the complete school or part of the school), the renovated area shall be designed to utilize a BMS of the same, or compatible, manufacturer, as an extension of the existing system. When another manufacturer is selected, the new system must be capable of operating the existing system and to provide an interface that will result in a single Internet connection as a combined system, except as directed by Atlanta Public Schools. The replacement system must be able to pick up all control points and request new control points.
1. Each school shall have a Laptop with all applicable software dedicated to operating the Energy Management System.
2. The Building Automation System (BAS) for new installations shall be a product of Trane Technologies, Inc. or Automated Logic, Corp. No others will be accepted, unless approved by APS. Johnson Controls may be installed on existing facilities where it is already installed.

C. Minimum BMS Functions
1. Building automation is the process of controlling, monitoring and providing status of the connected building systems in the most economical way, providing real-time information on

building operation and on its controlled parameters and assisting in troubleshooting of building environmental controls-related problems. The system shall be capable of the following:

a. Monitor/control HVAC zone and space temperatures from a central remote location workstation. The remote operator shall be able to view equipment graphics and locations floor plans and adjust equipment as required, to meet changing conditions.
b. Start/Stop all energy consuming equipment and accurately monitor status (includes interior/exterior lighting).
c. Monitor/record building electricity usage and demand and perform demand control routines.
d. Monitor/record outdoor temperature and relative humidity.
e. Monitor/record fire alarm system activities.
f. Monitor/control chiller and boiler plant equipment (includes hot water temperature control/reset).
g. Initiate local and remote alarms when monitored equipment status changes from set parameters, and in emergencies.
h. Monitor/control economizer and ventilation controls.
i. Record equipment operating hours and trends.
j. Provide manual override with security password at the school site for emergency operations.
k. Monitor discharge temperature control, and monitor outside air, CO_2, enthalpy and temperature for space comfort.
l. Must be able to reset the unit from the front-end of the controls.

D. Other requirements

1. Fire alarm shutdown of HVAC equipment shall be coordinated with the BMS contractor and shall not utilize equipment safety circuits to shut down the unit. Example: connect to the condensate overflow shutdown switch for WSHP's.
2. Fire alarm shutdown shall be a hardwired shutdown initiated with Fire alarm certified components and will be totally independent of the BMS or ASC (application specific controller, or unitary controller.)
3. Provide a full-service contract for two (2) years after acceptance by APS. Year one (1) shall run concurrent with the warranty period followed by a second-year full service contract, labor & parts for all HVAC projects (renovations and new construction).
4. Provide ability for remote central control workstation to perform global notifications to school facilities for equipment scheduling and operation. Provide web-based, blade server, and latest version of Microsoft.
5. Trane, ALC and Johnson Controls shall be acceptable manufacturers of Direct Digital Control (DDC) Building Automation Systems (BMS using an open protocol system (BACNET) and compatible with existing APS systems. Consultation with APS Project Manager and Maintenance Department is required, to determine appropriate DDC system if the existing DDC Controls are not Trane
6. Successful DDC applications are characterized by control of the desired building parameters with high accuracy and reliability and with minimal operating and maintenance costs.
7. To have a successful DDC installation, four engineering expertise must interact: Facilities Engineering, HVAC Engineering, commissioning and DDC Applications Engineering.
8. The engineers should work within the boundaries of a defined project and operate and maintain the system to meet safety and occupancy requirements.

1.3 SCOPE DEFINITIONS

A. **Definition of:** HVAC system, DDC Systems, level of facilities automation, architectural requirements.
B. **Design of:** HVAC System, Architecture, Control and Alarm Logic, Networking, report generation.
C. **Installation of:** HVAC System, DDC hardware, software, OWS, Presentation, interfaces, communications, and as-built documentation.
D. **Contractor Start-up Commissioning:** HVAC, TAB, DDC validation, calibration, application SW verification, end-to-end testing, operation under normal conditions, operation under fault conditions, documentation and verification of specified system. Contractor is responsible for checking 100% of their installed scope. Contractors shall complete commissioning checklists in

addition to manufacturer's checklists. Checklists shall be signed by the project Forman having direct knowledge of the work performed. Signed checklists shall be reviewed and approved by the general contractor and sent to the CxP indicating system is ready for CxP team commissioning.

E. **Documentation Turnover:** Final turnover to the owner, documentation, test and validate all mechanical systems through automation view and function, operation, training and review of system performance.

F. **Continuous Operation:** Performance verification, DDC upgrades services.

1. System Management shall consist of networked stand-alone DDC panels; Standalone Application Specific Controllers (ASCs); Portable Operator Terminals (Laptop Computer); System must be web-based.
2. Specific computer requirements:
   Laptop with 7th generation I7-7500U Intel processor, 16 GB memory, 2 TB hard drive, 512 GB SSD (solid state drive) or better. Windows 10 operating system.
   HP Wireless optical mouse.
   Swiss Gear 18.5" Travel Gear Odyssey Laptop Backpack
3. Server requirements: No requirements as system will be installed on Atlanta Public Schools Virtual server.
4. The BMS shall be capable of control and management of multiple building functions, such as HVAC equipment, alarm systems, lighting, energy management, historical data collection and archiving; monitor coolers/freezers, walk-ins; capable of stand-alone or remote control through networking. IT closets
5. The BMS shall be modular and shall permit modular expansion of both capacity and functionality through the addition of sensors, actuators, stand-along DDC panels and other devices.
6. Direct Digital Controls shall be used at all individual HVAC equipment items and/or systems and networked into the Building Automation System. The system shall be able to operate independently after programming from the Central EMS. Where sensors are located in ductwork, loop piping and mixed air stations, access panels shall be provided for service and maintenance.

1.4 DESIGN REQUIREMENTS

A. The design professional shall include the following in a detailed HVAC Control System plan as part of the final contract documents:

1. Heating Mode System Diagram.
2. Cooling Mode System Diagram.
3. Control System Diagram
4. A detailed description of the Sequence of Operation separately for heating and cooling, including system start-up procedures, temperature control strategies for various climate/weather conditions, change over operation and system shutdown procedures. Evidence of the approved sequence of operation shall be exhibited prior to the complete installation.
5. Fire Emergency Mode System Diagram, together with a detailed description of the Sequence of Operation during a fire or other Emergency condition.
6. A total Energy Management System Diagram for the individual on-site building(s) and the Central remote Station Interface. Diagram shall include exact location of device controllers, routers, repeaters, routing of the communications link/links, and any other on network device related totally or in part to the building automation system; i.e. Room Numbers, controller names, BACnet ID schedule.

1.5 BMS REQUIREMENTS

A. The Building Management System shall be fully installed as a complete package by the Building Management contractor. The system shall include all wiring, installation of devices, calibrations, and adjustments that are necessary for a complete and fully operational system. High resolution color graphics shall be provided. These graphics shall be dynamic displaying the most current data on the screen. Set points such as, input/outputs shall be changeable through these color graphic screens. Provide a manual control menu to allow the operator to manually turn on or off points, start and stop equipment, manually adjust outputs, restart control calculations, or release points to automatic control. Place as much information as possible on the equipment graphic. Primary equipment will be identified with; Type,

model number, serial number; location: floor/section/room number as well as area served. Secondary equipment, such as, Powered Induction Units, Fan Coil Units, VRFs, etc. will be identified with the Primary Equipment via a pull down menu listing secondary equipment: type, model number, serial number and serving: room/number, area, section or other as well as area served. Submit each primary equipment graphic with all associated secondary equipment graphics for approval. An Equipment Summary document shall be included as part of the graphics package; the equipment summary document shall provide the type of equipment, room number, equipment ID, model number, serial number, location, start-up date; set temperature and real time temperature with "alert". The Equipment Summary shall be interactive as to provide a direct link to the specific equipment graphic when the operator double clicks the Equipment ID/Type Equipment.

B. The Building Management System shall provide a complete graphic floor plan showing all areas of the facility including room numbers and space temperatures and AHUs/RTUs/PMUs/DOAS/ERUs associated with each room/space.
   1. DOAS/ERUs shall be shown in an equipment tree showing what areas and/or units they serve.

C. The Building Management System shall be connected and operable via the APS LAN. The system shall also provide for backup via a dedicated telephone line.

D. Products – The Building Management System shall be the product of either of the following approved vendors: Johnson Controls, Automated Logic ALC and Trane. No others accepted.

E. All DDC components shall be of the same manufacturer with the FMS Contractor being responsible for any devices connected to the DDC system.

F. Performance – The FMS contractor shall provide a DDC system with the minimum standards as outlined:
   1. BAC Net compliant per ASHRAW/ANSI standard 135.
   2. The FMS shall be capable of controlling multiple building functions such as lighting alarm systems, HVAC equipment, and HVAC Equipment alarms.
   3. The FMS shall be modular and shall permit modular expansion of both capacity and functionality through the addition of sensors, actuators, valves and stand-alone DDC panels.
   4. The DDC shall be used at all individual HVAC equipment components and/or systems and networked into the FMS, web based ready, if requested and capable of operation after programming from the central site located at 1631 LaFrance Street.
   5. The FMS contractor shall comply with all other requirements as determined by the design officials.
   6. The system shall provide global set point and schedule modifications and popup operation sequence for any mechanical device shown by graphic.
   7. All equipment shall be scheduled in accordance with APS standards prior to completion of the project.
   8. Graphics shall be consistent with other graphic design on same vendors systems with any new upgrades presented to APS in the planning stage

1.6 OTHER REQUIREMENTS

A. Provide global modification of schedules and set points to all linked devices within the structure.

B. All control wiring shall be in green conduit in mechanical rooms; exposed areas, such as stairwells, electrical rooms etc. and shall be plenum rated. Pull boxes shall be labeled as controls with the voltage of enclosed wires. Exposed control wiring in the classrooms shall be in conduit and the conduit will be installed into the corridor and terminated.

C. All control wiring shall be purple.

D. Provide a UPS for the Supervisory controller and each control panel (RCP). The UPS shall be sized to accommodate the equipment load requirements for a minimum of ten minutes. The UPS shall be installed in a ventilated lockable cabinet. The UPS shall be rack mounted if located in the IDF or MDF rooms.

E. Provide an outdoor air temperature, and separate outdoor air humidity sensor that is not part of the equipment and it will be mounted on the facility in a location coordinated with APS and the Commissioning Provider.

F. The controls contractor will not remove hardwired or programmed safeties, or take over the refrigeration cycle of any vendor's equipment. Integration will consist of providing set points, controlling occupancy, reading available unit provided point information, and damper control if deemed absolutely necessary.

G. Provide space temperature sensors:
Classroom – with software controllable adjustment band of 1-3 degrees
Common spaces – non-adjustable
MDF/IDF closets
Freezers/coolers – with thermal-break to prevent false alarms

H. Provide thermostat guards:
All thermostat guards will be approved by APS prior to installation:
Style and installation location/methods
1. Wire protective grill to prevent tampering and/or damage for adjustable sensors
enclosed cover type for non-adjustable sensors.
Steel plate sensors will be utilized in common areas and hallways as deemed appropriate
If key type, provide an extra set. Keys shall be supplied to the APS HVAC shop during building turnover and closeout.

1.7 BMS SUPPLEMENTAL REQUIREMENTS

A. Web based system with analog phone line back-up
B. Full building floor plan and equipment graphics on computer at APS site
C. Must show discharge air temperatures
D. Training (32 hours in increments as required) for operational personnel
E. The Training syllabus shall be submitted to and approved by APS as soon as practical to allow the scheduling and designation of personnel in a timely manner. The information contained in the program shall include how the training will be conducted; when and where the sessions will be held; names and company affiliation of trainers; recommended reference materials; outside reading, etc. Atlanta Public Schools will furnish the lists of APS personnel for each training session.
F. ALL controls shall be serviceable and replaceable by APS contracted controls vendor.
G. Same day warranty response time (within eight (8) hours)
H. Surge protection and UPS backup shall be installed at each BMS main interface control (BCU, NAE, SC, LGR, or other supervisory controller) and will include all controls components located in the cabinet.
I. If the communications link extends between buildings, it will include surge protection.
J. Equipment identification tags located on ceilings or adjacent surfaces
K. Equipment room and graphic numbers must coordinate
L. A copy of all necessary diagnostic software must be provided
M. Old systems and new systems must fully integrate and communicate
N. Provide training and all service tools with connection kits and related software that is used by BMS controls vendor service technicians. All software will be installed on APS computers during training sessions. Training will be provided for (4) Atlanta Public Schools HVAC Technicians.
O. Provide additional training to allow APS techs to install and download programs in-house directly to control devices.
P. Installation:
Q. The BMS contractor shall install all system components as specified and in accordance with all applicable standards and codes; i.e., UL-916-PAZ X products, NFPA70, FCC-Part J, ASHRAW/ANSI 135- (BAC Net).
R. Sensor Space and Temperature – Space temperature sensors shall be installed within the controlled space remote from the mechanical equipment device at the code recommended height.
S. Space temperature sensors shall be provided with a 1-3 degree controllable adjustment.
T. Flat plate temperature sensors shall be installed hallways, and common areas.
U. System Acceptance
1. The BMS shall be connected to operate at the APS Central Site for a period of 48 hours, and have a demo conducted by the FMS contractor with the following representatives present: FMS Contractor, Mechanical Contractor, Project Engineer, APS Project Manager and APS Maintenance.

1.8 MINIMUM SYSTEM POINT LISTS

A. For minimum system points list, refer to controls-trending section 23 09 95.

End of Section 23 09 13 Instrumentation and Control Devices for HVAC

SECTION 23 09 93 – SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Description
2. Typical Sequence of Operations and Requirements for Single Zone VAV RTUs
3. Typical Sequence of Operations and Requirements for VAV RTUs
4. Typical Sequence of Operations and Requirements for Single Zone VAV AHUs
5. Typical Sequence of Operations and Requirements for VAV AHUs
6. Typical Sequence of Operations and Requirements for ERUs
7. Typical Sequence of Operations and Requirements for DOAS
8. Typical Sequence of Operations and Requirements for VAVs
9. Typical Sequence of Operations and Requirements for PIUs
10. Typical Sequence of Operations and Requirements for WSHPs
11. Typical Sequence of Operations and Requirements for VRFCs.
12. Typical Sequence of Operations and Requirements for Mini-Splits
13. Typical Sequence of Operations and Requirements for Electric Heaters
14. Typical Sequence of Operations and Requirements for Exhaust Fans
15. Typical Sequence of Operations and Requirements for Supply Fans
16. Typical Sequence of Operations and Requirements for Kitchen MAUs
17. Typical Sequence of Operations and Requirements for Chillers
18. Typical Sequence of Operations and Requirements for Water Source Heat Pump Loop
19. Typical Sequence of Operations and Requirements for Boilers
20. Typical Sequence of Operations and Requirements for Cooling Towers
21. Typical Sequence of Operations and Requirements for Pumps

B. Legend:
1. AHU: Air Handling Unit
2. APS: Atlanta Public Schools
3. BMS: Building Management System
4. DDC: Direct Digital Control System
5. DOAS: Dedicated Outdoor Air System
6. EF: Exhaust Fan
7. ERU: Energy Recovery Unit
8. LCT: Leaving Coil Temperature
9. MAU: Make-up Air Unit
10. NSB: Night Set-Back
11. PIU: Powered Induction Unit
12. RTU: Roof Top Unit
13. VAV: Variable Air Volume
14. VRF: Variable Refrigerant Flow
15. VRFC: Variable Refrigerant Fan Coil
16. WSHP: Water Source Heat Pump

1.2 DESCRIPTION

A. It is APS' goal to have a standardized sequence of operations for similar equipment at every school. Sequence of operations located in this section are typical requirements for each piece of equipment. Unless otherwise directed by APS; installed equipment shall operate as described throughout this section.

1.3 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR SINGLE ZONE VAV RTUS

A. Operation of Single Zone RTUs

1. Start Mode
   a. Unit is enabled according to owner defined schedule programmed in the Building Management System (BMS).
   b. Staggered start application shall prevent all controlled equipment from simultaneously restarting after a power outage or fire alarm restart. The order in which equipment (or groups of equipment) is started, along with the time delay between starts shall be user-selectable.
   c. Supply fan will "soft start" via the frequency inverter and slowly ramp fan up to set point.
   d. Unit starts up with 100% return air. The unit then follows the optimal start sequence.
2. Optimal Start/Morning Warm-Up/Morning Cool Down
   a. The building exhaust and relief fans shall remain off until set points are reached.
   b. Unit starts morning warm up and cool down mode based on optimal run time so that the space temperatures are at set point before scheduled occupancy.
   c. During morning warm up, outside air dampers are closed, relief damper is closed, cooling is disabled, return air damper open, supply fan shall be enabled and heating shall be enabled as needed. NOTE: Dehumidification mode is suspended during morning warm-up.
   d. During morning cool down, outside air dampers are closed, relief damper is closed, heating is disabled, return air damper open, supply fan shall be enabled and cooling shall be enabled as needed.
3. Occupied Mode
   a. During occupied mode, supply fan runs continuously.
   b. When each unit is turned ON by the Direct Digital Control System (DDC), using the time scheduling, timed override or event programming, heating and cooling shall be provided as required. NOTE: The outside air dampers shall remain closed until the occupied time of the zone.
   c. The unit provides modulating capacity to stage compressors on or modulate gas heat in order to maintain zone single temperature set point of **73** [°F] ± **2** [°F] for dead band between heating and cooling set points (adj.).
   d. An occupant adjustable zone sensor shall have the ability to reset zone set point **70-76** [°F] (adj.)
   e. Compressor operates subject to its own internal safeties and controls.
   f. Compressor stage has a minimum runtime to prevent short cycling.
   g. Heat operates subject to its own internal safeties and controls.
   h. If OAD and RAD have independent or separate operators, dampers shall not function proportionally. OAD shall be fully open before RAD modulates closed to achieve OA cfm.
4. Unoccupied Mode
   a. The supply fan shall be disabled; the outside air damper shall close and return air damper remains open.
   b. If the space temperature space sensor drifts out of the Night Set Back (NSB) set point range of **65 - 78** [°F] (adj.), the rooftop unit shall be enabled to satisfy set point. The outside air damper shall remain closed.
   c. During unoccupied mode, unit cycles supply fan, compressors and hot-gas-reheat to maintain unoccupied humidity set points.
   d. Dehumidification operates when the space wet bulb temperature is greater than set point of **62** [°F WB] (adj.). When operating in dehumidification mode the unit shall maintain a Leaving Coil Temperature (LCT) of < 55 and enable the hot gas reheat in order to maintain space temperature set point. The unit shall stay in dehumidification mode until the wet bulb temperature of the space is less than **60** [°F WB] (adj.).
   e. Unit can be enabled in occupied mode from BMS for **2** hours (adj.).

5. Dehumidification Mode
    a. In occupied mode, dehumidification operates when the space relative humidity is greater than the humidity set point of **60** [%RH] (adj.). When operating in dehumidification mode the unit shall maintain a LCT of < 55 and enable the hot gas reheat in order to maintain set point. The unit shall stay in dehumidification mode until the relative humidity of the space is less than **55** [% RH] (adj.). Outside air damper shall close/modulate to min/min.
    b. In unoccupied mode, dehumidification operates when the space wet bulb temperature is greater than set point of **62** [°F WB] (adj.). When operating in dehumidification mode the unit shall maintain a LCT of < 55 and enable the hot gas reheat in order to maintain space temperature set point. The unit shall stay in dehumidification mode until the wet bulb temperature of the space is less than **60** [°F WB] (adj.).
    c. If return air relative humidity rises above the space humidity set point upper limit while in economizer, dehumidification takes precedence, and unit shall come out of economizer and go into dehumidification.
    d. If space temperature drops below temperature set point while in dehumidification, temperature set point takes precedence, and unit shall come out of dehumidification and go into heat mode.
    e. If space temperature rises above temperature set point while in dehumidification, temperature set point takes precedence, and unit shall come out of dehumidification and go into cool mode.
    f. If CO_2 exceeds **900** [ppm] (adj.) while in dehumidification, humidity control shall take precedence over demand ventilation until return air relative humidity set point is satisfied.
6. Economizer Mode
    a. Economizer shall enable using comparative enthalpy i.e.; when outdoor air enthalpy is below return air enthalpy and a call for cooling with dry bulb override to enable economizer for OAT less than 55 °F.
    b. When operating in economizer mode, maximum outside air and return air dampers shall modulate to maintain discharge air temperature to satisfy space set point.
    c. If the maximum OA damper reaches maximum open position and cannot maintain the discharge air temperature at set point, then the supply fan's speed automatically modulates up from minimum to 100% to achieve the space temperature set point.
    d. On further increase in space temperature above the set point, then the fan speed shall reset to minimum set point and mechanical cooling should enable and assist in order to maintain set point.
    e. Heating shall never be enabled in economizer mode.
7. Demand Control Ventilation Mode
    a. The use of outdoor air for ventilation shall be provided only during scheduled hours of occupancy.
    b. Unit enters purge mode when CO_2 level is greater than set point of **900** [ppm] (adj.). When operating in purge mode the outside air damper modulates open to the scheduled maximum outside air CFM set point and remains there until the space CO_2 is below set point of **700** [ppm] (adj.). Unit OA damper should never open past the scheduled maximum purge OA flow.
8. Building Pressurization
    a. The exhaust fan tracks the supply fan with an offset of [CFM] (adj.). Determined mathematically by the engineer.
    b. A pressure sensor is used for monitoring building pressure.

B. Alarms and Shutdowns
   1. Emergency Shutdown: The unit shall shutdown in response to a contact closure to the DDC system indicating the presence of fire or other emergency condition. Upon fire alarm reset, unit shall return to operating mode. Equipment shall not lock out after multiple fire alarm events.
   2. Supply Air Smoke Detection: Unit shall shut down and close dampers on detection of smoke. Alarm is sent to the fire alarm panel.
   3. Return Air Smoke Detection: Unit shall shut down and close dampers on detection of smoke. Alarm is sent to the fire alarm panel.
   4. Unit shuts down on signal from fire alarm system.
   5. Unit shuts down on activation of the supply fan high static pressure switch
   6. Unit shuts down and BMS alarms upon activation of condensate overflow switch.
   7. BMS alarms on dirty filter.
   8. BMS alarms on any motor failure to start.

C. BMS Shall Monitor and Display
   1. Supply fan start/stop
   2. Supply fan status
   3. Supply fan speed
   4. Exhaust fan start/stop
   5. Exhaust fan status
   6. Exhaust fan speed
   7. Cooling start/stop
   8. Cooling status
   9. Compressor status
   10. Compressor modulation
   11. Heat start/stop
   12. Heat status
   13. Heat modulation
   14. Hot gas reheat start/stop
   15. Hot gas reheat status
   16. Hot gas reheat modulation
   17. Occupied/unoccupied mode
   18. Relief damper enable.
   19. Supply air temperature
   20. Leaving coil temperature
   21. Outside air temperature
   22. Outside air humidity
   23. Return air temperature
   24. Return air humidity
   25. Space temperature
   26. Space humidity
   27. Space CO_2
   28. Space temperature set point
   29. Space humidity set point
   30. Space CO_2 set point
   31. Filter status
   32. Condensate overflow switch status.
   33. Building Pressure

1.4 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR VAV RTUS

A. Operation of VAV RTUs

1. Start Mode
   a. Unit is enabled according to owner defined schedule programmed in the Building Management System (BMS).
   b. Staggered start application shall prevent all controlled equipment from simultaneously restarting after a power outage or fire alarm restart. The order in which equipment (or groups of equipment) is started, along with the time delay between starts shall be user-selectable.
   c. Supply fan will "soft start" via the frequency inverter and slowly ramp fan up to set point.
   d. Unit starts up with 100% return air. The unit then follows the optimal start sequence. NOTE: Terminal units downstream shall open dampers prior to unit start up in order to prevent RTU from tripping on high static and likewise terminal units shall remain open during shut down until RTU has shut down completely.
2. Optimal Start/Morning Warm-Up/Morning Cool Down
   a. The building exhaust and relief fans shall remain off until set point is reached.
   b. Unit starts morning warm up and cool down mode based on optimal run time so that the space temperatures are at set point before scheduled occupancy.
   c. During morning warm up the outside air dampers are closed, relief damper is closed, cooling is disabled, return air damper open, supply fan shall be enabled and heating shall be enabled as needed. NOTE: Dehumidification mode is suspended during morning warm-up.
   d. During morning cool down the outside air dampers are closed, relief damper is closed, heating is disabled, return air damper open, supply fan shall be enabled and cooling shall be enabled as needed.
3. Occupied Mode
   a. During occupied mode, supply fan runs continuously.
   b. When the unit is enabled by the DDC system during normal occupied hours, all the unit functions shall be enabled for normal heating and cooling operations. The unit will operate under supply air temperature sensor control.
   c. The unit provides modulating capacity to stage compressors on or modulate gas heat in order to maintain the supply air temperature set point of **55** [°F] (adj.). Unless in SAT reset.
   d. Compressor operates subject to its own internal safeties and controls.
   e. Compressor stage has a minimum runtime to prevent short cycling.
   f. Heat operates subject to its own internal safeties and controls.
   g. If OAD and RAD have independent or separate operators, dampers shall not function proportionally. OAD shall be fully open before RAD modulates closed to achieve OA cfm.
4. Unoccupied Mode
   a. The supply fan shall be disabled; the outside air damper shall close and return air damper remains open.
   b. If the space temperature space sensor drifts out of the NSB set point range of **65 - 78** [°F] (adj.), the rooftop unit shall be enabled to satisfy set point. The outside air damper shall remain closed.
   c. During unoccupied mode, unit cycles supply fan, compressors and hot gas reheat to maintain unoccupied humidity set points.
   d. In unoccupied mode, dehumidification mode operates when the space wet bulb temperature is greater than set point of **62** [°F WB] (adj.). When operating in dehumidification mode the unit shall maintain a DAT of < 55 [°F] and enable the hot gas reheat (when available) in order to maintain the space temperature set point. The unit shall stay in dehumidification mode until the wet bulb temperature of the space is less than **60** [°F WB] (adj.).Terminal units shall operate to maintain space temperature when units are in dehumidification mode.
   e. Unit can be enabled in occupied mode from BMS for **2** hours (adj.).

5. Dehumidification Mode
   a. In occupied mode, dehumidification operates when the space relative humidity is greater than the humidity set point of **60** [%RH] (adj.). When operating in dehumidification mode the unit shall maintain a DAT of < 55 [°F] and enables the hot gas reheat (when available) in order to maintain the space temperature set point. If hot gas reheat is not available, the unit discharges **55** °F air and terminal units modulate to minimum supply air flow and engage reheat. The unit shall stay in dehumidification mode until the relative humidity of the space is less than **55** [% RH] (adj.). The outside air damper shall close/modulate to min/min.
   b. In unoccupied mode, dehumidification operates when the space wet bulb temperature is greater than the set point of **62** [°F WB] (adj.). When operating in dehumidification mode the unit shall maintain a DAT of < 55 [°F] and enable the hot gas reheat (when available) in order to maintain the space temperature set point. If hot gas reheat is not available, the unit discharges **55** °F air and terminal units modulate to minimum supply air flow and engage reheat. The unit shall stay in dehumidification mode until the wet bulb temperature of the space is less than **60** [°F WB] (adj.).
   c. Terminal units shall operate to maintain space temperature when unit is in dehumidification mode
   d. If return air relative humidity rises above the space humidity set point upper limit while in economizer, dehumidification takes precedence, and unit shall come out of economizer and go into dehumidification.
   e. If space temperature drops below temperature set point while in dehumidification, temperature set point takes precedence, and unit shall come out of dehumidification and go into heat mode.
   f. If space temperature rises above temperature set point while in dehumidification, temperature set point takes precedence, and unit shall come out of dehumidification and go into cool mode.
   g. If CO_2 exceeds **900** [ppm] (adj.) while in dehumidification, humidity control shall take precedence over demand ventilation until return air relative humidity set point is satisfied.
6. Economizer Mode
   a. Economizer shall enable using comparative enthalpy i.e.; when outdoor air enthalpy is below return air enthalpy and a call for cooling with dry bulb override to enable economizer for OAT less than 55 °F.
   b. When operating in economizer mode, maximum outside air and return air dampers shall modulate to maintain discharge air temperature to satisfy space set point.
   c. Economizer mode shall disable if outdoor air enthalpy rises above return air enthalpy for **15** minutes (adj.).
   d. If the maximum OA damper reaches maximum open position and cannot maintain the discharge air temperature at set point, then the supply fan's speed automatically modulates up from minimum to 100% to achieve the space temperature set point.
   e. On further increase in space temperature above the set point, then the fan speed shall reset to minimum set point and mechanical cooling should enable and assist in order to maintain set point.
   f. Heating shall never be enabled in economizer mode.
7. Demand Control Ventilation Mode
   a. The use of outdoor air for ventilation shall be provided only during scheduled hours of occupancy.
   b. If any of terminal units have a CO_2 level greater than the set point of **900** [ppm], the RTU OA damper will modulate from min/min to max CO_2 OA damper position until the terminal unit CO_2 levels drop below **700** [ppm] (adj.).

8. Building Pressurization
    a. The exhaust fan tracks the supply fan with an offset of [CFM] (adj.). Determined mathematically by the engineer.
    b. Pressure sensor used for monitoring building pressure.
9. Supply Fan
    a. During occupied mode, the supply fan runs continuously.
    b. Unit supply fan modulates speed to maintain duct static pressure set point of [in. W.C.] (adj.) (Determined by T&B).
    c. Supply fan static pressure optimization shall monitor the position of each VAV terminal unit and reset the supply pressure set point to the lowest value that meets the most demanding zone's airflow requirements.
10. Supply Air Temperature Reset
    a. Supply air temperature set point shall reset based on percentage of terminal units in heating or cooling mode. The SAT shall increase **1** °F for every **10** minutes that **80**% (adj.) or more of the RTUs associated terminal units are in heat mode, until the unit reaches the maximum reset temperature or, **80**% (adj.) of the RTUs associated terminal units are in cooling mode. The SAT shall decrease **1** °F for every **10** minutes that **80**% (adj.) or more of the RTUs associated terminal units are in cooling mode, until the unit reaches the minimum reset temperature or, **80**% (adj.) of the RTUs terminal units are in heating mode. The maximum amount of the reset shall be editable between **55** [°F] and **65** [°F] (adj.).
    b. While in SAT, if the space relative humidity rises above the space humidity set point upper limit, the SAT reset shall be deactivated.

B. Alarms and Shutdowns
1. Emergency Shutdown: The unit shall shutdown in response to a contact closure to the DDC system indicating the presence of fire or other emergency condition. Upon fire alarm reset, unit shall return to operating mode. Equipment shall not lock out after multiple fire alarm events.
2. Supply Air Smoke Detection: Unit shall shut down and close dampers on detection of smoke. Alarm is sent to the fire alarm panel.
3. Return Air Smoke Detection: Unit shall shut down and close dampers on detection of smoke. Alarm is sent to the fire alarm panel.
4. Unit shuts down on signal from fire alarm system.
5. Unit shuts down on activation of the supply fan high static pressure switch
6. Unit shuts down and BMS alarms upon activation of condensate overflow switch.
7. BMS alarms on dirty filter.
8. BMS alarms on any motor failure to start.

C. BMS Shall Monitor and Display
1. Supply fan start/stop
2. Supply fan status
3. Supply fan speed
4. Exhaust fan start/stop
5. Exhaust fan status
6. Exhaust fan speed
7. Cooling start/stop
8. Cooling status
9. Compressor status
10. Compressor modulation
11. Heat start/stop
12. Heat status
13. Heat modulation
14. Hot gas reheat start/stop
15. Hot gas reheat status

16. Hot gas reheat modulation
17. Occupied/unoccupied mode
18. Relief damper enable.
19. Supply air temperature
20. Leaving coil temperature
21. Outside air temperature
22. Outside air humidity
23. Return air temperature
24. Return air humidity
25. Space temperature
26. Space humidity
27. Space CO_2
28. Space temperature set point
29. Space humidity set point
30. Space CO_2 set point
31. Duct static pressure
32. Duct static pressure set point
33. Filter status
34. Condensate overflow switch status
35. Building Pressure

1.5 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR SINGLE ZONE VAV AHUS

A. Operation of Single Zone AHUs

1. Start Mode
   a. Unit is enabled according to owner defined schedule programmed in BMS.
   b. Staggered start application shall prevent all controlled equipment from simultaneously restarting after a power outage or fire alarm restart. The order in which equipment (or groups of equipment) is started, along with the time delay between starts shall be user-selectable.
   c. Supply fan will "soft start" via the frequency inverter and slowly ramp fan up to set point.
   d. Unit starts up with 100% return air. The unit then follows the optimal start sequence.
2. Optimal Start/Morning Warm-Up/Morning Cool Down
   a. The building exhaust and relief fans shall remain off until set point is reached.
   b. Unit starts morning warm up and cool down mode based on optimal run time so that the space temperatures are at set point before scheduled occupancy.
   c. During morning warm up, outside air dampers are closed, relief damper is closed, cooling is disabled, return air damper open, supply fan shall be enabled and heating shall be enabled as needed. Dehumidification mode is suspended during morning warm-up.
   d. During morning cool down, outside air dampers are closed, relief damper is closed, heating is disabled, return air damper open, supply fan shall be enabled and cooling shall be enabled as needed.
3. Occupied Mode
   a. During occupied mode, supply fan runs continuously.
   b. When each unit is turned ON by the DDC system using the time scheduling, timed override or event programming, heating and cooling shall be provided as required. The outside air dampers shall remain closed until the occupied time of the zone.
   c. The unit provides modulating capacity to stage compressors on or modulate heat in order to maintain zone single temperature set point of **73** [°F] ± **2** [°F] for dead band between heating and cooling set points (adj.).
   d. Occupant adjustable zone sensor shall have the ability to reset zone set point **70-76** [°F] (adj.)

e. Refrigerant Circuit shall operate by cycling or staging compressors and operate hot-gas bypass to match compressor output to cooling load to maintain discharge temperature.
f. Cycle condenser fans to maintain maximum hot-gas pressure.
g. Operate low-ambient control kit to maintain minimum hot-gas pressure.
h. Compressor operates subject to its own internal safeties and controls.
i. Compressor stage has a minimum runtime to prevent short cycling.
j. Heat operates subject to its own internal safeties and controls.
k. If OAD and RAD have independent or separate operators, dampers shall not function proportionally. OAD shall be fully open before RAD modulates closed to achieve OA cfm.

4. Unoccupied Mode
   a. The supply fan shall be disabled; the outside air damper shall close and return air damper remains open.
   b. If the space temperature space sensor drifts out of the NSB set point range of **65 - 78** [°F] (adj.), the rooftop unit shall be enabled to satisfy set point. The outside air damper shall remain closed.
   c. During unoccupied mode, unit cycles supply fan, compressors and hot gas reheat to maintain unoccupied humidity set points.
   d. In unoccupied mode, dehumidification operates when the space wet bulb temperature is greater than set point of **62** [°F WB] (adj.). When operating in dehumidification mode the unit shall maintain a LCT of < 55 and enable the hot gas reheat in order to maintain space temperature set point. The unit shall stay in dehumidification mode until the wet bulb temperature of the space is less than **60** [°F WB] (adj.).
   e. Unit can be enabled in occupied mode from BMS for **2** hours (adj.).
5. Dehumidification Mode
   a. In occupied mode, dehumidification operates when the space relative humidity is greater than the humidity set point of **60** [%RH] (adj.). When operating in dehumidification mode the unit shall maintain a LCT of < 55 and enable the hot gas reheat in order to maintain space temperature set point. The unit shall stay in dehumidification mode until the relative humidity of the space is less than **55** [% RH] (adj.). Outside air damper shall close/modulate to min/min.
   b. In unoccupied mode, dehumidification operates when the space wet bulb temperature is greater than set point of **62** [°F WB] (adj.). When operating in dehumidification mode the unit shall maintain a LCT of < 55 and enable the hot gas reheat in order to maintain space temperature set point. The unit shall stay in dehumidification mode until the wet bulb temperature of the space is less than **60** [°F WB] (adj.).
   c. If return air relative humidity rises above the space humidity set point upper limit while in economizer, dehumidification takes precedence, and unit shall come out of economizer and go into dehumidification.
   d. If space temperature drops below temperature set point while in dehumidification, temperature set point takes precedence, and unit shall come out of dehumidification and go into heat mode.
   e. If space temperature rises above temperature set point while in dehumidification, temperature set point takes precedence, and unit shall come out of dehumidification and go into cool mode.
   f. If CO_2 exceeds **900** [ppm] (adj.) while in dehumidification, humidity control shall take precedence over demand ventilation until return air relative humidity set point is satisfied.
6. Economizer Mode
   a. Economizer shall enable using comparative enthalpy i.e.; when outdoor air enthalpy is below return air enthalpy and a call for cooling with dry bulb override to enable economizer for OAT less than 55 °F.

b. When operating in economizer mode, maximum outside air and return air dampers shall modulate to maintain discharge air temperature to satisfy space set point.
c. Economizer mode shall disable if outdoor air enthalpy rises above return air enthalpy for **15** minutes (adj.).
d. If the maximum OA damper reaches maximum open position and cannot maintain the discharge air temperature at set point, then the supply fan's speed automatically modulates up from minimum to 100% to achieve the space temperature set point.
e. On further increase in space temperature above the set point, then the fan speed shall reset to minimum set point and mechanical cooling should enable and assist in order to maintain set point.
f. Heating shall never be enabled in economizer mode.

7. Demand Control Ventilation Mode
   a. The use of outdoor air for ventilation shall be provided only during scheduled hours of occupancy.
   b. Unit enters purge mode when CO_2 level is greater than set point of **900** [ppm] (adj.). When operating in purge mode the outside air damper modulates open to the scheduled maximum outside air CFM set point and remains there until the space CO_2 is below set point of **700** [ppm] (adj.). Unit OA damper should never open past the scheduled maximum purge OA flow.
8. Building Pressurization
   a. The exhaust fan tracks the supply fan with an offset of [CFM] (adj.). Determined mathematically by the engineer.
   b. Pressure sensor used for monitoring building pressure.

B. Alarms and Shutdowns
1. Emergency Shutdown: The unit shall shutdown in response to a contact closure to the DDC system indicating the presence of fire or other emergency condition. Upon fire alarm reset, unit shall return to operating mode. Equipment shall not lock out after multiple fire alarm events.
2. Supply Air Smoke Detection: Unit shall shut down and close dampers on detection of smoke. Alarm is sent to the fire alarm panel.
3. Return Air Smoke Detection: Unit shall shut down and close dampers on detection of smoke. Alarm is sent to the fire alarm panel.
4. Unit shuts down on signal from fire alarm system.
5. Unit shuts down on activation of the supply fan high static pressure switch
6. Unit shuts down and BMS alarms upon activation of condensate overflow switch.
7. BMS alarms on dirty filter.
8. BMS alarms on any motor failure to start.

C. BMS Shall Monitor and Display
1. Supply fan start/stop
2. Supply fan status
3. Supply fan speed
4. Exhaust fan start/stop
5. Exhaust fan status
6. Exhaust fan speed
7. Cooling start/stop
8. Cooling status
9. Compressor status
10. Compressor modulation
11. Heat start/stop
12. Heat status
13. Heat modulation
14. Hot gas reheat start/stop

15. Hot gas reheat status
16. Hot gas reheat modulation
17. Reheat start/stop
18. Reheat status
19. Occupied/unoccupied mode
20. Relief damper enable.
21. Supply air temperature
22. Leaving coil temperature
23. Outside air temperature
24. Outside air humidity
25. Return air temperature
26. Return air humidity
27. Space temperature
28. Space humidity
29. Space CO_2
30. Space temperature set point
31. Space humidity set point
32. Space CO_2 set point
33. Filter status
34. Condensate overflow switch status.
35. Building Pressure

1.6 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR VAV AHUS

A. Operation of VAV AHUs

1. Start Mode
   a. Unit is enabled according to owner defined schedule programmed in BMS.
   b. Staggered start application shall prevent all controlled equipment from simultaneously restarting after a power outage or fire alarm restart. The order in which equipment (or groups of equipment) is started, along with the time delay between starts shall be user-selectable.
   c. Supply fan will "soft start" via the frequency inverter and slowly ramp fan up to set point.
   d. Unit starts up with 100% return air. The unit then follows the optimal start sequence. Terminal units downstream shall open dampers prior to unit start up in order to prevent AHU from tripping on high static and likewise terminal units shall remain open during shut down until AHU has shut down completely.
2. Optimal Start/Morning Warm-Up/Morning Cool Down
   a. The building exhaust and relief fans shall remain off until set point is reached.
   b. Unit starts morning warm up and cool down mode based on optimal run time so that the space temperatures are at set point before scheduled occupancy.
   c. During morning warm up, outside air dampers are closed, relief damper is closed, cooling is disabled, return air damper open, supply fan shall be enabled and heating shall be enabled as needed. Dehumidification mode is suspended during morning warm-up.
   d. During morning cool down, outside air dampers are closed, relief damper is closed, heating is disabled, return air damper open, supply fan shall be enabled and cooling shall be enabled as needed.
3. Occupied Mode
   a. During occupied mode, supply fan runs continuously.
   b. When the unit is enabled by the DDC system during normal occupied hours, all the unit functions shall be enabled for normal heating and cooling operations. The unit will operate under supply air temperature sensor control.
   c. The unit provides modulating capacity to stage compressors on or modulate gas heat in order to maintain the supply air temperature set point of **55** [°F] (adj.). Unless in SAT reset.

d. Refrigerant Circuit shall operate by cycling or staging compressors and operate hot-gas bypass to match compressor output to cooling load to maintain discharge temperature.
e. Cycle condenser fans to maintain maximum hot-gas pressure.
f. Operate low-ambient control kit to maintain minimum hot-gas pressure.
g. Compressor operates subject to its own internal safeties and controls.
h. Compressor stage has a minimum runtime to prevent short cycling.
i. Heat operates subject to its own internal safeties and controls.
j. If OAD and RAD have independent or separate operators, dampers shall not function proportionally. OAD shall be fully open before RAD modulates closed to achieve OA cfm.

4. Unoccupied Mode
   a. The supply fan shall be disabled; the outside air damper shall close, and return air damper remains open.
   b. If the space temperature space sensor drifts out of the NSB set point range of **65 - 78** [°F] (adj.), the air handling unit shall be enabled to satisfy set point. The outside air damper shall remain closed.
   c. During unoccupied mode, unit cycles supply fan, compressors and hot gas reheat to maintain unoccupied humidity set points.
   d. In unoccupied mode, dehumidification mode operates when the space wet bulb temperature is greater than set point of **62** [°F WB] (adj.). When operating in dehumidification mode the unit shall maintain a DAT of < 55 [°F] and enable the hot gas reheat (when available) in order to maintain the space temperature set point. The unit shall stay in dehumidification mode until the wet bulb temperature of the space is less than **60** [°F WB] (adj.).Terminal units shall operate to maintain space temperature when units are in dehumidification mode.
   e. Unit can be enabled in occupied mode from BMS for **2** hours (adj.).
5. Dehumidification Mode
   a. In occupied mode, dehumidification operates when the space relative humidity is greater than the humidity set point of **60** [%RH] (adj.). When operating in dehumidification mode the unit shall maintain a DAT of < 55 [°F] and enable the hot gas reheat (when available) in order to maintain the space temperature set point. If hot gas reheat is not available, the unit discharges **55** °F air and terminal units modulate to minimum supply air flow and engage reheat. The unit shall stay in dehumidification mode until the relative humidity of the space is less than **55** [% RH] (adj.). The outside air damper shall close/modulate to min/min.
   b. In unoccupied mode, dehumidification operates when the space wet bulb temperature is greater than the set point of **62** [°F WB] (adj.). When operating in dehumidification mode the unit shall maintain a DAT of < 55 [°F] and enable the hot gas reheat (when available) in order to maintain the space temperature set point. If hot gas reheat is not available, the unit discharges **55** °F air and terminal units modulate to minimum supply air flow and engage reheat. The unit shall stay in dehumidification mode until the wet bulb temperature of the space is less than **60** [°F WB] (adj.).
   c. Terminal units shall operate to maintain space temperature when unit is in dehumidification mode.
   d. If return air relative humidity rises above the space humidity set point upper limit while in economizer, dehumidification takes precedence, and unit shall come out of economizer and go into dehumidification.
   e. If space temperature drops below temperature set point while in dehumidification, temperature set point takes precedence, and unit shall come out of dehumidification and go into heat mode.
   f. If space temperature rises above temperature set point while in dehumidification, temperature set point takes precedence, and unit shall come out of dehumidification and go into cool mode.

g. If CO_2 exceeds **900** [ppm] (adj.) while in dehumidification, humidity control shall take precedence over demand ventilation until return air relative humidity set point is satisfied.

6. Economizer Mode
   a. Economizer shall enable using comparative enthalpy i.e.; when outdoor air enthalpy is below return air enthalpy and a call for cooling with dry bulb override to enable economizer for OAT less than 55 °F.
   b. When operating in economizer mode, maximum outside air and return air dampers shall modulate to maintain discharge air temperature to satisfy space set point.
   c. Economizer mode shall disable if outdoor air enthalpy rises above return air enthalpy for **15** minutes (adj.).
   d. If the maximum OA damper reaches maximum open position and cannot maintain the discharge air temperature at set point, then the supply fan's speed automatically modulates up from minimum to 100% to achieve the space temperature set point.
   e. On further increase in space temperature above the set point, then the fan speed shall reset to minimum set point and mechanical cooling should enable and assist in order to maintain set point.
   f. Heating shall never be enabled in economizer mode.
7. Demand Control Ventilation Mode
   a. The use of outdoor air for ventilation shall be provided only during scheduled hours of occupancy.
   b. If any of terminal units have a CO_2 level greater than the set point of **900** [ppm], the AHU OA damper will modulate from min/min to max CO_2 OA damper position until the terminal unit CO_2 levels drop below **700** [ppm] (adj.).
8. Building Pressurization
   a. The exhaust fan tracks the supply fan with an offset of [CFM] (adj.). Determined mathematically by the engineer.
   b. Pressure sensor used for monitoring building pressure.
9. Supply Fan
   a. During occupied mode, the supply fan runs continuously.
   b. Unit supply fan modulates speed to maintain duct static pressure set point of [in. W.C.] (adj.) (Determined by T&B).
   c. Supply fan static pressure optimization shall monitor the position of each VAV terminal unit and reset the supply pressure set point to the lowest value that meets the most demanding zone's airflow requirements.
10. Supply Air Temperature Reset
   a. Supply air temperature set point shall reset based on percentage of terminal units in heating or cooling mode. The SAT shall increase **1** °F for every **10** minutes that **80**% (adj.) or more of the AHUs associated terminal units are in heat mode, until the unit reaches the maximum reset temperature or, **80**% (adj.) of the AHUs associated terminal units are in cooling mode. The SAT shall decrease **1** °F for every **10** minutes that **80**% (adj.) or more of the AHUs associated terminal units are in cooling mode, until the unit reaches the minimum reset temperature or, **80**% (adj.) of the AHUs terminal units are in heating mode. The maximum amount of the reset shall be editable between **55** [°F] and **65** [°F] (adj.).
   b. While in SAT, if the space relative humidity rises above the space humidity set point upper limit, the SAT reset shall be deactivated.

B. Alarms and Shutdowns
1. Emergency Shutdown: The unit shall shutdown in response to a contact closure to the DDC system indicating the presence of fire or other emergency condition. Upon fire alarm reset, unit shall return to operating mode. Equipment shall not lock out after multiple fire alarm events.

2. Supply Air Smoke Detection: Unit shall shut down and close dampers on detection of smoke. Alarm is sent to the fire alarm panel.
3. Return Air Smoke Detection: Unit shall shut down and close dampers on detection of smoke. Alarm is sent to the fire alarm panel.
4. Unit shuts down on signal from fire alarm system.
5. Unit shuts down on activation of the supply fan high static pressure switch
6. Unit shuts down and BMS alarms upon activation of condensate overflow switch.
7. BMS alarms on dirty filter.
8. BMS alarms on any motor failure to start.

C. BMS Shall Monitor and Display
1. Unit on system graphic
2. Supply fan start/stop
3. Supply fan status
4. Supply fan speed
5. Exhaust fan start/stop
6. Exhaust fan status
7. Exhaust fan speed
8. Cooling start/stop
9. Cooling status
10. Compressor status
11. Compressor modulation
12. Heat start/stop
13. Heat status
14. Heat modulation
15. Hot gas reheat start/stop
16. Hot gas reheat status
17. Hot gas reheat modulation
18. Occupied/unoccupied mode
19. Relief damper enable.
20. Supply air temperature
21. Supply air humidity
22. Leaving coil temperature
23. Outside air temperature
24. Outside air humidity
25. Return air temperature
26. Return air humidity
27. Space temperature
28. Space humidity
29. Space CO_2
30. Space temperature set point
31. Space humidity set point
32. Space CO_2 set point
33. Duct static pressure
34. Duct static pressure set point
35. Filter status
36. Condensate overflow switch status
37. Building Pressure

1.7 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR ERUS

A. Operation of ERUs

1. Start Mode
   a. Unit is enabled according to owner defined schedule programmed in BMS.
   b. Staggered start application shall prevent all controlled equipment from simultaneously restarting after a power outage or fire alarm restart. The order in which equipment (or groups of equipment) is started, along with the time delay between starts shall be user-selectable.
   c. When unit is commanded on or enabled, fan does not start until outside air damper is proven open.
2. Optimal Start/Morning Warm-Up/Morning Cool Down
   a. The unit does not run during morning warm-up, cool down, or optimal start.
3. Occupied Mode
   a. During occupied mode, supply fan runs continuously.
   b. Unit operates to discharge neutral air to space at **70** °F (adj.) and less than **55** % [RH] (adj.) when OAT is greater than **60** °F (adj.).
   c. Unit operates to discharge neutral air to space at **74** °F (adj.) and less than **55** % [RH] (adj.) when OAT is less than **60** °F (adj.).
   d. If ERU is attached to the RA side of an RTU/AHU, unit shall discharge air at the same temperature as the associated RTU/AHU discharge air temperature set point. Or the average DAT if serving multiple units.
   e. Hot gas reheat enables to maintain discharge air temperature set point.
   f. Compressor operates subject to its own internal safeties and controls.
   g. Compressor stage has a minimum runtime to prevent short cycling.
   h. Gas heat operates subject to its own internal safeties and controls.
4. Unoccupied Mode
   a. The fans shall stop, the outside air damper shall close, and exhaust damper closes.
   b. During unoccupied mode, unit is disabled.
   c. Unit can be enabled in occupied mode from BMS for **2** hour(s) (adj.
5. Demand Control Ventilation
   a. The use of outdoor air for ventilation shall be provided only during scheduled hours of occupancy.
   b. On units equipped for DCV:
      1) Supply fan shall run based off of duct static pressure for units with CO_2 operated VAV dampers.
      2) Supply fan ramps up to desired speed needed for OA flow (as measured by OA flow station) when CO_2 levels rise above 900 ppm (adj.). When levels drop below 700 ppm, fan shall ramp down to regular ventilation speed.
      3) Exhaust fans shall remain unchanged.
6. Building Pressurization
   a. Supply fan is balanced per contract documents.
   b. Exhaust fan is balanced per contract documents.

B. Alarms and Shutdowns

1. Emergency Shutdown: The unit shall shutdown in response to a contact closure to the DDC system indicating the presence of fire or other emergency condition. Upon fire alarm reset, unit shall return to operating mode. Equipment shall not lock out after multiple fire alarm events.
2. Supply Air Smoke Detection: Unit shall shut down and close dampers on detection of smoke. Alarm is sent to the fire alarm panel.
3. Return Air Smoke Detection: Unit shall shut down and close dampers on detection of smoke. Alarm is sent to the fire alarm panel.
4. Unit shuts down on signal from fire alarm system.

5. Unit shuts down and BMS alarms upon activation of condensate overflow switch.
6. BMS alarms on dirty filter.
7. BMS alarms on motor failure to start.
8. BMS alarms on wheel failure.

C. BMS Shall Monitor and Display
1. Unit on system graphic
2. Supply fan start/stop
3. Supply fan status
4. Supply fan speed
5. Exhaust fan start/stop
6. Exhaust fan status
7. Exhaust fan speed
8. Cooling start/stop
9. Cooling status
10. Compressor status
11. Compressor modulation
12. Heat start/stop
13. Heat status
14. Heat modulation
15. Hot gas reheat start/stop
16. Hot gas reheat status
17. Hot gas reheat modulation
18. Occupied/unoccupied mode
19. Wheel start/stop
20. Wheel bypass damper status
21. Recirculation damper status
22. Relief damper enable.
23. OA damper status
24. Supply air temperature
25. Supply air humidity
26. Supply air temperature set point
27. Supply air humidity set point
28. Leaving coil temperature
29. Outside air temperature
30. Outside air humidity
31. Return air temperature
32. Return air humidity
33. Exhaust air temperature
34. OA flow
35. OA flow set point
36. CO_2 (where applicable)
37. CO_2 set point (where applicable)
38. Duct static pressure (where applicable)
39. Duct static pressure set point (where applicable)
40. Filter status
41. Wheel differential pressure
42. Condensate overflow switch status.
43. Building Pressure

1.8 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR DOAS

A. Operation of DOAS and Split DOAS
1. Start Mode
a. Unit is enabled according to owner defined schedule programmed in BMS.

b. Staggered start application shall prevent all controlled equipment from simultaneously restarting after a power outage or fire alarm restart. The order in which equipment (or groups of equipment) is started, along with the time delay between starts shall be user-selectable.
c. When unit is commanded on or enabled, fan does not start until outside air damper is proven open.

2. Optimal Start/Morning Warm-Up/Morning Cool Down
   a. The unit does not run during morning warm-up, cool down, or optimal start.
3. Occupied Mode
   a. During occupied mode, supply fan runs continuously.
   b. Unit operates to discharge neutral air to space at **70** °F (adj.) and less than **55** % [RH] (adj.) when OAT is greater than **60** °F (adj.).
   c. Unit operates to discharge neutral air to space at **74** °F (adj.) and less than **55** % [RH] (adj.) when OAT is less than **60** °F (adj.).
   d. Hot gas reheat enables to maintain discharge air temperature set point.
   e. Compressor operates subject to its own internal safeties and controls.
   f. Compressor stage has a minimum runtime to prevent short cycling.
   g. Gas heat operates subject to its own internal safeties and controls.
   h. Electric duct heater operates subject to its own internal safeties and controls.
4. Unoccupied Mode
   a. The fans shall stop, the outside air damper shall close, and exhaust damper closes.
   b. During unoccupied mode, unit is disabled.
   c. Unit can be enabled in occupied mode from BMS for **2** hour(s) (adj.).
5. Demand Control Ventilation
   a. The use of outdoor air for ventilation shall be provided only during scheduled hours of occupancy.
   b. On units equipped for DCV:
      1) Supply fan shall run based off of duct static pressure for units with CO_2 operated VAV dampers.
      2) Supply fan ramps up to desired speed needed for OA flow (as measured by OA flow station) when CO_2 levels rise above 900 ppm (adj.). When levels drop below 700 ppm, fan shall ramp down to regular ventilation speed.

B. Alarms and Shutdowns
1. Emergency Shutdown: The unit shall shutdown in response to a contact closure to the DDC system indicating the presence of fire or other emergency condition. Upon fire alarm reset, unit shall return to operating mode. Equipment shall not lock out after multiple fire alarm events.
2. Supply Air Smoke Detection: Unit shall shut down and close dampers on detection of smoke. Alarm is sent to the fire alarm panel.
3. Unit shuts down on signal from fire alarm system.
4. Unit shuts down and BMS alarms upon activation of condensate overflow switch.
5. BMS alarms on dirty filter.
6. BMS alarms on motor failure to start.

C. BMS Shall Monitor and Display
1. Unit on system graphic
2. Supply fan start/stop
3. Supply fan status
4. Supply fan speed
5. Cooling start/stop
6. Cooling status
7. Compressor status
8. Compressor modulation
9. Heat start/stop

10. Heat status
11. Heat modulation
12. Hot gas reheat start/stop
13. Hot gas reheat status
14. Hot gas reheat modulation
15. Occupied/unoccupied mode
16. OA damper status
17. Supply air temperature
18. Supply air humidity
19. Supply air temperature set point
20. Supply air humidity set point
21. Leaving coil temperature
22. Outside air temperature
23. Outside air humidity
24. OA flow
25. OA flow set point
26. CO_2 (where applicable)
27. CO_2 set point (where applicable)
28. Duct static pressure (where applicable)
29. Duct static pressure set point (where applicable)
30. Filter status
31. Condensate overflow switch status.

1.9 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR VAVS

A. Operation of OA only VAVs
   1. Start Mode:
      a. Unit is interlocked with associated ERU operation.
      b. Unit is enabled according to defined schedule programmed in BMS.
   2. Occupied Mode
      a. Unit enters purge mode when CO_2 level is greater than set point of 900 [ppm] (adj.).
      b. When operating in purge mode the VAV damper modulates open to the scheduled maximum outside air CFM set point and remains there until the space CO_2 is below set point of 700 [ppm] (adj.).
      c. Local sensor monitors the CO_2 levels and reports back to the ERU controller.
   3. Alarms and Shutdowns
      a. BMS alarms when space CO_2 is greater than **1500** ppm (adj.) for 30 minutes during occupied hours.
   4. BMS Shall Monitor and Display
      a. Unit system graphic
      b. Damper position
      c. Air flow
      d. Air flow set point
      e. CO_2 levels
      f. CO_2 set point
      g. Supply air temperature

B. Operation of VAVs with reheat
   1. Start Mode
      a. Unit is interlocked with RTU/AHU operation.
      b. Unit is enabled according to defined schedule programmed in BMS.
      c. Airflow switch enables heating strip.
      d. A sensor downstream of heat strip will monitor air temperature leaving the VAV.

e. Unit shall open damper prior to RTU/AHU start up in order to prevent RTU/AHU from tripping on high static and likewise terminal units shall remain open during shut down until RTU/AHU has shut down completely.

2. Occupied Mode
   a. A local zone sensor shall monitor the temperature and report it back to the RTU controller.
   b. Unit runs in order to maintain space temperature set point of 72 [°F] +/- 2 [°F] for dead band between heating and cooling set points (adj.).
   c. On a call for cooling based on the temperature of the space sensor, the damper will modulate to the maximum cooling CFM. As the space temperature begins to reach set point, the damper will modulate to maintain minimum CFM.
   d. On a call for heat, the damper will modulate to maintain the heating CFM and stage the electric heat strips to maintain set point. When the space temperature is satisfied, the heating stage shall be off and the damper shall maintain minimum CFM.
   e. Heating sequence does not energize until airflow is at minimum.
   f. A temperature adjustment slide on the zone sensor shall allow the local set point to be adjusted from +/- 3 [°F].
3. Unoccupied Mode
   a. In unoccupied mode, damper closes to minimum position.
   b. In unoccupied mode, unit operates damper and heating to maintain cooling space temperature set point of 78 [°F] (adj.) and heating space temperature set point of 65 [°F] (adj.).
   c. An override button located on the zone sensor shall index the unit to an "Override" mode for a time period of 1 hour (adj.).
4. Demand Control Ventilation Mode
   a. The air damper shall modulate air delivery based upon CO_2 levels, maintaining a maximum of 900 [ppm] (adj.)
   b. Unit enters purge mode when CO_2 level is greater than set point. When operating in purge mode the air damper modulates open to the scheduled minimum outside air CFM set point and remains there until the space CO_2 is below set point of 700 [ppm]. Heat strip will enable to maintain space temperature set point.
5. Alarms and Shutdowns
   a. BMS alarms when space CO_2 is greater than **1500** ppm (adj.) for 30 minutes during occupied hours.
   b. BMS alarms on high and low space temperature.
6. BMS Shall Monitor and Display
   a. Unit system graphic
   b. Damper position
   c. Air flow
   d. Air flow set point
   e. CO_2 levels
   f. CO_2 set point
   g. Supply air temperature
   h. Space temperature
   i. Space temperature set point

2.0 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR PIUS

A. Operation of PIUs
1. Start Mode
   a. Unit is interlocked with associated RTU/AHU operation
   b. Unit is enabled according to user definable schedule in BMS.
2. Optimal Start
   a. During optimal start mode, the terminal unit supply air damper modulates to the minimum position. Unit fan and electric heating are disabled.

3. Occupied Mode
    a. Unit operates damper and heating in order to maintain zone single temperature set point of 72 [°F] +/- 2 [°F] for dead band between heating and cooling set points (adj.).
    b. On a call for cooling based on the temperature of the room sensor, the primary air damper will modulate to the maximum cooling CFM. As the room temperature begins to reach set point, the damper will modulate to maintain minimum CFM.
    c. On a call for heat, the primary air damper will modulate to maintain the heating CFM. On further call for heating, the fan shall be enabled.
    d. On continued call for heat when primary air damper is at heating CFM and fan is enabled, the electric heat shall enable as necessary to maintain space temperature set point.
    e. On rise in space CO_2 level above 1000 [PPM] (adj.), primary air damper modulates to maintain heating CFM set point. When CO_2 falls below set point, unit returns to normal operation.
    f. Occupant adjustable zone sensor shall have the ability to reset zone set point +/- 2 [°F].
4. Unoccupied Mode
    a. In unoccupied mode, unit operates damper and heating in order to maintain the unoccupied set point range of 65-78 [°F] (adj.).
    b. Unit can be enabled in occupied mode from room sensor for 1 hour(s) (adj.) via occupancy switch on space thermostat.

B. Alarms and Shutdowns
1. BMS alarms on high/low space temperature.
2. BMS alarms when space CO_2 is greater than **1500** ppm (adj.) for 30 minutes during occupied hours.

C. BMS shall monitor and display
1. Discharge air temperature
2. Supply air flow
3. Supply air flow set point
4. Space temperature
5. Space temperature set point
6. Space CO_2
7. Space CO_2 set point
8. Fan start/stop
9. Damper position

2.1 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR WSHPS

A. Operation of WATER SOURCE HEAT PUMPS
1. Start Mode
    a. Unit is enabled according to user definable schedule in BMS.
2. Optimal Start/Morning Warm-Up/Morning Cool Down
    a. Unit starts morning warm-up or cool down mode based on optimal run time so that the space temperatures are at set point before scheduled occupancy.
    b. During morning warm-up, the water source heat pump supply fan will start and DX heating will be enabled as needed. Dehumidification mode is suspended during morning warm-up.
    c. During morning cool down, the water source heat pump supply fan will start and DX cooling will be enable as needed.
3. Occupied Mode
    a. Supply fan runs continuously during occupancy.
    b. Unit runs in order to maintain space temperature set point of **72** [°F] - +/- **2** [°F] for dead band between heating and cooling set points (adj.).
    c. A temperature adjustment slide on the zone sensor shall allow the local set point to be adjusted from **70 – 76** [°F].
    d. Compressor is enabled on rise in space temperature above set point.

e. On drop in space temperature below set point, compressor is enabled and reversing valve is in heating position.

4. Unoccupied Mode
   a. During unoccupied mode water source heat pump is off.
   b. If any 3 water source heat pumps' space temperature drifts out of night set-back temperature range set point of **65 - 78** [°F] (adj.) unit and water source heat pump loop shall be enabled to satisfy set point.
   c. Dehumidification operates when the space wet bulb temperature is greater than set point of **62** [°F WB] (adj.). When operating in dehumidification mode, the unit shall go to 100% cooling and enable the hot gas reheat in order to deliver neutral air to the space. The unit shall stay in dehumidification mode until the wet bulb temperature of the space is less than **60**[°F WB] (adj.).
   d. Unit can be enabled in occupied mode from space sensor for **2** hours (adj.) via occupancy switch on zone thermostat
5. Dehumidification Mode
   a. In occupied mode, dehumidification operates when the space relative humidity is greater than the humidity set point of **57** ± **3** [% RH] (adj.). When operating in dehumidification mode, the unit shall go to 100% cooling and enable the hot gas reheat in order to deliver neutral air to the space. The unit shall stay in dehumidification mode until the relative humidity of the space is less than **54** [% RH] (adj.).
   b. In unoccupied mode, dehumidification operates when the space wet bulb temperature is greater than set point of **62** [°F WB] (adj.). When operating in dehumidification mode, the unit shall go to 100% cooling and enable the hot gas reheat in order to deliver neutral air to the space. The unit shall stay in dehumidification mode until the wet bulb temperature of the space is less than **60** [°F WB] (adj.).
   c. On a drop in temperature and call for heating, while in dehumidification mode, temperature set point takes precedence, and unit shall come out of dehumidification and go into heat mode
   d. On a rise in temperature and call for cooling, while in dehumidification mode, temperature set point takes precedence, and unit shall come out of dehumidification and go into cool mode.

B. Alarms and Shutdowns
   1. Unit shuts down on signal from fire alarm panel.
   2. WSHP is disabled in the event of the active loop pump failing while the system is enabled.
   3. BMS alarms on dirty filter.
   4. BMS alarms on motor failure to start.

C. BMS shall monitor and display:
   1. Unit system graphic
   2. Fan status
   3. Fan start/stop
   4. Heat start/stop
   5. Reheat start/stop
   6. Reversing valve position
   7. Unit damper position
   8. Isolation valve position
   9. Zone temperature
   10. Zone humidity
   11. Zone temperature set point
   12. Zone humidity set point
   13. Supply air temperature
   14. Filter status
   15. Condensate switch

2.3 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR VRFCs

A. Operation of VRFC Units (adjustable)

1. Set-Up
   a. Return air averaging sensor has been disabled and unit runs off of space sensor.
      1) Note: Not applicable for restroom and corridor units. These units run off of RA sensor.
   b. Unit has been set up for single set point mode.
   c. Fan is set to Auto Mode.
   d. Occupant Fan control is disabled.
   e. Occupant has on/off control.
   f. Thermostat on/off dead band changed to 1°F.
   g. Discharge blades locked at 0°.
   h. Nav. Controller face template has been installed.
2. Start Mode
   a. Unit is enabled according to user definable schedule in BMS.
3. Optimal Start/Morning Warm-Up/Morning Cool Down
   a. Unit starts morning warm up and cool down mode based on optimal run time so that the space temperatures are at set point before scheduled occupancy.
   b. During morning warm-up, cooling disabled and heating enabled as needed to reach space temperature set point.
   c. During morning cool down, heating is disabled, supply fan shall be enabled and cooling shall be enabled as needed.
4. Occupied Mode
   a. Unit cycles fan to maintain heating or cooling set points.
   b. Unit enables heating and cooling when space temperature exceeds heating or cooling set points.
   c. Unit runs in order to maintain space temperature set point of **73** [°F] +/- **1** [°F].
   d. If unit is in cooling mode and space temperature rises > **1** [°F] (adj.) above set point, unit goes into active cooling. Controlled by equipment manufacturer.
   e. If unit is in heating mode and space temperature drops > **1** [°F] (adj.) below set point, unit goes into active heating. Controlled by equipment manufacturer.
   f. A temperature adjustment slide on the zone sensor shall allow the local set point to be adjusted from **70 to 76** [°F].
   g. Unit changes mode from heating/cooling when space temperature is **1.9** [°F] from set point. Controlled by controls contractor.
   h. Unit responds to adjustment of set point of the space temperature thermostat.
5. Unoccupied Mode
   a. In unoccupied mode, the VRFC utilizes unoccupied set points and resets to occupied mode upon a signal from BMS controls system.
   b. If space temperature drifts below night set-back temperature set point range of **65 - 78** (adj.) unit shall be enabled to satisfy set point until space is greater than **4** °F (adj.) inside set-back temperature set point range.
   c. On a rise in space humidity above **62** [°F WB] (adj.) unit shall energize the dehumidification mode until wet bulb temperature of the space is less than **60** [°F WB] (adj.).
   d. Unit can be enabled during unoccupied mode to operate in occupied mode from space sensor via occupancy switch on zone thermostat. Unit will remain in occupied mode until next scheduled unoccupied mode unless turned off at switch.
6. Dehumidification Mode/Dry Mode (Controlled by controls contractor)
   a. Dry mode operates when unit is not in active cooling or heating.
   b. Dry mode is enabled to operate when space < ± **0.9** [°F] (adj.) from set point.

c. In occupied mode, dehumidification operates when the space relative humidity is greater than the humidity set point of **57** ± **3** [% RH] (adj.). When operating in dehumidification mode the unit should go to in to cooling mode and slow down supply fan or otherwise known as dry mode. The unit should stay in dehumidification mode until the relative humidity of the space is less than **54** [% RH] (adj.).

d. In unoccupied mode, dehumidification operates when the space wet bulb temperature is greater than set point of **62** [°F WB] (adj.). When operating in dehumidification mode the unit should go to in to cooling mode and slow down supply fan or otherwise known as dry mode The unit shall stay in dehumidification mode until the wet bulb temperature of the space is less than **60** [°F WB] (adj.).

e. Note:
   1) Rest room VRFCs do not require humidity sensor and shall not go into dry mode.
   2) Corridor cassettes should have area humidity sensors to enable dry mode per cluster.

B. Alarms and Shutdowns
1. Unit shuts down and BMS alarms upon activation of condensate overflow switch.
2. Unit shuts down and BMS alarms upon activation of fire alarm.
3. BMS alarms on dirty filter.
4. BMS alarms on motor failure to start.
5. BMS alarms on low refrigerant pressure.

C. BMS shall monitor and display
1. Unit factory controller interfaces with BMS system to monitor available points.
2. Unit and tag I.D.
3. Fan status.
4. Space temperature
5. Zone humidity
6. Space temperature set point
7. Zone humidity set point
8. Fan speed
9. Operation mode

2.4 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR MINI-SPLITS

A. Operation of Mini-Split Heat Pumps
1. Unit cycles fan to maintain heating or cooling set points.
2. Unit enables when space temperature exceeds heating or cooling set points.
3. Unit runs in order to maintain space temperature set point of 72 [°F] +/- 2 [°F] for dead band between heating and cooling set points (adj.).
4. Compressor runs subject to its own internal safeties and controls.
5. Units serving data rooms shall not be on a schedule and be capable of running 24/7 if necessary.

B. Alarms and Shutdowns
1. Unit shuts down and BMS alarms upon activation of condensate overflow switch.
2. BMS alarms on motor failure to start.
3. BMS alarms on low refrigerant pressure.
4. BMS alarms on high/low space temperature.

C. BMS shall monitor and display
1. Unit on system graphic
2. Space temperature
3. Space temperature set point
4. Operation mode

2.5 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR ELECTRIC HEATERS

A. Operation of Electric Heaters
   1. Unit shall be enabled/disabled through the control system based upon outside air temperature.
   2. Unit runs as necessary to maintain a minimum space temperature set point of 72 °F (adj.).
      a. Space temperature set points will vary depending on space served.
   3. Unit shall not run on a schedule (unless directed by APS) and be capable of running 24/7 if necessary.

B. Alarms and Shutdowns
   1. BMS alarms if status does not match command.
   2. BMS alarms on high/low space temperature.

C. BMS shall monitor and display
   1. Unit on system graphic
   2. Space temperature
   3. Space temperature set point
   4. Unit command
   5. Unit status
   6. Unit enable

2.6 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR EXHAUST FANS

A. Operation of Gang Bathroom Exhaust Fans
   1. Fans shall operate on an occupancy schedule.

B. Operation of Single Bathroom Exhaust Fans
   1. Fans shall be interlocked with light switch.

C. Operation of Electrical Rooms and Other Temperature Sensitive Areas Exhaust Fans
   1. Fans shall run to maintain space temperature set point.
   2. APS to determine space temperature set point.
   3. Space temperature shall be monitored by BMS.
   4. BMS shall send an alarm when space temperature set point is not within temperature range.

D. Operations of Parking Deck and Parking Garage Exhaust Fans
   1. Fans shall run when CO is >35 ppm (adj.) **and/or** when NO_2 is >2.5 ppm (adj.).
   2. Fans run for 15 minutes (adj.) after CO and/or NO_2 values are below set point.
   3. BMS shall send an alarm on high CO when levels are greater than 100 ppm (adj.).
   4. BMS shall send an alarm on high NO_2 when levels are greater than 3 ppm (adj.).
   5. On High CO and NO_2 levels, buzzer in area shall sound.

E. Alarms and Shutdowns
   1. BMS shall alarm on fan failure.

F. BMS shall monitor and display:
   1. Unit on system graphic
   2. Fan status.
   3. Fan command.

2.7 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR SUPPLY FANS

A. Operation of Supply Fans
   1. During scheduled occupied hours, the unit shall be enabled to run.
   2. BMS enables unit during occupied hours and disables operation during unoccupied hours.

B. Alarms and Shutdowns
   1. BMS initiates an alarm when a SF start command is given and the motor fails to start.

C. BMS shall monitor and display
   1. Unit on system graphic
   2. Supply fan status

2.8 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR KITCHEN MAUS

A. Operation of MAU
   1. Unit is interlocked with kitchen hood operation.

2.9 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR CHILLERS

A. Operation of Water Cooled Chillers
   1. The central plan is enabled during optimal start.
   2. During occupied hours, the central plant is enabled only when three or more air handling units (adj.) have chilled water valves open 10% or more and fan run status is proven for each unit.
   3. On receipt of start signal from BMS, the secondary chilled water pumps are enabled to run for 10 minutes (adj.) before chilled water production and primary pumps are enabled.
   4. Chilled water flow is established before unit is enabled.
   5. When enabled to run, the chiller operates under its own control to maintain chilled water supply temperature demand set point.
   6. When outdoor air temperature is greater than 55°F and enthalpy is above 22 BTU/lb, chilled water production is provided by the chiller.
   7. When outdoor air temperature is below 54°F and enthalpy is below 22 BTU/lb, water side economizer is enabled. If chilled water set point is not met after 30 minutes of economizer operation, chillers are enabled.
   8. Chiller operation is locked out when outdoor air temperature is below 45°F.
   9. Chiller restart sequence and chilled water proof-of-flow switch operation have been verified.
   10. Chillers operate as lead/lag with each chiller able to provide 100% of the chilled water capacity required at peak load. Lead/lag status is alternated every 15 days to maintain equal runtime.
   11. In order to prevent short cycling, the chiller runs for and is off for minimum adjustable times, unless shutdown due to internal safeties and controls.

B. Alarms and Shutdowns
   1. In the event that the lead chiller shuts down or fails to run after a set period of time from the initial start signal, the lag chiller shall operate and an alarm status shall be sent to the BMS.
   2. Controller measures chilled water differential pressure and monitors the chilled water differential pressure set point to provide alarm if chiller has insufficient water flow.
   3. If chilled water differential pressure is 25% (adj.) greater or lower than set point alarm is sent to BMS.
   4. If chilled water flow is 25% (adj.) less than set point alarm is sent to BMS.
   5. If chilled water supply temperature is greater than 55°F (adj.) or less than 38°F (adj.) alarm is sent to BMS.
   6. On failure of evaporator barrel heater, alarm shall be sent to BMS.

C. BMS shall monitor and display
   1. Chiller start/stop
   2. Chiller status
   3. Chilled water supply temperature
   4. Chilled water return temperature
   5. Chilled water supply temperature set point and reset set point
   6. Chilled water differential pressure
   7. Chilled water differential pressure set point
   8. Chilled water flow
   9. Condenser water leaving temperature
   10. Condenser water supply temperature
   11. Head pressure control valve position

3.0 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR WATER SOURCE HEAT PUMP LOOP

A. Operation of Water Source Heat Pump Loop
1. The Average loop temperature will be 80 °F.
2. **Heating mode:** If the condenser loop return temperature is lower than the condenser loop supply temperature by less than 3 °F (Adj.) the set point shall remain unchanged. If the condenser loop return temperature is lower than the condenser supply temperature by >3 °F (Adj.) for 30 minutes (Adj.) the set point shall adjust up 1 °F every 15 minutes (Adj.) not to exceed 85 °F (Adj.).
3. **Cooling mode:** If the condenser loop return temperature is higher than the condenser supply temperature by >3 °F (Adj.) for 30 minutes (Adj.) the set point shall adjust down 1 °F every 15 minutes (Adj.) not to go below 75 °F (Adj.)
4. The supply temperature shall never get above 90 °F or less than 70 °F.

B. Alarms and Shutdowns
1. If the loop temperature reaches the point that exceeds the capacity for the compressors to function properly the BAS will disable the compressors and generate an alarm through the BAS, and disable the compressors until the loop temperature is back into acceptable operating range for at least 5 minutes (Adj.).

2.	Alarm level 1	High temp WSHP Level 1	95 °F for 5 minutes (Adj.)
3.	Alarm level 2	High temp WSHP Level 2	100 °F for 5 minutes (Adj.)
4.	Alarm level 1	Low temp WSHP Level 1	65 °F for 5 minutes (Adj.)
5.	Alarm level 2	Low temp WSHP Level 2	60 °F for 5 minutes (Adj.)

3.1 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR BOILERS

A. Operation of Boilers for WSHP Loop
1. On a call for heating from WSHP loop and when proof of flow is established.
2. Boilers shall not run when cooling tower loop is operating.
3. Boilers operate in lead/lag mode and are rotated every month through a scheduled shutdown to equalize runtime.
4. One boiler shall function as lead boiler and the second boiler (lag) shall be enabled if lead boiler fails or cannot maintain loop water temperature.
5. If building loop water temperature drops below a set point of 65 [°F] (adj.), the lag boiler shall stage on and run in unison with the lead boiler to maintain hot water loop temperature set point.
6. As the building loop water temperature rises back to 3 [°F] (adj.) off set point of 85 [°F] (adj.), the lag boiler shall stage off.
7. Boiler controls maintains supply water at sufficient temperature (120 – 140 [°F]) to achieve loop temperature set point of 85 [°F] (adj.).

B. Operation of Boilers for Heating Hot Water
1. Boilers operate in lead/lag to maintain equal runtime.
2. BMS enables boiler internal controls.
3. Boiler enables when outside air temperature is < 60 [°F] (adj.) or call for heat.
4. Boiler pump is interlocked with associated boiler.
5. One boiler shall function as lead boiler and the second boiler (lag) shall be enabled if lead boiler fails or cannot maintain loop water temperature.
6. When demand exceeds the capacity of lead boiler, lag boiler enables.
7. Boiler controls maintains supply water at sufficient temperature (**160-180** [°F] (adj.)) to achieve loop temperature set point.
8. Primary hot water loop temperature set point is reset based on the following outside air temperature parameters:
   a. OAT: 60 [°F] HW Set point: 120 [°F] ; OAT: 30 [°F] HW Set point: 160 [°F] (adj.)
9. When boiler is de-energized, associated primary pump will continue to operate for **5** minutes (adj.) before cycling off.
10. Hot water loop pumps modulate speed to maintain loop water differential pressure.

11. If the lead pump reaches 95% (adj.) speed, the lag pump is enabled and both pumps modulate together to maintain the differential pressure set point.
12. When the two pump operation reaches 40% (adj.) speed, the lag pump is cycled off.
13. Hot water loop pumps alternate lead/lag weekly (adj.) to maintain equal runtime for the pumps.
14. Heating water loop shall be enabled during unoccupied period whenever 3 (adj.) terminal unit valves are enabled by zone occupancy override or night set back set points.

C. Alarms and Shutdowns
1. Boiler emergency cut-off switch shuts boiler down.
2. Alarm is generated when boiler emergency cut-off switch is activated.
3. Alarm is generated on lead boiler failure to start.
4. Boiler is removed from alternation schedule and lag boiler is enabled when lead boiler fails to start.
5. Boiler 'On' status is verified within 30 second time delay, or alarm is generated.
6. Boiler shuts down and an alarm is generated on interlocked primary pump failure.
7. BMS alarms when any boiler safety device engages.
8. BMS alarms when hot water loop supply temperature is more than **20** [°F] (adj.) above or below set point.
9. BMS alarms on pump failure.

D. BMS shall monitor and display:
1. Unit on system graphic.
2. Outside air temperature.
3. Supply water temperature.
4. Return water temperature.
5. Boiler run time.
6. Boiler alarms.

3.2 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR COOLING TOWERS

A. Operation of Cooling Towers in Water Source Heat Pump System
1. CT pump(s) starts on activation on call for tower water.
2. Cooling tower fans shall cycle, including low and high speed, to balance load on the cooling tower cells to maintain water source loop supply temperature as determined by water source loop temperature reset.
3. If there are 2 or more cooling towers, and lead tower fan reaches 50%, run lag cooling tower fan at same speed, modulating both up and down to maintain WSHP loop temperature set point.
4. If the loop water temperature is > 75 [°F] (adj.) the cooling tower shall be enabled and the isolation valve shall open. Integrated unit controls enable pump, modulate bypass valve, and modulate fan speed as necessary to maintain loop supply water temperature set point.
5. On a drop in loop supply temperature to 70 [°F] (adj.), the cooling tower shall de-energize and isolation valve shall close.
6. On a drop in water temperature below 40 [°F] (adj.), basin heater shall engage to maintain basin temperature at greater than 40 [°F] (adj.). Heater shall turn off when water temperature exceeds 45 [°F] (adj.). The basin heater shall be controlled independently of the BAS in order to ensure that the basin heater will still function in the event of a controls failure.
7. A water level control in the cooling tower basin shall operate to maintain water level by opening the makeup water valve.
8. Cooling tower shall not run when boiler loop is operating.

B. Operation of Cooling Towers serving Water Cooled Chillers
1. The BMS shall enable/disable the cooling tower, reset the condenser water temperature set point, and initiate a high temperature alarm should the condenser water set point be exceeded (when the tower is active).
2. Unit starts on activation of either chiller or on call for condenser water.

3. BMS or packaged controls provided with the cooling tower modulate the fans and 3-way valve to maintain the condenser temperature set point (adj.) as specified and required by the chiller manufacturer.
4. When tower water economizer is utilized and when outdoor air temperature is below 54°F and enthalpy is below 22 BTU/lb, water side economizer is enabled. If chilled water set point is not met after 30 minutes of economizer operation, chillers are enabled.
5. When water side economizer is enabled, the condenser water pumps and cooling tower fan speeds are modulated by the packaged controls to maintain the chilled water temperature set point.
6. On a drop in outside air temperature below owner defined limits, basin heater shall engage to maintain basin temperature at greater than 40°F.
7. A water level control in the cooling tower basin shall operate to maintain water level by opening the makeup water valve.

C. Alarms and Shutdowns
1. BMS alarms on cooling tower fan failure.
2. BMS alarms on isolation valve failure.
3. BMS alarms on low water level.
4. The BMS shall initiate a high temperature alarm should the tower water set point be exceeded (when the tower is active).
5. BMS alarms on tower basin high and low temperature.

D. BMS shall monitor and display:
1. Unit on system graphic
2. Cooling tower isolation valve position.
3. Fan status.
4. Fan speed.
5. Basin water temperature.
6. Entering tower water temperature.
7. Leaving tower water temperature.
8. Makeup water flow meter reading

3.3 TYPICAL SEQUENCE OF OPERATIONS AND REQUIREMENTS FOR PUMPS

A. Operation of Cooling Tower Pumps
1. Cooling tower pumps shall run whenever cooling tower is called to run.
2. Once flow is established, the BMS enables cooling sequences as necessary to maintain loop water temperature set point.
3. If the lead pump reaches 95% (adj.) speed, the lag pump is enabled and both pumps modulate together to maintain loop water temperature set point.
4. When the two pump operation reaches 40% (adj.), speed, the lag pump is cycled off.
5. Pumps alternate lead/lag weekly to maintain equal runtime for the pumps.

B. Operation of Primary Chilled Water Pumps
1. Associated VFD operates to provide a ‘soft-start’ on pump start.
2. Differential pressure sensor is installed across pump and provides proof that the pump is in operation.
3. Pump runs on chiller start.
4. Isolation valves are proven open before pump is enabled.
5. Chiller sends a start signal through the BMS to the pump controller to start, run or stop the pump as needed.
6. Differential pressure sensor installed on the chilled water loop monitors the head pressure in the chilled water system and signals the lag pump to operate to maintain constant water pressure.
7. Pumps operate as lead/lag/backup with each pump able to provide 100% of the chilled water flow required at peak load and alternating every 15 days to maintain equal runtime for the pumps.
8. If the lead pump fails to start after a programmed amount of time, the BMS system shall automatically switch and start the standby pump and indicate a pump failure alarm.

C. Operation of Secondary Chilled Water Pumps
   1. Associated VFD operates to provide a 'soft-start' on pump start.
   2. Differential pressure sensor is installed across pump and provides proof that the pump is in operation.
   3. Pump runs on cooling demand from system to provide chilled water as needed.
   4. Chiller sends a start signal through the BMS to the pump controller to start, run or stop the pump as needed.
   5. Differential pressure sensor installed on the chilled water loop monitors the head pressure in the chilled water system and signals the lag pump to operate to maintain constant water pressure.
   6. Pumps operate as lead/lag/backup with each pump able to provide 100% of the chilled water flow required at peak load and alternating every 15 days to maintain equal runtime for the pumps.
   7. In the event that the lead chilled water pump fails to run after a maximum period of time has run out from the initial moment that the start signal is sent from the chiller, the lag pump shall operate and an alarm status shall be sent to the BMS.

D. Operation of Building Loop Pumps
   1. Loop pumps shall be enabled 10 minutes (adj.) or as defined by optimal start (whichever is greater) prior to building going in occupied mode.
   2. Once flow is established, the BMS enables cooling or heating sequences as necessary to maintain loop water temperature set point.
   3. Unit VFD modulates pump speed to maintain system differential pressure. Maximum speed is set to____[Hz]. (Set by T&B).
   4. If the lead pump reaches 90% (adj.) speed, the lag pump is enabled and both pumps modulate together to maintain the differential pressure set point
   5. When the two pump operation reaches 60% (adj.) speed, the lag pump is cycled off.
   6. Pumps alternate lead/lag weekly to maintain equal runtime for the pumps.

E. Operation of Boiler Pumps
   1. Boiler pumps shall be interlocked with boiler operation.

F. Alarms and Shutdowns
   1. In the event that the lead pump fails to start, the lag pump is enabled and an alarm is sent to the BMS.
   2. When pump status does not match the run command, and alarm is sent to BMS and pump is disabled. Reset is required.
   3. When there is a VFD fault, an alarm is sent to the BMS.
   4. For loop used in a water-source heat pump system: In the event of the active loop pump failing while the system is enabled, the water source heat pumps compressors are disabled to prevent unwanted safety cutout.

G. BMS shall monitor and display:
   1. Unit on system graphic
   2. Pump status
   3. Pump speed
   4. Proof of flow switch
   5. Pump alarms

End of Section 23 09 93 Sequence of Operations for HVAC Controls

SECTION 23 09 95 – CONTROLS TRENDING REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Trending Requirements

B. Legend:
   1. AHU: Air Handling Unit
   2. APS: Atlanta Public Schools
   3. BMS: Building Management System
   4. CHW: Chilled Water
   5. CT: Cooling Tower
   6. DDC: Direct Digital Control System
   7. DOAS: Dedicated Outdoor Air System
   8. DP: Differential Pressure
   9. EF: Exhaust Fan
   10. ERU: Energy Recovery Unit
   11. FCU: Fan Coil Unit
   12. HW: Hot Water
   13. HHW: Heating Hot Water
   14. LCT: Leaving Coil Temperature
   15. MAU: Make-up Air Unit
   16. NSB: Night Set-Back
   17. OA: Outside Air
   18. PIU: Powered Induction Unit
   19. RA: Return Air
   20. RTU: Roof Top Unit
   21. SF: Supply Fan
   22. SZ: Single Zone
   23. VAV: Variable Air Volume
   24. VFD: Variable Frequency Drive
   25. VRF: Variable Refrigerant Flow
   26. VRFC: Variable Refrigerant Fan Coil
   27. WH: Water Heater
   28. WSHP: Water Source Heat Pump

1.2 Trending Requirements for Building Automation Controls Contractor

A. Data may be complied using direct digital controls trend logging where available. Otherwise, the Contractor shall temporarily install calibrated time versus temperature/humidity recorders for this purpose. The HVAC systems and controls shall have been fully operational for a minimum of 24 hours in advance of commencing data compilation.

B. Provide a trend report for each HVAC system that is part of the buildings DDC system. The trend report shall include a value for each set point listed in the sequence of operation and any points that may be used to confirm proper sequence and operation. Identify any values that do not meet the sequence of operation requirements, make repairs (re-program) and run a new trend for the system. Document each deficiency and corrective action taken.

C. A test report shall be provided consisting of a seventy-two (72) hour trend, with 5-15 minute intervals (adj.), verifying all temperature set points listed in the sequence of operation. The trend report shall be provided to the CxP in CSV or EXCEL format. All systems (AHUs, ERUs, EFs, SFs, VAVs, etc.) will be included in this section.

D. For all equipment tested, provide trend reports in CSV or excel format of the control variable over time (project selected), demonstrating that the control loop responds to changes of the control variable set point without excessive overshoot and undershoot. Show that set point is reached, it is stable and maintained. Control loop trend data shall be in real-time with the time between data points 5-15 minute intervals (Adj.) Change of value trending is unacceptable.

E. Provide seventy-two (72) hours of trend data, at 5-15 min intervals (adj.), to verify all systems are functioning as specified. Trend reports will verify control set point adjustment per the temperature reset schedules (as required by sequence of operation). Trend alarm points shall include all major mechanical failures.
F. Temperatures shall be 0.1 of degree. Humidity, percentages, etc. shall be whole numbers.
G. Provide the following trends for:

1. VAV RTU/PMU Trending and Alarms:

VAV RTU/PMU Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupancy						
Mode(Heating/Cooling/De-hum)						
Air Flow						
Air Flow Set Point						
OA Temperature						
OA Humidity						
OA Damper Position						
RA Damper Position (Where Applicable)						
Return Fan Speed (Where Applicable)						
Return Fan Status (Where Applicable)						
RA Humidity						
RA Temperature						
CO_2 Set Point						
CO_2 Actual						
Mixed Air Temperature						
Supply Fan Speed						
Supply Fan Status						
Supply Air Temperature						
Compressor Command						
Compressor Status						
Compressor Modulation						
Leaving Coil Temperature						
Hot Gas Reheat Status (Where Applicable)						
Hot Gas Reheat Modulation (Where Applicable)						
Heat Command						
Heat Status						
Heat Modulation						
Duct Static Pressure						
Duct Static Pressure Set Point						

Space Humidity Set Point						
Space Humidity						
Space Wet Bulb Temperature						
Space Wet Bulb Temperature Set Point						
Number of Heating Calls						
Number of Cooling Calls						
Low Zone Temperature						
Filter Status						
Any associated alarms						

2. SZ VAV RTU/PMU Trending and Alarms:

SZ VAV RTU/PMU Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupancy						
Mode(Heating/Cooling/De-hum)						
Air Flow						
Air Flow set point						
OA Temperature						
OA Humidity						
OA Damper Position						
RA Damper Position (Where Applicable)						
Return Fan Speed (Where Applicable)						
Return Fan Status (Where Applicable)						
RA Humidity						
RA Temperature						
CO_2 Set Point						
CO_2 Actual						
Mixed Air Temperature						
Supply Fan Speed						
Supply Fan Status						
Supply Air Temperature						
Compressor Command						
Compressor Status						
Compressor Modulation						
Leaving Coil Temperature						
Hot Gas Reheat Status						
Hot Gas Reheat Modulation						
Heat Command						

Heat Status						
Heat Modulation						
Space Temperature						
Space Temperature Set Point						
Space Humidity Set Point						
Space Humidity						
Space Wet Bulb Temperature						
Space Wet Bulb Temperature Set Point						
Filter Status						
Any associated alarms						

3. ERU Trending and Alarms:

ERU Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupancy						
Mode						
Air Flow						
Air Flow set point						
Outside Air Humidity						
Outdoor Air Temperature						
Outdoor Air Damper Position						
Outdoor Air Flow						
Exhaust Air Damper Position (Where Applicable)						
Exhaust Fan Speed (Where Applicable)						
Exhaust Fan Status (Where Applicable)						
Exhaust Temperature						
Exhaust Air Humidity (Where Applicable)						
Entering Wheel Temperature						
Leaving Wheel Temperature						
Supply Fan Speed						
Supply Fan Status						
Supply Air Temperature						
Supply Air Temperature Set Point						
Supply Air Flow						
Supply Air Flow Set Point						
Supply Air Humidity						

Supply Air Humidity Set Point						
Compressor Command						
Compressor Status						
Compressor Modulation						
Leaving Coil Temperature						
Heating Command						
Heating Status						
Heating Modulation						
Hot Gas Reheat Status						
Hot Gas Reheat Modulation						
Duct Static Pressure (VAV/CO_2)						
Duct Static Pressure Set Point (VAV/CO_2)						
Wheel Start/Stop						
Wheel Status						
Bypass Damper Status						
Filter Status						
Any associated alarms						

4. DOAS Trending and Alarms:

DOAS Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupancy						
Mode						
Air Flow						
Air Flow Set Point						
Outside Air Humidity						
Outdoor Air Temperature						
Outdoor Air Damper Position						
Outdoor Air Flow						
Supply Fan Speed						
Supply Fan Status						
Supply Air Temperature						
Supply Air Temperature Set Point						
Supply Air Flow						
Supply Air Flow Set Point						
Supply Air Humidity						
Supply Air Humidity Set Point						

Compressor Command						
Compressor Status						
Compressor Modulation						
Leaving Coil Temperature						
Heating Command						
Heating Status						
Heating Modulation						
Hot Gas Reheat Status						
Hot Gas Reheat Modulation						
Duct Static Pressure (VAV/CO_2)						
Duct Static Pressure Set Point (VAV/CO_2)						
Filter Status						
Any associated alarms						

5. VAV AHU Trending and Alarms:

VAV AHU Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupancy						
Mode (Heating/Cooling/Dehum)						
Air Flow						
Air Flow Set Point						
OA Temperature						
OA Humidity						
OA Damper Position						
RA Damper Position (Where Applicable)						
Return Fan Speed (Where Applicable)						
Return Fan Status (Where Applicable)						
RA Humidity						
RA Temperature						
CO_2 Set Point						
CO_2 Actual						
Mixed Air Temperature						
Supply Fan Speed						
Supply Fan Status						
Supply Air Temperature						
Pre-Heat Command (Where Applicable)						

Pre-Heat Status (Where Applicable)						
Pre-Heat Modulation (Where Applicable)						
CHW valve command (where applicable)						
CHW valve status (where applicable)						
CHW valve modulation (where applicable)						
HHW valve command (where applicable)						
HHW valve status (where applicable)						
HHW valve modulation (where applicable)						
Compressor Command (where applicable)						
Compressor Status (where applicable)						
Compressor Modulation (where applicable)						
Leaving Coil Temperature						
Hot Gas Reheat Status (Where Applicable)						
Hot Gas Reheat Modulation (Where Applicable)						
Heat Command						
Heat Status						
Heat Modulation						
Duct Static Pressure						
Duct Static Pressure Set Point						
Bypass damper command (Where Applicable)						
Bypass damper status (Where Applicable)						
Space Humidity Set Point						
Space Humidity						
Space Wet Bulb Temperature						
Space Wet Bulb Temperature Set Point						
Number of Heating Calls						
Number of Cooling Calls						
Low Zone Temperature						
Filter Status						
Any associated alarms						

6. SZ AHU Trending and Alarms:

SZ AHU Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupancy						
Mode (Heating/Cooling/Dehum)						
Air Flow						
Air Flow set point						
OA Temperature						
OA Humidity						
OA Damper Position						
RA Damper Position (Where Applicable)						
Return Fan Speed (Where Applicable)						
Return Fan Status (Where Applicable)						
RA Humidity						
RA Temperature						
CO_2 Set Point						
CO_2 Actual						
Mixed Air Temperature						
Supply Fan Speed						
Supply Fan Status						
Supply Air Temperature						
Pre-Heat Command (Where Applicable)						
Pre-Heat Status (Where Applicable)						
Pre-Heat Modulation (Where Applicable)						
CHW valve command (where applicable)						
CHW valve status (where applicable)						
CHW valve modulation (where applicable)						
HHW valve command (where applicable)						
HHW valve status (where applicable)						
HHW valve modulation (where applicable)						
Compressor Command (where applicable)						
Compressor Status (where applicable)						

Compressor Modulation (where applicable)						
Leaving Coil Temperature						
Hot Gas Reheat Status (Where Applicable)						
Hot Gas Reheat Modulation (Where Applicable)						
Heat Command						
Heat Status						
Heat Modulation						
Space Temperature						
Space Temperature Set Point						
CO_2 Set Point						
CO_2 Actual						
Space Humidity Set Point						
Space Humidity						
Space Wet Bulb Temperature						
Space Wet Bulb Temperature Set Point						
Filter Status						
Any associated alarms						

7. Water Source Heat Pump Trending and Alarms:

Water Source Heat Pump Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupancy						
Damper Position						
Mode (Heat/Cooling/Dehum)						
Isolation Valve Position						
Reversing Valve Position						
Fan Start/Stop						
Fan Status						
Compressor Status						
Hot Gas Reheat Enable						
Hot Gas Reheat Status						
Discharge Air Temperature						
Zone Temperature						
Zone Temperature Set Point						
Zone Humidity						
Zone Humidity Set Point						
Filter Status						
Any associated alarms						

8. FCU Trending and Alarms:

FCU Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupancy						
Mode						
Zone Temperature						
Zone Set Point						
Fan Speed						
Supply Air Temperature						
Supply Air Temperature Set Point						
CHW Valve Command						
CHW Valve Position						
HW Valve Command						
HW Valve Position						
Zone Humidity						
Zone Humidity Set Point						
Zone Wet Bulb						
Zone Wet Bulb Set Point						
Filter Status						
Any associated alarms						

9. VRFC Trending and Alarms:

VRFC Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range Alarm Range	Alarm Delay
Occupancy						
Mode						
Zone Temperature						
Zone Set Point						
Fan Speed						
Supply Air Temperature						
Supply Air Temperature Set Point						
Zone Humidity						
Zone Humidity Set Point						
Zone Wet Bulb						

Zone Wet Bulb Set Point						
Filter Status						
Any associated alarms						

10. PIU Trending and Alarms:

PIU Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupancy						
Damper Position						
Airflow						
Airflow Set Point						
Supply Air Temperature						
Fan Command						
Fan Status						
Zone Temperature						
Zone Temperature Set Point						
Heating Status						
Zone Humidity (Where Applicable)						
Zone Humidity Set Point (Where Applicable)						
Zone Wet Bulb (Where Applicable)						
Zone Wet Bulb Set Point (Where Applicable)						
CO_2 Actual (Where applicable)						
CO_2 Set Point (Where applicable)						
Filter Status (Where Applicable)						
Any associated alarms						

11. VAV Terminal Unit Trending and Alarms:

VAV Terminal Unit Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupancy						
Damper Position						
Airflow						
Airflow Set Point						

Supply Air Temperature						
Zone Temperature						
Zone Temperature Set Point						
Heating Status						
Zone Humidity (Where Applicable)						
Zone Humidity Set Point (Where Applicable)						
Zone Wet Bulb (Where Applicable)						
Zone Wet Bulb Set Point (Where Applicable)						
CO_2 Actual (Where Applicable)						
CO_2 Set Point (Where Applicable)						
Any associated alarms						

12. VAV OA Trending and Alarms:

VAV OA Terminal Unit Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupancy						
Damper Position						
Airflow						
Airflow Set Point						
CO_2 Actual						
CO_2 Set point						
Any associated alarms						

13. Mini Split System Trending and Alarms:

Mini Split System Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Mode						
Status						
Fan Status						
Zone Temperature						
Zone Set Point						
Any associated alarms						

14. MAU Trending and Alarms:

MAU Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupancy						
Mode of Operation						
Low Limit Thermostat						
Heat Command						
Supply Fan Command						
Supply Fan Status						
Supply Air Set Point						
Supply Air Temperature						
Any associated alarms						

15. Exhaust/Supply Fans Trending and Alarms:

Exhaust/Supply Fans Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Start/Stop						
Status						
Any associated alarms						

16. Chiller Trending and Alarms:

Chiller Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupied						
Chiller Entering Temperature						
Chilled Water Temperature Set point						
Chiller Leaving Temperature						
Chiller Flow						
Isolation Valves Command						
Isolation Valves Status						
Chiller Percent Load						
Any associated alarms						

17. Chilled Water System Trending and Alarms

Chilled Water System Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Secondary Loop DP Set point						
Secondary Loop DP						
Secondary Loop Flow						
Secondary Loop Return Temperature						
Primary Loop Pump 1 Status						
Primary Loop Pump 2 Status						
Secondary Loop Pump 1 Status						
Secondary Loop Pump 2 Status						
Primary Loop Pump 1 VFD Speed						
Primary Loop Pump 2 VFD Speed						
Secondary Loop Pump 1 VFD Speed						
Secondary Loop Pump 2 VFD Speed						
Primary Pump 1 Start/Stop						
Primary Pump 2 Start/Stop						
Secondary Pump 1 Start/Stop						
Secondary Pump 2 Start/Stop						
Chiller Condenser Entering Temp						
Chiller Condenser Leaving Temp						
# CHW Valves Open (Where Applicable)						
Any associated alarms						

18. Cooling Tower Loop Trending and Alarms

Cooling Tower Loop Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupancy						
Outside Air Temperature						
CT P-1 Start/Stop						
CT P-1 Status						

CT P-1 VFD Speed						
CT P-2 Start/Stop						
CT P-2 Status						
CT P-2 VFD Speed						
CT Loop Temperature Supply						
CT Loop Temperature Return						
CT Set Point						
CT Fan Start/Stop						
CT Fan speed						
CT Fan Status						
CT Bypass Valve						
Any associated alarms						

19. Boiler Trending and Alarms:

Boiler Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Boiler System Enable						
Boiler Enable						
Boiler Status						
Boiler 2 Enable						
Boiler 2 Status						
Boiler Isolation Valve						
Boiler Pump 1 Status						
Boiler Pump 1 Start/Stop						
Boiler Pump 2 Status						
Boiler Pump 2 Start/Stop						
Outdoor Air Temperature						
Boiler 1 Entering Water Temperature						
Boiler 1 Leaving Water Temperature						
Boiler 2 Entering Water Temperature						
Boiler 2 Leaving Water Temperature						
Hot Water Return Temperature						
Hot Water Supply Temperature						
Any associated alarms						

20. Hot Water System Trending and Alarms:

Hot Water System Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
Occupancy						
Outside Air Temperature						
HWP-1 Start/Stop						
HWP-1 Status						
HWP-1 VFD Speed						
HWP-2 Start/Stop						
HWP-2 Status						
HWP-2 VFD Speed						
Secondary Loop Differential Pressure Set point						
Secondary Loop Differential Pressure						
Hot Water Supply Set point						
Hot Water Supply Temperature						
Hot Water Return Temperature						
# HW Valves Open (Where Applicable)						
Any associated alarms						

21. WSHP Loop Water Trending and Alarms:

WSHP Loop Water System Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration		Alarm Range Alarm Range	Alarm Delay
Occupancy						
Outside Air Temperature						
Loop Water Supply Set Point						
Loop Water Supply Temperature						
Loop Water Return Temperature						
Loop Water DP						
Loop Water DP Set Point						
Any associated alarms						

22. Domestic HW Trending and Alarms:

Domestic HW Trending and Alarms						
Point	Trend Interval	Operational Trend Duration	Testing Trend Duration	Alarm Type	Alarm Range	Alarm Delay
WH Set Point						
WH Status						
Circulating Pump Status						
Any associated alarms						

H. CSV or EXCEL file format is required for all output.
I. Startup Reports, Prefunctional Checklists, and Trend Logs: Submit for approval of CxP .
J. Trend Logs and Monitoring. Trend logs required in the testing requirements will be set up and executed by the Contractor and provided to and analyzed by the CxP. Monitoring using data loggers will be conducted by the controls contractor if it is not possible through the BMS. Trend logs and monitoring are conducted after Test & Balance and subsequent trouble-shooting are complete and systems are in normal operation without frequent service shutdowns, etc.
K. Adequate storage method and media for trends is the sole responsibility of the control's contractor.
L. A Sample trend is to be provided by the control's contractor to the CxP for review prior to beginning record trends. Trend logs will contain Descriptive labels for each data point trended as well as a date and time stamp. Gaps in trend data will be accompanied with an explanation and may be cause for resub- mission of trends.

End of Section 23 09 95 Controls – Trending

SECTION 23 11 23 – FACILITY NATURAL GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Facility Natural Gas Piping Requirements
   2. Testing Requirements

B. Legend:
   1. APS: Atlanta Public Schools

1.2 GENERAL NATURAL GAS PIPING REQUIREMENTS

A. All gas piping shall be welded black steel or when pipe is 2.5” and greater or when located in return air plenum.
B. When black steel pipe is 2” and smaller, pipe can have black malleable fittings.
C. Mechanical compression fittings are acceptable, Viega MegaPress fittings or equivalent, where code allows, as approved by APS.
D. Underground black steel pipe shall be factory coated and wrapped.
E. Approved plastic gas piping may be used underground.
   1. All installers shall be certified by pipe manufacturer.
F. Underground pipe shall have tracer wire installed adjacent to pipe with access to or termination of tracer wire above ground.
G. Detectable warning tape shall be installed directly above underground gas piping no less than 12 inches below finished grade.
H. Piping shall be sleeved where pipe penetrates walls, floors, or ceilings.
I. Sediment tees shall be installed where pipe rises and before equipment connections.
J. Shut off valves shall be installed at each piece of equipment served.
K. Shut off valves shall be easily accessible and within 6 feet of equipment.
L. Pressure taps shall be installed on low pressure side of shut off valve.
M. Regulators and overpressure protection devices shall be installed at each piece of equipment served where required.
N. Flexible gas connectors shall not be used for HVAC or plumbing equipment.
O. Piping shall be supported every 6-8 feet depending on size of pipe.
P. Pipe shall be supported within every 2 feet of a change in direction.
Q. Piping shall be supported with pipe-stand with roller-type pipe support and height adjustable where running across roof, floor, etc., or clevis hanger where suspended horizontally.
R. Dielectric unions, flanges, etc. shall be used where copper alloy and ferrous material are connected.
S. Exterior pipe shall be primed and painted. Color shall be chosen by APS based on location.
T. All piping shall be labeled to indicate service pressure. Label shall read “Natural Gas” and show direction and pressure.

1.3 TESTING REQUIREMENTS

A. Piping shall be inspected and purged per local authorities, engineers, and NFPA requirements.
B. Defective joints or piping shall be replaced.
C. Test and inspection reports shall be documented and delivered to Engineer and APS.

End of Section 23 11 23 Facility Natural Gas Piping

SECTION 23 21 13 – HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Chilled and Condenser Water Piping Requirements
   2. Makeup Water Piping Requirements
   3. Condensate Piping Requirements
   4. Hot Water Piping Requirements
   5. Underground Piping Requirements

B. Legend:
   1. APS: Atlanta Public Schools
   2. PRV: Pressure Reducing Valve
   3. T&P: Temperature and Pressure

1.2 CHILLED AND CONDENSER WATER PIPING REQUIREMENTS

A. Pipe shall be schedule 40 black steel with welded, or threaded joints.
B. Pipe smaller than 2" can be type L hard drawn copper pipe.
   1. Joints shall be silver brazed or mechanically compressed fittings.
      a. Solder must meet standards for utilization in a soldered joint suitable for 150 lb. service minimum.
C. All changes in direction and branches shall be manufactured fittings.
D. All high points shall have air vents with a service valve.
   1. Automatic air vents shall be installed in mechanical rooms.
   2. Manuals air vents shall be installed at each coil.
E. Flexible pipe connections for condenser water service shall be suitable for 150 psi of working pressure.
F. Expansion tank shall be installed in mechanical plant and correct tank pressure verified.
G. Air separator shall be installed in mechanical plant.
H. Differential pressure sensors taps shall be installed on side of pipe.
I. Install dielectric fittings in piping at connections of dissimilar metals.
J. T&P ports shall be installed on either side of water coils, equipment, and within 12" of any installed control device.
K. Pipe shall be supported every 8 feet including vertical runs.
L. Pipe shall be sleeved when penetrating walls, ceilings, and floors.
   1. Sleeves where piping penetrates walls, floors, or ceiling, do not count as support.
M. Walls shall not be used as piping support.

1.3 MAKEUP WATER PIPING REQUIREMENTS

A. Pipe shall be type L drawn temper copper with wrought copper fittings and soldered joints.
B. All changes in direction and branches shall be manufactured fittings.
C. Install PRV for makeup water.
D. Install backflow preventer. Install air gap drain piping to nearest floor drain or hub drain.
E. Install makeup water assembly.
F. Install dielectric fittings in piping at connections of dissimilar metals.

1.4 CONDENSATE PIPING REQUIREMENTS

A. Condensate drain pipe shall be type M drawn-temper copper pipe.
   1. Fittings shall be wrought copper.
   2. Joints shall be soldered or compression fittings.
   3. Solder shall be lead-free.
B. All changes in direction and branches shall be manufactured fittings.
C. Cleanout shall be every 25 feet.
D. Install dielectric fittings in piping at connections of dissimilar metals.

E. Condensate pipe shall be supported every 6 feet including vertical runs. There shall be no sagging in condensate pipe.
F. Pipe shall be supported in such a way to provide required slope (1/8" per foot) for proper drainage.
G. Piping shall be sleeved where pipe penetrates walls, floors, or ceilings.
    1. Sleeves where piping penetrates walls, floors, or ceiling, do not count as support.
H. Walls shall not be used as piping support.

1.5 HOT WATER PIPING REQUIREMENTS

A. Pipe shall be schedule 40 black steel with welded, or threaded joints.
B. Pipe smaller than 2" shall be type L hard drawn copper pipe.
    1. Joints shall be silver brazed or compression fittings.
        a. Solder must meet standards for utilization in a soldered joint suitable for 150 lb. service minimum.
C. No Victaulic pipe or fittings.
D. All changes in direction and branches shall be manufactured fittings.
E. All high points shall have air vents.
    1. Automatic air vents shall be installed in mechanical rooms.
    2. Manuals air vents shall be installed at each coil.
F. Install dielectric fittings in piping at connections of dissimilar metals.
G. Hot water pipe shall have 300 lb. dielectric unions.
H. T&P ports shall be installed on either side of water coils, equipment, and within 12" of any installed control device.
I. HW pipe shall be supported every 8 feet including vertical runs.
J. Piping shall be sleeved where pipe penetrates walls, floors, or ceilings.
    1. Sleeves where piping penetrates walls, floors, or ceiling, do not count as support.
K. Walls shall not be used as piping support.
L. Expansion tank shall be installed in mechanical plant and correct tank pressure verified.

1.6 UNDERGROUND PIPE REQUIREMENTS

A. Condenser water pipe underground shall be polypropylene PP-R or HDPE pipe with fused joints.
    1. Aquatherm heat fused piping or equivalent as approved by APS is acceptable.
B. Chilled water pipe located underground shall be pre-insulated double walled pipe.
C. Heating Hot water pipe located underground shall be pre-insulated double walled pipe.

End of Section 23 21 13 Hydronic Piping

SECTION 23 21 23 – HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Pump Requirements
   2. Start-Up Requirements

B. Legend
   1. APS: Atlanta Public Schools
   2. T&P: Temperature and Pressure
   3. VFD: Variable Frequency Drive

1.2 GENERAL PUMP REQUIREMENTS

A. Atlanta Public Schools prefers to use pumps, fans and motors manufactured by the following companies: Patterson Bell and Gossett, Armstrong, Taco or equal.

B. Pumps shall be based mounted close coupled design for all main building heating, chilled water, condenser water, and cooling tower loops. Boiler pumps under 2 HP can be installed in-line with supports to the overhead structure.

C. All motors shall be high efficiency and inverter duty rated. With bearing grounding rings to prevent premature bearing failure.

D. Grout pump bases to housekeeping pads.

E. Vibration isolation from piping and floors shall be provided when pumps are located above ground level.

F. Pipe shall have stainless steel flex connectors on pipe over 2.5”.

G. Pump manufacturer to provide VFD for pumps.

H. Pumps shall be floor mounted where applicable.

I. Piping arrangements at the pumps shall not make use of a triple duty valve; they are to have check and butterfly valves. Butterfly valves shall be installed on the suction and discharge.

J. T&P test ports/plugs shall be installed in pipe on both entering and leaving sides of the pumps.

K. Pressure gauge manifold shall be installed at each pump.

1.3 START-UP REQUIREMENTS

A. Start-up, including a coupling alignment, shall be conducted and documented by a factory-authorized technician.

End of Section 23 21 23 Hydronic Pumps

SECTION 23 23 00 – REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Refrigerant Piping Requirements
   2. Testing Requirements

B. Legend:
   1. APS: Atlanta Public Schools
   2. VRF: Variable Refrigerant Flow

1.2 GENERAL REFRIGERANT PIPING REQUIREMENTS

A. Piping shall be installed by technician trained by the equipment manufacturer of equipment refrigerant piping is serving. Proof of completed training shall be provided to APS.

B. Refrigerant piping shall be hard/rigid copper.

C. The last six (6) feet of pipe run to VRF indoor unit may be soft copper.

D. Fittings shall be brazed. Compression fittings may be used at the equipment and or devices as approved by APS.
   1. If fittings and joints are brazed, nitrogen must be used for purging while brazing.

E. If piping is installed below ground or incased in concrete, provide a protective conduit.

F. Piping shall be sleeved where pipe penetrates walls, floors, or ceilings.
   1. Where penetrations are exposed to occupants, escutcheons shall be used in addition to sleeves.

G. Pipe penetrations through roof shall have an insulated weather-proof chase housing with curb and seals. Alta Products, LLC Pipe Chase Housing, Alta Curb, and Exit Seals or equivalent (as approved by APS) shall be installed.
   1. At no time shall the rubber multi-port –utter type pipe chase be allowed.
   2. Provide for the connection to the Pipe Chase.

H. Exterior VRF Refrigerant piping shall be neatly racked using strut channel and pipe clamps supported by equipment support stand or setting on non-penetrative stands/blocks.
   1. Pipe clamps shall be of the type that allows for insulation to be continuous through clamp.
   2. Piping shall be installed to allow for access to condensers.

I. Pipe installation shall allow for enough room for:
   1. Access to equipment
   2. Installation of insulation

J. Refrigerant pipe shall be supported every 6 feet including vertical runs. There shall be no sagging in refrigerant pipe.

K. Pipe shall be supported within 12-20” (inches) of a change in direction.

L. In no case shall multiple refrigerant piping be installed in a single clevis type hanger

M. Supports for vertical runs of refrigerant pipe shall be of the clamp type that allows for continuous insulation throughout clamp.

N. Length requirements, fitting requirements, trap requirements, expansion requirements, and accessory requirements shall be provided by manufacturer’s requirements.

O. Supports shall have saddles at each location.

P. Supports and saddles shall not compress insulation.

Q. Saddles shall be the type that can be affixed to clevis and/or trapeze hangers.
   1. Snap n’ Shield or equivalent as approved by APS.
   2. Alternative to saddles include items equivalent to Armacell’s Armafix Insulation Pipe Hanger.

R. At no time (including temporarily) should there be anything hung from or supported from refrigerant piping.

S. Refrigerant pipes shall not be affixed together included but not limited to zip tied together.

T. All piping shall be insulated with flexible elastomeric insulation.

U. All piping shall be labeled. The insulation shall be labeled to indicate service. The service shall not be referred to or have in the description as simply “Gas”.

V. Refrigerant pipe and insulation located outside shall have aluminum or metal jacketing.

1.3 TESTING REQUIREMENTS

A. Technician performing piping tests (pressure and vacuum testing) shall have completed equipment manufacturers training and provide proof of training.

B. Refrigerant piping shall be tested based upon the following:

1. Pressure (3 steps)
    a. Step 1. A pressure of 150 psi is applied for 3 min. If there are no indications of leaks continue to Step 2.
    b. Step 2. A pressure of 325 psi is applied for 5 minutes. If there are no indications of leaks continue to Step 3.
    c. Step 3. A pressure of 550 psi is applied for 24 hours. If there are no indications of a leak, vacuum test can then be started.
2. Vacuum
    a. Evacuate the piping to 4,000 microns and hold for 15 minutes. Break the vacuum with dry nitrogen to a level of 2-3 psig.
    b. Evacuate the system to 1,500 microns and hold for 20 minutes. Break the vacuum with dry nitrogen to a level of 2-3 psig.
    c. Evacuate the system to 500 microns or less. (Should not be lower than 400 microns). Microns should hold for 1 hour. If there is a rise in microns of over 30 microns, redo vacuum test.
    d. If system has been rested and system still cannot pass, system should be checked for leaks.

C. If equipment manufacturer has an alternate testing procedure, contractor may use the alternate on approval by APS.

D. Times, temperature, and pictures of gauges must be taken, recorded and submitted to APS. Any manufacturer testing documentation must be filled out and submitted as well.

E. Digital micron gauge is required for vacuum testing.

F. If the outdoor temperature is variable, use (Tp –Tc) x 0.80 to calculate the temperature drop for pressure testing. (Tp is the temperature when system is pressurized and Tc is the temperature when the pressure is checked).

G. System Operation Endurance Test: The system shall be placed in cooling for one hour and then into heating for one hour, this process shall be performed three (3) times. If any issues occur, they should be corrected/fixed.

End of Section 23 23 00 Refrigerant Piping

SECTION 23 25 00 – HVAC Water Treatment

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Water Treatment Requirements
B. Legend:
   1. APS: Atlanta Public Schools

1.2 WATER TREATMENT REQUIREMENTS

A. System and Equipment Treatment shall be provided by an approved APS vendor.
B. As part of the Mechanical System start up, System flushing and final Chemical Treatment shall be the contractor's responsibility. Contractor shall coordinate with the approved vendor for water treatment requirements, procedures and schedule.
C. All reports shall be reviewed by the CxP and/or Mechanical Engineer.
D. The reports shall be included in the close out documents.

End of Section 23 25 00 HVAC Water Treatment

SECTION 23 31 00 – HVAC DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General HVAC Ducts Requirements
   2. Exterior Duct Requirements
   3. Duct Liner Requirements
   4. Duct Sealer and Mastic Requirements
   5. Testing Requirements

B. Legend:
   1. AHU: Air Handling Unit
   2. APS: Atlanta Public Schools
   3. DALT: Duct Air Leakage Test
   4. DOAS: Dedicated Outdoor Air System
   5. DOR: Designer of Record
   6. ERU: Energy Recovery Unit
   7. PIU: Powered Induction Unit
   8. RTU: Roof Top Unit
   9. VOC: Volatile Organic Compounds

1.2 GENERAL HVAC DUCTS REQUIREMENTS

A. Ductwork shop drawings shall be submitted and approved by APS and DOR prior to installation.
B. Duct construction must be in accordance with current SMACNA standards and compliant with local code.
C. Ductwork shall be metal duct unless otherwise directed by APS or DOR.
D. Ductwork shall be rectangular, flat-oval, or spiral.
   1. Snap-lock duct shall not be used.
E. Both single-wall and double-wall ducts and fittings may be used.
F. Large ductwork shall have internal bracing in accordance with SMACNA and DOR requirements.
   1. Internal Bracing shall have Condi locks.
   2. Internal Bracing shall not be uni-strut type material.
G. Ductwork must be supported per SMACNA and at a minimum of every 8 feet.
H. Ductwork shall not press against structure, piping, conduit, etc. to cause insulation to be compressed, and/or affect the intended insulation value or not provide a continuous installation of the insulation.
I. Ductwork shall be externally insulated.
J. Duct liner for thermal insulation is not acceptable.
K. All joints need to be sealed, including longitudinal joints.
L. Ductwork shall not have field made fittings or duct sections. Fittings and duct shall be fabricated by manufacturer or shop.

1.3 EXTERIOR DUCT REQUIREMENTS

A. Exterior duct shall have flexible canvas connector at RTU/ERU/DOAS and insulated with elastomeric insulation.
B. Exterior ductwork shall be externally insulated and provided with aluminum/metal cladding.
C. Ductwork shall be supported via threaded rod, trapeze hanger or big foot supports or equal as approved by APS.
D. Ductwork shall be sloped to prevent ponding.
E. Ductwork shall not be temporarily supported after adhesive sealer or insulation is applied.

1.4 DUCT LINER REQUIREMENTS

A. Duct liner shall be used for noise reduction first 15 feet from RTU/ERU/DOAS/AHUs or 3 feet on PIUs.
   1. Fabricated duct silencers, VibroAcoustics or equal as approved by APS, can be used as an alternative to liner.
B. Duct liner shall be pinned and/or mastic applied per manufacturer's instructions.
C. Raw edges of duct liner shall be buttered.
D. Leading edge of liner shall have metal nosing.

1.5 DUCT SEALER AND MASTIC REQUIREMENTS

A. Duct sealer and mastic shall be mold and mildew resistant.
B. Duct sealer and mastic shall be low VOC.

1.6 TESTING REQUIREMENTS (DALT)

A. All medium and high pressure ductwork (operating pressure of more than 1.0" W.C. E.S.P.) shall be tested at l.5 times the design operating pressure of the system to which it is connected, or at the total fan pressure at shutoff, whichever is greater.
B. All visible and audible air leaks from the ductwork systems shall be repaired.
C. The DALT shall be witnessed by the CxP and/or the Mechanical Engineer.

End of Section 23 31 00 HVAC Ducts

SECTION 23 33 13 – FIRE AND SMOKE DAMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Requirements
   2. Fire Damper Requirements
   3. Smoke Damper Requirements
   4. Fire/Smoke Combination Damper Requirements
   5. Testing Requirements

1.2 GENERAL REQUIREMENTS

A. The following manufacturers are approved for use:
   1. Ruskin
   2. Nailor
   3. Greenheck
   4. Or approved by APS.
B. It is recommended to use the manufacturer with approved installation instructions for atypical installation.
C. If manufacturer chosen does not have a UL approved method for installation application and manufacturer will not approve installation, a different fire/smoke damper manufacturer shall be submitted.
D. Mandatory pre-installation meeting is required for anyone that has anything to do with installation. This includes but not limited to sheet metal, electrician, carpenter, etc.

1.3 FIRE DAMPER REQUIREMENTS

A. Fire dampers shall be installed per manufacturer's instructions.
B. Installing contractor shall have a copy of manufacturer's instructions on hand at all times.
C. Fire dampers cannot have large annular spacing.
D. Proper expansion space (annular space) shall be left around damper sleeve and wall opening per manufacturer's instructions.
   1. Spacing shall not be filled with firestop materials, fill, void or cavity materials unless otherwise indicated in manufacturer's installation instructions.
E. Fire dampers must have retaining angles on all sides unless manufacturer's has an alternative in their instructions.
F. Retaining angles must meet manufacturer's recommendations for thickness.
G. Corners of retaining angles cannot have gaps and must overlap; unless approved by manufacturer.
H. Retaining angles must lay flat against structure unless otherwise approved by manufacturer.
I. Retaining angles must be secured to sleeve and//or wall with screws and screw spacing as detailed in manufacturer's instructions.
J. Sleeves must meet manufacturer's recommendations for thickness.
K. Single sided fire dampers must be secured to sleeve and wall as detailed in manufacturer's instructions.
L. UL approved assembly shall not be modified in any way.
M. Fire dampers shall be framed in wall as detailed in manufacturer's instructions.
N. Fire dampers that close on the horizontal plane shall be spring loaded dampers.
   1. Access panels shall be installed on spring release side of damper.
O. Fire damper fusible links shall be rated for a minimum of 165 °F.
P. Fire dampers shall be rated for 1-1/2 hours.
Q. Access panels in ductwork shall be provided for routine maintenance and testing.

1.4 SMOKE DAMPER REQUIREMENTS

A. Smoke dampers shall be installed per manufacturer's instructions.
B. Installing contractor shall have a copy of manufacturer's instructions on hand at all times.
C. Smoke dampers cannot have large annular spacing.
D. Proper expansion space (annular space) shall be left around damper sleeve and wall opening per manufacturer's instructions.
    1. Spacing shall not be filled with firestop materials, fill, void or cavity materials unless otherwise indicated in manufacturer's installation instructions.
E. Smoke dampers shall be Class 1 low leakage.
F. Smoke dampers shall be secured to sleeve with screws and screw spacing as detailed in manufacturer's instructions.
G. Sleeves must meet manufacturer's recommendations for thickness.
H. Retaining angles shall be provided and installed per manufacturer's instructions.
I. Sealed per smoke wall rating.
J. Smoke damper actuators shall be provided with test switch.
K. Smoke detector shall be mounted within 5 feet of smoke damper.
L. Electrical junction boxes shall be labeled for electrical circuitry.
M. Panelboard schedule should identify circuit with smoke damper.
N. Access panels in ductwork shall be provided for routine maintenance and testing.

1.5 FIRE/SMOKE COMBINATION DAMPER REQUIREMENTS

A. Fire/Smoke dampers shall be installed per manufacturer's instructions.
B. Installing contractor shall have a copy of manufacturer's instructions on hand at all times.
C. Fire/Smoke dampers cannot have large annular spacing.
D. Proper expansion space (annular space) shall be left around damper sleeve and wall opening per manufacturer's instructions.
    1. Spacing shall not be filled with firestop materials, fill, void or cavity materials unless otherwise indicated in manufacturer's installation instructions.
E. Fire/Smoke dampers must have retaining angles on all sides unless manufacturer's has an alternative in their instructions.
F. Retaining angles must meet manufacturer's recommendations for thickness.
G. Corners of retaining angles cannot have gaps and must overlap; unless approved by manufacturer.
H. Retaining angles must lay flat against structure unless otherwise approved by manufacturer.
I. Retaining angles must be secured to sleeve and//or wall with screws and screw spacing as detailed in manufacturer's instructions.
J. Sleeves must meet manufacturer's recommendations for thickness.
K. Single sided fire dampers must be secured to sleeve and wall as detailed in manufacturer's instructions.
L. UL approved assembly shall not be modified in any way.
M. Fire/Smoke dampers shall be framed in wall as detailed in manufacturer's instructions.
N. Sealed per smoke wall rating.
O. Fire/Smoke dampers that close on the horizontal plane shall be spring loaded dampers.
    1. Access panels shall be installed on spring release side of damper.
P. Fire/Smoke damper fusible links shall be rated for a minimum of 165 °F.
Q. Fire/Smoke dampers shall be rated for 1-1/2 hours.
R. Fire/Smoke damper actuators shall be provided with test switch.
S. Electrical junction boxes shall be labeled for electrical circuitry.
T. Panelboard schedule should identify circuit with smoke damper.
U. Smoke detector shall be mounted within 5 feet of fire/smoke damper.
V. Access panels in ductwork shall be provided for routine maintenance and testing.

1.6 TESTING REQUIREMENTS

A. It is recommended to test all damper prior to inspections and commissioning.

B. Fire dampers, smoke dampers, and Fire/Smoke combination dampers are to be tested (closed and reset) by mechanical and/or electrical contractor and witnessed by the CxP and if required by the city Inspector and or Fire Marshall.

End of Section 23 33 13 Fire and Smoke Dampers

SECTION 23 34 00 – FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Fan Requirements

1.2 GENERAL FAN REQUIREMENTS

A. Exhaust fans shall be direct drive unless unavailable due to size or manufacturer restrictions.
B. Direct drives shall come with factory mounted speed controller.
C. Roof mounted exhaust fans shall be mounted and secured to curbs.
D. Fans shall have external disconnect.
E. Motors shall be high efficiency.
F. Backdraft dampers shall be provided.
G. Bird screens shall be provided.
H. Suspended and ceiling fans shall have vibration isolators.
I. Start-up shall be performed and documented.

End of Section 23 34 00 Fans

SECTION 23 38 00 – VENTILATION HOODS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Kitchen Hood Make-Up Air Requirements
   2. Start-Up Requirements

B. Legend:
   1. APS: Atlanta Public Schools
   2. EOR: Engineer of Record
   3. MAU: Make-Up Air Unit
   4. VFD: Variable Frequency Drive

1.2 KITCHEN HOOD MAKE-UP AIR REQUIREMENTS

A. The following manufacturers are approved for use:
   1. Greenheck
   2. Captive-Aire
   3. Rupp Air
   4. Or approved by APS.

B. Hood shall be stainless steel.

C. Exhaust fan shall be installed with outlet 40” above roof minimum.

D. Exhaust hoods joints exposed to grease shall be welded with continuous welds.
   1. Filters/baffles or grease extractors and makeup air diffusers easily accessible for cleaning.

E. MAU shall include gas heat.
   1. Fuel type shall be natural gas or same as available on project site.
   2. Unit shall be a minimum of 80% efficient.

F. Unit shall be power vented with integral motorized fan interlocked with gas valve.

G. Unit shall have a regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shut off in one bode.
   1. Gas control valve shall be modulating 0-10 Vdc or minimum of 4:1 turndown.
   2. Igniter shall be electronically controlled electric spark with flame sensor.
   3. Fan thermal switch operates fan on heat exchanger temperature
   4. Differential pressure switch shall verify open vent for vent flow.
   5. There shall be a control transformer.
   6. High limit thermal switch or fuse to stop burner.

H. Furnace heat shall run based upon field adjustable discharge temperature set point.
   1. Discharge temperature sensor shall be factory mounted and wired to controller.

I. Fans shall be centrifugal with the following features:
   1. Energy efficient motors.
   2. VFDs.
   3. Permanently lubricated motors.

J. Fans shall operate via on-off switch on hood.

K. Exhaust fan shall have an integral grease trough with drain fitting.

L. Hoods shall be supplied with wet chemical fire suppression system.

M. Fire suppression system shall have automatic detection and release and/or manual release of fire suppression agent by hood operator.

N. Exhaust fan and kitchen gas valves shall be interlocked with fire suppression system to operate fan(s) during fire-suppression agent release.

O. Units shall be provided with external disconnect.

1.3 START-UP REQUIREMENTS

A. Engage a factory-employed service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions. Provide documentation of Certification.

End of Section 23 38 00 Ventilation Hoods

SECTION 23 41 00 – PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Filter Requirements

B. Legend:
   1. AHU: Air Handling Unit
   2. APS: Atlanta Public Schools
   3. DOAS: Dedicated Outdoor Air System
   4. ERU: Energy Recovery Unit
   5. FCU: Fan Coil Unit
   6. PIU: Powered Induction Unit
   7. PMU: Pad Mounted Unit
   8. RTU: Roof Top Unit
   9. VRF: Variable Refrigerant Flow
   10. VRFC: Variable Refrigerant Fan Coil
   11. WSHP: Water Source Heat Pump

1.2 GENERAL FILTER REQUIREMENTS

A. During construction, all air moving equipment and all equipment with coils shall have construction filters.
   1. VRF system shall not run during construction.

B. All equipment shall come with 2 sets of pleated filters.
   1. VRF indoor units shall be provided with 2 sets of washable filters.

C. Filters shall be a minimum of MERV 8 during construction.

D. After acceptance, filters shall be MERV 13 for AHUS, RTUs, PMUs, DOAS, and ERUs.

E. After acceptance, filters shall be MERV 13 for Cassettes providing area conditioning and return air recirculation.

F. After acceptance, PIUs, WSHPs, FCUs, etc. shall be provided with MERV 8 filters.

End of Section 23 41 00 Particulate Air Filtration

SECTION 23 52 00 – BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Boiler Requirements
   2. Start-Up Requirements

B. Legend
   1. APS: Atlanta Public Schools
   2. BMS: Building Management System
   3. T&P: Temperature and Pressure

1.2 GENERAL BOILER REQUIREMENTS

A. Boilers shall be condensing boilers.

B. Electric and Gas-fired boilers are acceptable; manufactured by the following companies: Lochinvar, Patterson-Kelly, or manufacturer approved by APS. Stainless Steel Heat Exchangers Preferred.

C. Condensing boilers shall have neutralization kits.

D. Boilers shall have a hose end drain valve with a cap and chain installed at piping on leaving side of boiler.

E. Boilers shall be provided with isolation valves. Valves shall not be installed directly to the boiler connection, provide a spool piece and union between the boiler connections and valve.

F. T&P test ports/plugs shall be installed in pipe on both entering and leaving sides of boiler.

G. Thermometers shall be installed on both leaving and entering sides of the boiler.

H. Boilers shall have a primary/secondary system with dedicated boiler pump interlocked with boiler.
   1. Pump shall be controllable by BMS.

I. No draft induced powered fans will be acceptable. Boiler flues shall be designed to not require these fans.

J. Boiler flue shall be per manufacturer's instructions.

K. Boilers shall have Building Automation System Interface to allow for building automation system to monitor, control, and display boiler status and alarms.

L. If there are multiple boilers, one boiler shall be designated as master boiler with factory master boiler controller.

1.3 START-UP REQUIREMENTS

A. Start-up shall be conducted and documented by a factory-authorized technician.

End of Section 23 52 00 Boilers

SECTION 23 55 13 – FUEL FIRED DUCT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Fuel Fired Duct Heater Requirements
   2. Control Requirements
   3. Testing Requirements

B. Legend:
   1. APS: Atlanta Public Schools
   2. EOR: Engineer of Record

1.2 FUEL FIRED DUCT HEATER REQUIREMENTS

A. The following manufacturers are approved for use:
   1. Lennox Industries, Inc.
   2. Modine Manufacturing Company
   3. Reznor/Thomas & Betts Corporation
   4. Or approved by APS.

B. Fuel type shall be natural gas or same as available on project site.

C. Unit shall be factory assembled.

D. Unit shall be power vented with integral motorized fan interlocked with gas valve.

E. Unit shall have a regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shut off in one bode.
   1. Gas control valve shall be modulating 0-10 Vdc or minimum of 4:1 turndown.
   2. Igniter shall be electronically controlled electric spark with flame sensor.
   3. Fan thermal switch operates fan on heat exchanger temperature
   4. Differential pressure switch shall verify open vent for vent flow.
   5. There shall be a control transformer.
   6. High limit thermal switch or fuse to stop burner.

F. Units shall have condensate drain connection kits.

G. Condensate pump shall be provided for condensing duct heaters.

H. Units shall have vibration isolation at hangers.

I. Duct heaters shall be supported independently of duct.

1.3 CONTROL REQUIREMENTS

A. Thermostat for operation in downstream of unit in duct or in space depending of intended use.

1.4 TESTING REQUIREMENTS

A. Duct heater shall be tested by a factory-authorized service representative. Documentation shall be provided to APS and EOR.

End of Section 23 55 13 Fuel Fired Duct Heaters

SECTION 23 57 00 – HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Frame Plate Heat Exchanger Requirements

B. Legend:
   1. APS: Atlanta Public Schools
   2. T&P: Temperature and Pressure

1.2 FRAME PLATE HEAT EXCHANGER REQUIREMENTS

A. The following manufacturers are approved for use:
   1. Alfa Laval, Inc.
   2. API Heat Transfer, Inc
   3. APV; SPX Corporation
   4. ITT Corporation
   5. Mueller
   6. TACO Incorporated
   7. Or approved by APS.

B. Heat exchanger shall be freestanding.

C. Heat exchanger shall have stainless steel sheets.

D. Frame shall accommodate 25% additional plates.

E. Arrange piping for easy maintenance of heat exchanger.

F. T&P ports shall be installed on entering and leaving piping.

G. Hose end drain valve with cap and chain shall be installed.

H. Shut-off valves shall be installed at heat exchanger inlet and outlet connections. Do not install valves directly to the heat exchanger connection; provide a spool piece and union between the heat exchanger connections and valve.

I. Do not flush water system through the heat exchanger; provide a temporary bypass.

J. Thermometers shall be installed on inlet and outlet piping.

K. Leak test shall be conducted after installation.
   1. Repair leaks and retest. Repeat as required.

End of Section 23 57 00 Heat Exchangers for HVAC

SECTION 23 64 00 – CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Chiller Requirements
   2. Warranty
   3. Additional Warranty
   4. Freeze Protection
   5. Installation
   6. Start-Up

1.2 GENERAL CHILLER REQUIREMENTS

A. Manufacturer: The following manufactures are preferred:
   1. Trane
   2. Daikin
   3. JCI/York
   4. All substitutions must be approved by APS.

B. The following types of chillers are acceptable:
   1. Centrifugal, Electric 200 Ton plus.
   2. Reciprocating, all sizes
   3. Screw less than 200 tons
   4. Air cooled scroll less than 150 tons

C. All equipment submittals shall include the Noise/Decibels when in maximum load & speed.
   1. Provide information on sound attenuation and/or screening options.

D. Chillers shall have digital scroll compressor on first stage of cooling.

E. Integral disconnect switch shall be provided.

F. Marine boxes shall be provided where available.

G. All chillers shall have a self-diagnostic monitor.

H. Chiller panels shall be equipped to read and monitor the following:
   1. Entering/leaving chilled water and condenser water temperatures.
   2. Evaporator and condenser refrigerant pressure.
   3. Evaporator and condenser entering/leaving water pressure.
   4. Oil pressure and sump oil temperature.
   5. Motor amperage.
   6. Read faults.

I. Chiller controller shall be capable of recording history of alarms.

J. Chillers shall be provided with a Building Automation System Interface to allow for unit monitoring, control, and display of chiller status and alarms.

1.3 WARRANTY

A. Parts and labor for first 2 years.

1.4 ADDITIONAL WARRANTY

A. 100% service warranty shall be provided for 3 years.
   1. Service shall be per manufacturer’s service recommendations.
   2. Warranty services shall be included in submittals.

1.5 FREEZE PROTECTION

A. Evaporator barrel heater shall be tested for proper operation.
B. Exterior piping located above grade shall have heat tape/tracing installed.
   1. Heat tape/tracing and control system shall be installed in strict accordance with the manufacturer's recommendations.

1.6 INSTALLATION

A. Chillers shall be installed level on concrete equipment pad/slab.
B. Where chillers shall be located on roof, install chillers on structural steel.
C. Chillers installed on structural steel shall have service platforms.
D. Chillers shall be mounted on pad isolators.
E. Adequate clearance for service shall be per manufacturer's instructions for tube pulls, access to electrical panels, etc.
F. Flex connectors shall be used on piping at chiller connections where chillers are located in building or on roof.
G. Pipe vibration hangers shall be used on pipe within 20' of chiller where chillers are located in building or on roof.

1.7 START-UP

A. Start-up shall be conducted and documented by a factory-authorized technician.

End of Section 23 64 00 Chillers

SECTION 23 65 00 – COOLING TOWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Cooling Tower Requirements
   2. Freeze Protection
   3. Start-Up

B. Legend
   1. APS: Atlanta Public Schools
   2. BMS: Building Management System
   3. VFD: Variable Frequency Drive

1.2 GENERAL COOLING TOWER REQUIREMENTS

A. Manufacturer: The following cooling tower manufactures are preferred:
   1. Marley
   2. Evapco
   3. Baltimore Air Coil
   4. Or approved equal by APS Facilities. (Acceptable equals shall be approved by APS prior to purchase and fabrication).

B. Unit shall be provided with VFD.

C. Unit fan design shall be quiet fan technology.

D. Cooling towers shall **NOT** be located under trees or **NEAR** major planting areas and shall be installed at a minimum of 42 inched above grade.

E. The preferred location of the towers is on ground level. Roof location is as a last resort.
   1. Towers shall be located a minimum of 3 feet above pump suction.

F. Provide towers with centrifugal type basin spray nozzle wash down system.

G. Provide Towers with ladders, platforms and hand rails that are supplied by the manufacturer. Ladders must allow access to the top, interior and all basin areas of the tower.

H. Cooling towers shall have manufacturer supplied rigging booms installed with a chain hoist of capacity to raise the cooling tower motor.

I. Make-up water shall be introduced in mechanical plant when possible.

J. Make-up water piping shall have manual bypass around solenoid.

K. Make-up water shall have backflow prevention.

L. Make-up water shall have meter tied to BMS.

M. No tower heat exchangers (closed circuit) are allowed; only mechanical room installed plate frame heat exchangers unless approved by APS.

N. An inside shut-off valve shall be installed at the lowest point on the makeup water piping.

O. Stainless steel cold and hot water basins.

P. Tower ladders and walkways must be provided for servicing the cooling towers. Must be manufacturer installed.

Q. Vibration cutout switch required.

R. Cooling tower shall have basin level controller with high/low alarms.

1.3 FREEZE PROTECTION

A. Immersion heaters shall be Factory installed and connected in tower basins. Provide indicator (Lighted LED or other means) when energized.

B. Heat tape shall be installed on all make-up water piping. Heat tape can be monitored by the BMS but shall be independently controlled by traditional methods.
   1. Heat tape/tracing and control system shall be installed in strict accordance with the manufacturers' recommendations.

C. All exposed piping and underground piping to a depth of 18 inches shall be insulated against freezing to -20 °F (minus 20 degrees).

D. Provide automatic temperature controls for Immersion Heaters. Immersion heaters can be monitored by the BMS but shall be independently controlled by traditional methods.

1.4 START-UP

A. Start-up shall be conducted and documented by a factory-authorized technician.

End of Section 23 65 00 Cooling Towers

SECTION 23 73 00 – INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Packaged Outdoor HVAC Equipment Requirements
   2. Equipment Start-Up

B. Legend
   1. AHU: Air Handling Unit
   2. APS: Atlanta Public Schools
   3. BMS: Building Management System
   4. DDC: Direct Digital Control
   5. LAT: Leaving Air Temperature
   6. OA: Outside Air
   7. PMU: Pad Mounted Unit
   8. RTU: Roof Top Unit
   9. Temp: Temperature
   10. VFD: Variable Frequency Drive

1.2 GENERAL INDOOR CENTRAL-STATION AIR-HANDLING UNIT REQUIREMENTS

A. Manufacturer: The following manufactures are preferred: Trane, York, Daikin, or approved equal by APS Facilities. (Acceptable equals shall be approved by APS prior to purchase and fabrication).

B. All equipment submittals shall include the Noise/Decibels when in maximum load & speed.
   1. Provide information on sound attenuation options.

C. Units shall be direct drive with VFD with plug fans where applicable.

D. Condensate Drain Pans – ASHRAE Standard 62.1 requires the condensate drain pans be designed for self-drainage to preclude buildup of microbial slime. Atlanta Public Schools requires that condensate drain pans on all new equipment with cooling coils be sloped, in two directions, to assure positive drainage. The pans shall be constructed of stainless steel or polymer to resist corrosion and pooling of water. Sprayed foam on drain pans is not acceptable. The surface must be cleanable and not capable of harboring microbial growth. Follow manufacturer's trapping instructions to assure correct drainage under all operating conditions. Exposed internal insulation shall not be used — from the exit of the coil to the downstream end of the drain pan. Provide drain pans under water valves.

E. Cleanable Surfaces – The materials used on the interior of HVAC equipment and air delivery systems shall be cleanable. Porous insulation shall not be used for thermal and acoustical attenuation purposes.

F. Clearance and Access – Sufficient clearance must be provided to allow removal and replacement of filters, coils, fan wheels, bearings and shafts. All areas of the HVAC equipment and duct systems shall be totally accessible for inspection, cleaning and maintenance. Central air handling equipment shall be provided with hinged doors and/or removable panels with tool-less handles. Filter and cooling coils sections shall be equipped with access doors with tool-less handles. Less frequently accessed areas may have removable panels. Access to the ductwork interior shall be provided at areas where dirt is likely to accumulate, such as at turns and before and after any **duct mounted** devices, such as fire dampers. Sufficient clearance must be provided to allow removal and replacement of filters, coils, fan wheels bearings and shafts.

G. Air handling units shall be equipped with heating, cooling, and reheat capabilities.
   1. Compressors shall have at least one (1) inverter scroll compressor for modulating capabilities.
   2. Hot gas reheat shall be modulating form 0-100%.
   3. Gas heat shall be modulating with a minimum of 5:1 turndown.

H. Freeze Protection – **Freeze-Stats** and pre-heat coils shall be installed at mixed-air plenums and outside-air intakes. This system shall be monitored by the DDC system. (Chilled Water)

I. Valves and Drains – Fluid Control Valves and Floor Drains shall be installed at Air Handling Units.
J. Refrigeration system shall comply with requirements of ASHRAE 15 "Safety Standard for Refrigeration Systems." 410A, Factory charged with refrigerant and filled with oil. Inverter scroll or digital scroll compressors mounted of vibration isolators; with internal overcurrent and high temperature protection, internal pressure relief and crankcase heater.
K. Refrigeration System Specialties: Expansion valve with replaceable thermostatic element, Refrigeration Dryer, High-Pressure Switch, Low-Pressure Switch, Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air. Brass service valves installed in discharge and liquid lines. Hot-Gas reheat solenoid valve with a replaceable magnetic coil.
L. Refrigeration System Controls – Unit mounted enthalpy controller shall lock-out refrigerant system when outdoor-air enthalpy is less than 28 Btu/lb of dry air or outdoor-air temperature is less than 60 deg. F. Relative-humidity sensor energizes dehumidifier operation when relative humidity is more than 50 percent (adjustable)
M. Control Dampers – Damper location: factory installed inside unit for ease of blade axle and bushing service. Arrange dampers located in a mixing box to achieve convergent airflow to minimize stratification. Damper leakage: comply with requirements AMCA 500-D. Leakage shall not exceed 6.5 cfm per sq. ft. at a static-pressure differential of 4.0 inches water column when a torque of 5-inch pounds per sq. ft. is applied to the damper jackshaft. Blade Seals: Replaceable, continuous perimeter vinyl seals and jambs with stainless-steel compression – type seals.
N. Mounted Status Panel - Cooling/Off/Heating Controls: Control operational Mode. Damper Position: Indicate position of outdoor – air dampers in terms of percentage of outdoor air. Status Lights: Filter dirty, Fan operating, Cooling operating, Heating operating, General alarm. Digital Numeric Display: Outdoor dry-bulb temperature, Outdoor dew point temperature, Supply temperature, Return air relative humidity.
O. DDC control of the Units. The controls shall enable compressors, modulate wintertime & dehumidification heating, enable/control dehumidifier, start/stop fans, and open/close dampers. The controller shall receive temperature, humidity and scheduling inputs. Using the HVAC equipment providers DDC controller is NOT acceptable with or without an interface (such as Lon, BACnet or Modbus). The AHU graphics shall show all monitoring and control points including but not limited to fan status, compressor status, hot gas reheat status, heating status, mode, wheel status, unit LAT, cooling coil leaving air temperature, supply air temperature, supply air humidity, unit leaving dew point temp, return temp, return dew point, OA temp, and OA dew point.
P. DDC Temperature Control – Standalone control module for link between unit controls and the DDC temperature –control system. Control module shall be compatible with the specified control system. Links shall include, Start/stop interface relay, and relay to notify DDC temperature-control system alarm condition. Hardware interface or additional sensors for, room temperature, discharge-air temperature, refrigeration operating system, furnace operating, constant and variable motor loads, variable frequency-controller operation, cooling load, economizer cycles, air-distribution static pressure and ventilation-air volumes.
Q. BMS Interface – Factory-installed hardware and software to enable the BMS to monitor, control, and display unit status and alarms. Hardware Points – monitor on-off status, common trouble alarm. ASHRAE 135 (BACnet) communication interface with the BMS shall enable the BMS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at the unit control panel shall be available through the BMS.
R. Emergency Shutdown: The unit shall shutdown in response to a contact closure to the DDC system indicating the presence of fire or other emergency condition. Upon fire alarm reset, unit shall return to operating mode. Equipment shall not lock out after multiple fire alarm events.
S. Air Flow stations are required for outside air and return air (where applicable).
T. Duct detectors are required in **BOTH** supply and return for units greater than 2,000 cfm.
U. Tool less door handles must be installed on access doors.
V. Hail guards shall be provided.
W. Units shall not be installed over gym floors.

1.3 EQUIPMENT START-UP

A. Engage a factory-authorized service representative to perform start-up service. The start-up representative shall provide training documentation as part of the submittal process. At no time shall the equipment installation vendor remove the requirement for start-up documentation or warranties by the equipment provider. The installation and start-up checks shall be performed according to the manufacturer written instructions. If the project is commissioned, start-up check requirements shall also be performed as required as stated in the commissioning plan.

B. Inspect units for visible damage to furnace combustion chamber. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the High limit heat exchanger and alarms. Inspect units for visible damage to the refrigerant compressor, condenser and evaporator coils and fans.

C. Start refrigeration system when outdoor-air temperature is within normal operating limits and measure and the record the cooling coil leaving air, dry and wet bulb temperatures, cooling coil entering-air dry and wet bulb temperatures, condenser coil entering-air dry bulb temperature and condenser coil leaving-air dry bulb temperature. Simulate maximum cooling demand and inspect the compressor refrigerant suction & hot gas pressure and short-circulating of air through outside coil to outdoor-air intake. Inspect casing insulation for integrity, moisture content and adhesion, verify all clearances have been provided for servicing, verify that filters are installed, clean coils and inspect for construction debris, inspect and adjust vibration isolators and seismic restraints, verify bearing lubrication, clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding, adjust fan belts to proper alignment and tension, Start unit- inspect outdoor-air dampers for proper stroke and interlock with return-air dampers, verify operational sequence of controls. Measure and record airflows (plot fan volumes on fan curve),-supply-air volume, return-air flow and outdoor-air flow. After start-up – change filters, verify bearing lubrication and adjust tension. Remove and replace components that do not properly operate and repeat start-up.

End of Section 23 73 00 Indoor Central-Station Air-Handling Unit

SECTION 23 74 00 – PACKAGED OUTDOOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Packaged Outdoor HVAC Equipment Requirements
   2. Equipment Start-Up

B. Legend:
   1. APS: Atlanta Public Schools
   2. BMS: Building Management System
   3. DDC: Direct Digital Control
   4. LAT: Leaving Air Temperature
   5. OA: Outside Air
   6. PMU: Pad Mounted Unit
   7. RTU: Roof Top Unit
   8. Temp: Temperature
   9. VFD: Variable Frequency Drive

1.2 GENERAL PACKAGED OUTDOOR HVAC EQUIPMENT REQUIREMENTS

A. Manufacturer: The following manufactures are preferred: Trane, York, Daikin, or approved equal by APS Facilities. (Acceptable equals shall be approved by APS prior to purchase and fabrication).

B. All equipment submittals shall include the Noise/Decibels when in maximum load & speed.
   1. Provide information on sound attenuation options.

C. Equipment submittals shall provide points list equipment will provide to BMS.
   1. Manufacturer shall refer to points list required for project.

D. Units shall be direct drive with VFD.

E. Performance Requirements: Fabrication shall comply with requirements in ASHRAE 62.1, Section 5 – "Systems and Equipment," Section 7 – "Construction and System Start-up." Cabinet Thermal Performance Maximum Overall U-Value shall comply with requirements in ASHRAE/IESNA 90.1. Maximum Overall U-Value 0/10 Btu/h x sq. ft. degree F. The cabinet shall have additional insulation and vapor seals if required tom prevent condensation on the interior and exterior cabinet. Portions of the cabinet located downstream from the cooling coil shall have a thermal break at each thermal bridge between the exterior and interior casings to prevent condensation from occurring on the interior and exterior surfaces. Cabinet construction shall be double wall.

F. Exterior casing shall be fabricated for intended installation purpose ie; if unit is meant to be installed on a curb, do not install on steel with no curb and vice versa.

G. Curbs shall be insulated.

H. 6 layers of Greenboard shall be installed inside curb for sound attenuation.

I. Bead of caulking shall be used on curb seal to prevent curb from leaking.

J. Supply & Exhaust Fans: Plenum Fan Type: Single width, non-overloading, with backward-inclined or airfoil blades.

K. RTU/PMU units shall be equipped with heating, cooling, and reheat capabilities.
   1. Compressors shall have at least one (1) inverter scroll compressor for modulating capabilities.
   2. Hot gas reheat shall be modulating form 0-100%.
   3. Gas heat shall be modulating with a minimum of 5:1 turndown.

L. Refrigeration system shall comply with requirements of ASHRAE 15 "Safety Standard for Refrigeration Systems." 410A, Factory charged with refrigerant and filled with oil. Inverter scroll or digital scroll compressors mounted of vibration isolators; with internal overcurrent and high temperature protection, internal pressure relief and crankcase heater.

M. Refrigeration System Specialties: Expansion valve with replaceable thermostatic element, Refrigeration Dryer, High-Pressure Switch, Low-Pressure Switch, Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air. Brass service valves installed in discharge and liquid lines. Hot-Gas reheat solenoid valve with a replaceable magnetic coil.

N. Refrigeration System Controls – Unit mounted enthalpy controller shall lock-out refrigerant system when outdoor-air enthalpy is less than 28 Btu/lb of dry air (adj.) or outdoor-air temperature is less than 55 deg. F. Relative-humidity sensor energizes dehumidifier operation when relative humidity is more than **60%** percent (adjustable).

O. Control Dampers – Damper location: factory installed inside unit for ease of blade axle and bushing service. Arrange dampers located in a mixing box to achieve convergent airflow to minimize stratification. Damper leakage: comply with requirements AMCA 500-D. Leakage shall not exceed 6.5 cfm per sq. ft. at a static-pressure differential of 4.0 inches water column when a torque of 5 inch pounds per sq. ft. is applied to the damper jackshaft. Blade Seals: Replaceable, continuous perimeter vinyl seals and jambs with stainless-steel compression – type seals.

P. Mounted Status Panel - Cooling/Off/Heating Controls: Control operational Mode. Damper Position: Indicate position of outdoor – air dampers in terms of percentage of outdoor air. Status Lights: Filter dirty, Fan operating, Cooling operating, Heating operating, General alarm. Digital Numeric Display: Outdoor dry-bulb temperature, Outdoor dew point temperature, Supply temperature, Return air relative humidity.

Q. DDC control of the Units. The controls shall enable compressors, modulate wintertime & dehumidification heating, enable/control dehumidifier, start/stop fans, and open/close dampers. The controller shall receive temperature, humidity and scheduling inputs. Using the HVAC equipment providers DDC controller is NOT acceptable with or without an interface (such as Lon, BACnet or Modbus). The RTU/PMU graphics shall show all monitoring and control points including but not limited to fan status, compressor status, hot gas reheat status, heating status, mode, wheel status, unit LAT, cooling coil leaving air temperature, supply air temperature, supply air humidity, unit leaving dew point temp, return temp, return dew point, OA temp, and OA dew point.

R. DDC Temperature Control – Standalone control module for link between unit controls and the DDC temperature –control system. Control module shall be compatible with the specified control system. Links shall include, Start/stop interface relay, and relay to notify DDC temperature-control system alarm condition. Hardware interface or additional sensors for, room temperature, discharge-air temperature, refrigeration operating system, furnace operating, constant and variable motor loads, variable frequency-controller operation, cooling load, economizer cycles, air-distribution static pressure and ventilation-air volumes.

S. BMS Interface – Factory-installed hardware and software to enable the BMS to monitor, control, and display unit status and alarms. Hardware Points – monitor on-off status, common trouble alarm. ASHRAE 135 (BACnet) communication interface with the BMS shall enable the BMS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at the unit control panel shall be available through the BMS.

T. Emergency Shutdown: The unit shall shutdown in response to a contact closure to the DDC system indicating the presence of fire or other emergency condition. Upon fire alarm reset, unit shall return to operating mode. Equipment shall not lock out after multiple fire alarm events.

U. Air Flow stations are required for outside air and return air (where applicable).

V. Duct detectors are required in **BOTH** supply and return for units greater than 2,000 cfm.

W. Tool less door handles must be installed on access doors.

X. Hail guards shall be provided.

Y. Units shall not be installed over gym floors

1.3 EQUIPMENT START-UP

A. Engage a factory-authorized service representative to perform start-up service. The start-up representative shall provide training documentation as part of the submittal process. At no time shall the equipment installation vendor remove the requirement for start-up documentation or warranties by the equipment provider. The installation and start-up checks shall be performed according to the manufacturer written instructions. If the project is commissioned, start-up check requirements shall also be performed as required as stated in the commissioning plan.

B. Inspect units for visible damage to furnace combustion chamber. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the High limit heat exchanger and alarms. Inspect units for visible damage to the refrigerant compressor, condenser and evaporator coils and fans.

C. Start refrigeration system when outdoor-air temperature is within normal operating limits and measure and the record the cooling coil leaving air, dry and wet bulb temperatures, cooling coil entering-air dry and wet bulb temperatures, condenser coil entering-air dry bulb temperature and condenser coil leaving-air dry bulb temperature. Simulate maximum cooling demand and inspect the compressor refrigerant suction & hot gas pressure and short-circulating of air through outside coil to outdoor-air intake. Inspect casing insulation for integrity, moisture content and adhesion, verify all clearances have been provided for servicing, verify that filters are installed, clean coils and inspect for construction debris, inspect and adjust vibration isolators and seismic restraints, verify bearing lubrication, clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding, adjust fan belts to proper alignment and tension, Start unit- inspect outdoor-air dampers for proper stroke and interlock with return-air dampers, verify operational sequence of controls. Measure and record airflows (plot fan volumes on fan curve),-supply-air volume, return-air flow and outdoor-air flow. After start-up – change filters, verify bearing lubrication and adjust tension. Remove and replace components that do not properly operate and repeat start-up.

End of Section 23 74 00 Packaged Outdoor HVAC Equipment

SECTION 23 74 33 – DEDICATED OUTDOOR AIR UNITS AND ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Dedicated Outdoor Air and Energy Recovery Unit Requirements
   2. General Split Dedicated Outdoor Air Unit Requirements
   3. Equipment Start-Up

B. Legend
   1. APS: Atlanta Public Schools
   2. BMS: Building Management System
   3. DDC: Direct Digital Control
   4. DOAS: Dedicated Outdoor Air System
   5. ERU: Energy Recovery Unit
   6. LAT: Leaving Air Temperature
   7. OA: Outside Air
   8. PMU: Pad Mounted Unit
   9. RTU: Roof Top Unit
   10. Temp: Temperature
   11. VFD: Variable Frequency Drive

1.2 GENERAL DEDICATED OUTDOOR AIR AND ENERGY RECOVERY UNIT REQUIREMENTS

A. Manufacturer: The following manufactures are preferred: Trane, Carrier, Annexair, Greenheck, Aaon, Daikin, Munters, or approved equal by APS Facilities. (Acceptable equals shall be approved by APS prior to purchase and fabrication).

B. All equipment submittals shall include the Noise/Decibels when in maximum load & speed.
   1. Provide information on sound attenuation options.

C. Equipment submittals shall provide points list equipment will provide to BMS.
   1. Manufacturer shall refer to points list required for project.

D. Units shall be direct drive with VFD.

E. Performance Requirements: Fabrication shall comply with requirements in ASHRAE 62.1, Section 5 – "Systems and Equipment," Section 7 – "Construction and System Start-up." Cabinet Thermal Performance Maximum Overall U-Value shall comply with requirements in ASHRAE/IESNA 90.1. Maximum Overall U-Value 0/10 Btu/h x sq. ft. degree F. The cabinet shall have additional insulation and vapor seals if required to prevent condensation on the interior and exterior cabinet. Portions of the cabinet located downstream from the cooling coil shall have a thermal break at each thermal bridge between the exterior and interior casings to prevent condensation from occurring on the interior and exterior surfaces. Cabinet construction shall be double wall.

F. Curbs shall be insulated.

G. 6 layers of Greenboard shall be installed inside curb for sound attenuation.

H. Bead of caulking shall be used on curb seal to prevent curb from leaking.

I. Supply & Exhaust Fans: Plenum Fan Type: Single width, non-overloading, with backward-inclined or airfoil blades.

J. DOAS/ERU units shall be equipped with heating, cooling, and reheat capabilities.
   1. Compressors shall have at least one (1) inverter scroll compressor for modulating capabilities.
   2. Hot gas reheat shall be modulating form 0-100%.
   3. Gas heat shall be modulating with a minimum of 5:1 turndown.

K. Refrigeration system shall comply with requirements of ASHRAE 15 "Safety Standard for Refrigeration Systems." 410A, Factory charged with refrigerant and filled with oil. Inverter scroll or digital scroll compressors mounted of vibration isolators; with internal overcurrent and high temperature protection, internal pressure relief and crankcase heater.

L. Refrigeration System Specialties: Expansion valve with replaceable thermostatic element, Refrigeration Dryer, High-Pressure Switch, Low-Pressure Switch, Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air. Brass service valves installed in discharge and liquid lines. Hot-Gas reheat solenoid valve with a replaceable magnetic coil.

M. Refrigeration System Controls – Unit mounted enthalpy controller shall lock-out refrigerant system when outdoor-air enthalpy is less than 28 Btu/lb of dry air (adj.) or outdoor-air temperature is less than 55 deg. F. Relative-humidity sensor energizes dehumidifier operation when relative humidity is more than **60%** percent (adjustable).

N. Enthalpy wheels: Casing shall be steel with factory-painted finish; integral purge section limiting carryover of exhaust air between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg differential pressure; casing seals on periphery of rotor and on duct divider and purge section; support vertical rotors on grease-lubricated ball bearings having extended grease fittings or permanently lubricated bearings. Support horizontal rotors on tapered roller bearings.

O. Control Dampers – Damper location: factory installed inside unit for ease of blade axle and bushing service. Arrange dampers located in a mixing box to achieve convergent airflow to minimize stratification. Damper leakage: comply with requirements AMCA 500-D. Leakage shall not exceed 6.5 cfm per sq. ft. at a static-pressure differential of 4.0 inches water column when a torque of 5 inch pounds per sq. ft. is applied to the damper jackshaft. Blade Seals: Replaceable, continuous perimeter vinyl seals and jambs with stainless-steel compression – type seals.

P. Mounted Status Panel - Cooling/Off/Heating Controls: Control operational Mode. Damper Position: Indicate position of outdoor – air dampers in terms of percentage of outdoor air. Status Lights: Filter dirty, Fan operating, Cooling operating, Heating operating, General alarm. Digital Numeric Display: Outdoor dry-bulb temperature, Outdoor dew point temperature, Supply temperature, Return air relative humidity.

Q. DDC control of the Units. The controls shall enable compressors, modulate wintertime & dehumidification heating, enable/control dehumidifier, start/stop fans, and open/close dampers. The controller shall receive temperature, humidity and scheduling inputs. Using the ERU equipment providers DDC controller is NOT acceptable with or without an interface (such as Lon, BACnet or Modbus). The DOAS/ERU graphics shall show all monitoring and control points including but not limited to fan status, compressor status, hot gas reheat status, heating status, mode, wheel status, unit LAT, cooling coil leaving air temperature, supply air temperature, supply air humidity, unit leaving dew point temp, return temp, return dew point, OA temp, and OA dew point.

R. DDC Temperature Control – Standalone control module for link between unit controls and the DDC temperature –control system. Control module shall be compatible with the specified control system. Links shall include, Start/stop interface relay, and relay to notify DDC temperature-control system alarm condition. Hardware interface or additional sensors for, room temperature, discharge-air temperature, refrigeration operating system, furnace operating, constant and variable motor loads, variable frequency-controller operation, cooling load, economizer cycles, air-distribution static pressure and ventilation-air volumes.

S. BMS Interface – Factory-installed hardware and software to enable the BMS to monitor, control, and display unit status and alarms. Hardware Points – monitor on-off status, common trouble alarm. ASHRAE 135 (BACnet) communication interface with the BMS shall enable the BMS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at the unit control panel shall be available through the BMS.

T. Emergency Shutdown: The unit shall shutdown in response to a contact closure to the DDC system indicating the presence of fire or other emergency condition. Upon fire alarm reset, unit shall return to operating mode. Equipment shall not lock out after multiple fire alarm events.

U. Air Flow stations are required for outside air and return air (where applicable).

V. Duct detectors are required in **BOTH** supply and return for units greater than 2,000 cfm.

W. Wheel bypass dampers are required.

X. No recirculation dampers where exhaust is coming from toilet rooms.

Y. Tool less door handles must be installed on access doors.

Z. Hail guards shall be provided.

Z1a. Units shall not be installed on roof over gym floors

1.3 GENERAL SPLIT DEDICATED OUTDOOR AIR UNIT REQUIREMENTS

A. Manufacturer: The following manufactures are preferred: Trane, Carrier, Annexair, Greenheck, Aaon, Daikin, Munters, or approved equal by APS Facilities. (Acceptable equals shall be approved by APS prior to purchase and fabrication).

B. All equipment submittals shall include the Noise/Decibels when in maximum load & speed.
   1. Provide information on sound attenuation options.

C. Units shall be direct drive with VFD.

D. Performance Requirements: Fabrication shall comply with requirements in ASHRAE 62.1, Section 5 – "Systems and Equipment," Section 7 – "Construction and System Start-up." Cabinet Thermal Performance Maximum Overall U-Value shall comply with requirements in ASHRAE/IESNA 90.1. Maximum Overall U-Value 0/10 Btu/h x sq. ft. degree F. The cabinet shall have additional insulation and vapor seals if required to prevent condensation on the interior and exterior cabinet. Portions of the cabinet located downstream from the cooling coil shall have a thermal break at each thermal bridge between the exterior and interior casings to prevent condensation from occurring on the interior and exterior surfaces. Cabinet construction shall be double wall.

E. Supply & Exhaust Fans: Plenum Fan Type: Single width, non-overloading, with backward-inclined or airfoil blades.

F. DOAS units shall be equipped with heating, cooling, and reheat capabilities.
   1. Compressors shall have at least one (1) inverter scroll compressor for modulating capabilities.
   2. Hot gas reheat shall be modulating form 0-100%.
   3. Gas heat shall be modulating with a minimum of 5:1 turndown. (Where Applicable)
   4. Electric heat shall have SCR controllers.
   5. Unit may also be a heat pump.

G. Refrigeration system shall comply with requirements of ASHRAE 15 "Safety Standard for Refrigeration Systems." 410A, Factory charged with refrigerant and filled with oil. Inverter scroll or digital scroll compressors mounted of vibration isolators; with internal overcurrent and high temperature protection, internal pressure relief and crankcase heater.

H. Refrigeration System Specialties: Expansion valve with replaceable thermostatic element, Refrigeration Dryer, High-Pressure Switch, Low-Pressure Switch, Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air. Brass service valves installed in discharge and liquid lines. Hot-Gas reheat solenoid valve with a replaceable magnetic coil.

I. Refrigeration System Controls – Unit mounted enthalpy controller shall lock-out refrigerant system when outdoor-air enthalpy is less than 28 Btu/lb of dry air (adj.) or outdoor-air temperature is less than 55 deg. F. Relative-humidity sensor energizes dehumidifier operation when relative humidity is more than **60%** percent (adjustable).

J. DDC control of the Units. The controls shall enable compressors, modulate wintertime & dehumidification heating, enable/control dehumidifier, start/stop fans, and open/close dampers. The controller shall receive temperature, humidity and scheduling inputs. Using the ERU equipment providers DDC controller is NOT acceptable with or without an interface (such as Lon, BACnet or Modbus). The DOAS graphics shall show all monitoring and control points including but not limited to fan status, compressor status, hot gas reheat status, heating status, mode, unit LAT, cooling coil leaving air temperature, supply air temperature, supply air humidity, unit leaving dew point temp, OA temp, and OA dew point.

K. DDC Temperature Control – Standalone control module for link between unit controls and the DDC temperature –control system. Control module shall be compatible with the specified control system. Links shall include, Start/stop interface relay, and relay to notify DDC temperature-control system alarm condition. Hardware interface or additional sensors for, room temperature, discharge-air temperature, refrigeration operating system, furnace operating, constant and variable motor loads, variable frequency-controller operation, cooling load, economizer cycles, air-distribution static pressure and ventilation-air volumes.

L. BMS Interface – Factory-installed hardware and software to enable the BMS to monitor, control, and display unit status and alarms. Hardware Points – monitor on-off status, common trouble alarm. ASHRAE 135 (BACnet) communication interface with the BMS shall enable the BMS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at the unit control panel shall be available through the BMS.

M. Emergency Shutdown: The unit shall shutdown in response to a contact closure to the DDC system indicating the presence of fire or other emergency condition. Upon fire alarm reset, unit shall return to operating mode. Equipment shall not lock out after multiple fire alarm events.

N. Air Flow stations are required for outside air.

O. Duct detector is required for supply ductwork.

P. Tool less door handles must be installed on access doors/panels.

Q. No recirculation dampers where exhaust is coming from toilet rooms.

R. Hail guards shall be provided.

S. Units shall not be installed over gym floors.

1.4 EQUIPMENT START-UP

A. Engage a factory-authorized service representative to perform start-up service. The start-up representative shall provide training documentation as part of the submittal process. At no time shall the equipment installation vendor remove the requirement for start-up documentation or warranties by the equipment provider. The installation and start-up checks shall be performed according to the manufacturer written instructions. If the project is commissioned, start-up check requirements shall also be performed as required as stated in the commissioning plan.

B. Inspect units for visible damage to furnace combustion chamber. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the High limit heat exchanger and alarms. Inspect units for visible damage to the refrigerant compressor, condenser and evaporator coils and fans.

C. Start refrigeration system when outdoor-air temperature is within normal operating limits and measure and the record the cooling coil leaving air, dry and wet bulb temperatures, cooling coil entering-air dry and wet bulb temperatures, condenser coil entering-air dry bulb temperature and condenser coil leaving-air dry bulb temperature. Simulate maximum cooling demand and inspect the compressor refrigerant suction & hot gas pressure and short-circulating of air through outside coil to outdoor-air intake. Inspect casing insulation for integrity, moisture content and adhesion, verify all clearances have been provided for servicing, verify that filters are installed, clean coils and inspect for construction debris, inspect and adjust vibration isolators and seismic restraints, verify bearing lubrication, clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding, adjust fan belts to proper alignment and tension, Start unit- inspect outdoor-air dampers for proper stroke and interlock with return-air dampers, verify operational sequence of controls. Measure and record airflows (plot fan volumes on fan curve),-supply-air volume, return-air flow and outdoor-air flow. After start-up – change filters, verify bearing lubrication and adjust tension. Remove and replace components that do not properly operate and repeat start-up.

End of Section 23 74 33 Dedicated Outdoor Air Units and Energy Recovery Units

SECTION 23 81 26 – SPLIT-SYSTEM AIR CONDITIONERS (MINI-SPLITS)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Split-System Air Conditioners Requirements
   2. Additional Warranty

B. Legend
   1. APS: Atlanta Public Schools
   2. BMS: Building Management System

1.2 SPLIT-SYSTEM AIR CONDITIONERS REQUIREMENTS

A. The following manufacturers are approved for use:
   1. Daikin
   2. Trane
   3. Mitsubishi
   4. Samsung
   5. Or approved by APS.

B. Indoor Unit
   1. Condensate Overflow shut down shall be provided.
   2. Drain pan shall be provided.
   3. Drain hose shall be provided.
   4. Condensate pump shall be included.

C. Outdoor unit
   1. Compressor shall be scroll and variable speed.
   2. Motor shall be permanently lubricated with thermal overload protection.
   3. Unit shall have low ambient kit to allow for operation down to 0 °F.
   4. Heat pump unit shall have reversing valve and low temperature air cut off switch.

D. Units shall be secured to structure.

E. Space temperature shall be monitored by BMS.

F. Disconnect switch shall be provided integral to unit or separately mounted on building structure.

G. Start-up shall be performed per manufacturer’s instructions and documented.

1.3 ADDITIONAL WARRANTY

A. Compressor shall have a 5-year warranty from date of beneficial occupancy.

End of Section 23 81 26 Split System Air Conditioners

SECTION 23 81 29 – VARIABLE REFRIGERANT FLOW SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Variable Refrigerant Flow System Requirements
   2. Outdoor Unit Requirements
   3. Refrigerant Circuit Controller/Selector Requirements
   4. Indoor Unit Requirements
   5. Refrigerant Piping Testing Requirements
   6. Start-Up Requirements

B. Legend
   1. APS: Atlanta Public Schools
   2. VRF: Variable Refrigerant Flow
   3. VRFC: Variable Refrigerant Fan Coil

1.2 GENERAL VARIABLE REFRIGERANT FLOW SYSTEM REQUIREMENTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following who supply VRF Equipment: Three pipe systems are preferred.
   1. Daikin
   2. Mitsubishi
   3. Trane

B. The system shall be a variable capacity, split heat pump heat recovery air conditioning system capable of simultaneous cooling and heating.

C. The manufacturer supplied control system shall be capable of supporting remote controllers, schedule timers, system controllers, centralized controllers, an integrated web-based interface, graphical user workstation, and system integration to Building Management Systems via BACnet®.

D. Central controllers and BACNet interfaces shall be housed in dustproof enclosure rated for operation at 32 to 120 °F.

E. VRF control system shall have surge protection and battery back-up. All Central Controls shall be installed in a cabinet.

F. Individual room controllers shall have end-user lock-outs based upon APS direction at time of installation.

G. All refrigerant pipe shall be insulated. The insulation shall be labeled to indicate service. The service shall not be referred to or have in the description as simply “Gas”.

H. Refrigerant pipe insulation located outside shall have aluminum or metal jacketing.

1.3 OUTDOOR UNIT REQUIREMENTS

A. Outdoor units shall have hail guards, no exceptions.

B. All units shall be installed in a way such that refrigerant pipe, electrical wiring, and controls wiring does not block maintenance panels, no exceptions.

C. Units shall be installed on equipment rails, Big Foot System or equivalent approved by APS.

D. Condenser refrigerant piping, electrical power and control conduit for typical Split Systems and the Variable Refrigerant Flow systems shall make use of a Piping Chase for piping penetrations where installed on roof.

E. The Chase penetrations shall be sealed using compression type fittings. No services shall penetrate the top of the chase.
   1. Pipe penetrations through roof shall have an insulated weather-proof chase housing with curb and seals. Alta Products, LLC Pipe Chase Housing, Alta Curb, and Exit Seals or equivalent (as approved by APS) shall be installed.
   2. Pitch Pockets shall not be used.
   3. Units shall not be installed over gym floors

F. VRF Refrigerant piping shall be neatly racked using strut channel and pipe clamps supported by equipment support stand or setting on non-penetrative stands/blocks.
   1. Pipe clamps shall be of the type that allows for insulation to be continuous through clamp.
   2. Piping shall be installed to allow for access to condensers.
   3. In no case shall multiple refrigerant piping be installed in a single clevis type hanger.

1.4 REFRIGERANT CIRCUIT CONTROLLER/SELECTOR REQUIREMENTS

A. There shall be a minimum of one (1) spare port per unit.
B. Units shall be suspended using all-thread rod.
C. Full port isolation valves shall be installed.

1.5 INDOOR UNIT REQUIREMENTS

A. Below ceiling suspended units (See Daikin VRV FXHQ and all other similar products) shall not be used.
B. Units shall be suspended using all-thread rod.
   1. In areas where all-thread rod is exposed to occupants, rod shall be covered with a decorative covering approved by APS. Color of covering shall be approved by APS as well.
C. The last 6 feet of refrigerant pipe run at indoor unit shall be soft copper.
D. Isolation valves are required on refrigerant piping (both leaving and entering) within 3 feet of indoor unit.
E. Condensate cleanout shall be provided at each indoor unit.
F. Condensate lines must be insulated.
G. Units that are not recessed cassettes (VRFCs installed recessed in ceiling grid) shall be provided with vibration isolators.
H. Third-Party humidity sensors shall be installed for room and corridor units.
   1. Corridor cassettes should have area humidity sensors to enable dry mode per cluster. Humidity sensors should be installed in corridor 8’ high.
   2. Restroom units shall not have humidity sensors.
I. Spare washable filters shall be included with each unit.
J. Units shall not be installed over gym floors

1.6 TESTING REQUIREMENTS

A. Technician performing piping tests (pressure and vacuum testing) shall have completed equipment manufacturers training and provide proof of training.
B. Refrigerant piping shall be tested based upon the following:
   1. Pressure (3 steps)
      a. Step 1. A pressure of 150 psi is applied for 3 min. If there are no indications of leaks continue to step 2.
      b. Step 2. A pressure of 325 psi is applied for 5 minutes. If there are no indications of leaks continue to step 3.
      c. Step 3. A pressure of 550 psi is applied for 24 hours. If there are no indications of a leak, vacuum test can then be started.
   2. Vacuum
      a. Evacuate the piping to 4,000 microns and hold for 15 minutes. Break the vacuum with dry nitrogen to a level of 2-3 psig.
      b. Evacuate the system to 1,500 microns and hold for 20 minutes. Break the vacuum with dry nitrogen to a level of 2-3 psig.
      c. Evacuate the system to 500 microns or less. (Should not be lower than 400 microns). Microns should hold for 1 hour. If there is a rise in microns of over 30 microns, redo vacuum test.
      d. If system has been rested and system still cannot pass, system should be checked for leaks.
C. If equipment manufacturer has an alternate testing procedure, contractor may use the alternate on approval by APS.

D. Times, temperature, and pictures of gauges must be taken, recorded and submitted to APS. Any manufacturer testing documentation must be filled out and submitted as well.
E. Digital micron gauge is required for vacuum testing.
F. Digital micron gauge is required for vacuum testing.
G. If the outdoor temperature is variable, use (Tp –Tc) x 0.80 to calculate the temperature drop for pressure testing. (Tp is the temperature when system is pressurized and Tc is the temperature when the pressure is checked).
H. System Operation Endurance Test: The system shall be placed in cooling for one hour and then into heating for one hour, this process shall be performed three (3) times. If any issues occur, they should be corrected/fixed.

1.7 START-UP REQUIREMENTS

A. Engage a factory-employed service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions. Provide documentation of Certification.

End of Section 23 81 29 Variable Refrigerant Flow Systems

SECTION 23 81 46 – WATER SOURCE HEAT PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Water Source Heat Pump Requirements
   2. Water Source Heat Pumps Located in Corridor or Mezzanine
   3. Water Source Heat Pumps Located in Classroom
   4. Start-Up

B. Legend
   1. APS: Atlanta Public Schools
   2. OA: Outside Air
   3. T&P: Temperature and Pressure

1.2 GENERAL WATER SOURCE HEAT PUMP REQUIREMENTS

A. Manufacturer: The following water source heat pump manufactures are preferred:
   1. Trane
   2. Carrier
   3. Daikin
   4. Or approved equal by APS Facilities. (Acceptable equals shall be approved by APS prior to purchase and fabrication).

B. Dehumidification: Units serving Auditoriums, Music Rooms, Art Rooms, Special Needs, Safe Rooms, Book Storage, Cafeterias and Media Centers shall use dx reheat.

C. Where possible, CO_2 demand based ventilation shall be utilized where possible when units pull OA directly from the exterior of the building (not provided by an ERU/DOAS). In this case, modulating OA dampers shall be installed.

D. Condensate pumps shall not be utilized if possible; gravity preferred.

E. Provide units with Factory Furnished hose kit assemblies. The supply hose kit shall be provided with full port ball valves, balancing ports, unions & strainer. The return hose kit shall be provided with a full port valve and union.

F. Isolation control valves shall cycle with compressor.
   1. Valves shall open in time for unit to start and the valve shall close allowing sufficient time to remove heat from condenser.

G. T&P test ports/plugs shall be installed in pipe on both entering and leaving sides of the coil.

H. Manual air vents shall be installed at high point of coil.

1.3 WATER SOURCE HEAT PUMPS LOCATED IN CORRIDOR or MEZZANINE

A. Individual room water source heat pump/unit ventilators located on Mezzanine above corridors.
   1. Distributes conditioned air to classrooms, using hard ducts above the ceiling, to room diffusers. (flex duct can only be used for the last six (6) or eight (8) feet is acceptable
   2. Condensate drain piping from each unit shall be trapped and connected to a condensate main. All condensate traps shall have cleanouts.
   3. In no circumstances shall condensate piping be discharged through the exterior wall at each unit location, unless into a dry well or piping drainage system.
   4. Secondary drain pan overflow lines shall barely extend through ceiling.
   5. All units shall be serviceable from a ladder staged below the suspended ceiling height. In no case shall the removal of the ceiling be required to service unit.
   6. All units shall have a minimum of 3 feet clearance for maintenance and enough space for compressor and blower motor removal.
   7. Provide means of access for maintenance and unit removal for hard ceiling mounted units.
   8. Provide adequate clearance for filter removal.
   9. Provide filter racks and access doors.

1.4 WATER SOURCE HEAT PUMPS LOCATED IN CLASSROOM

A. Individual room water source heat pump/unit ventilators located inside mechanical closets in the classrooms.
   1. All Units shall be serviceable in mechanical closets. Provide double doors if required to allow for room for service. Units shall be installed on platform, a minimum of 24" high.
   2. All units shall have secondary drain pans.
   3. All units shall have minimum of 3 feet clearance for maintenance or enough space for compressor and blower motor removal.
   4. Provide adequate clearance for filter removal.
   5. Provide filter racks and access doors.

1.5 START-UP

A. Start-up shall be conducted and documented by a factory-authorized technician.

End of Section 23 81 46 Water Source Heat Pumps

SECTION 23 82 16 – AIR HEATING COILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Hydronic Air Heating Coils Requirements
   2. Electric Resistance Air Heating Coils Requirements

B. Legend:
   1. APS: Atlanta Public Schools
   2. EOR: Engineer of Record
   3. SCR: Silicon-Controlled Rectifier
   4. T&P: Temperature and Pressure

1.2 HYDRONIC AIR HEATING COILS REQUIREMENTS

A. The following manufacturers are approved for use:
   1. Trane
   2. JCI
   3. Carrier
   4. Greenheck
   5. Or approved by APS.

B. Coil fins shall be copper aluminum.

C. Manual air vents shall be installed at high point of coil.

D. T&P ports shall be installed on entering and leaving coil.

E. Circuit setter balancing valve to be installed on return side leaving control valve.

F. Strainer with full port ball valve for blowdown and hose end with cap shall be installed on supply side of coil.

G. Coil shall be connected to pipe with unions.
   1. Dielectric unions shall be used at connections of dissimilar metals.

H. A modulating control valve shall be installed where required.

I. 3-way or 2-way valves shall be installed based upon piping design.

J. Access panels for maintenance of coils shall be provided in ceiling and ductwork.
   1. Coils shall be isolated during system flush. Provide temporary coil by-pass.

1.3 ELECTRIC RESISTANCE AIR HEATING COILS REQUIREMENTS

A. The following manufacturers are approved for use:
   1. Berko
   2. Chromalox, Inc.
   3. Marley
   4. Nailor
   5. Q-Mark
   6. TPI Corporation
   7. Indeeco
   8. Or approved by APS.

B. Heating elements shall be open-coil resistance wire of 80/20 nickel/chromium.

C. Electric coils shall be equipped with:
   1. High temperature coil protection
      a. Automatically reset, thermal-cutout, safety device that is serviceable through terminal box without removing heater from duct or casing.
      b. Secondary protections shall include load-carrying, manually reset or manually replaceable, thermal cutouts that is factory wired in series with each heater stage.
   2. Magnetic contactor
   3. Prefer SCR Controller or not preferred multistage controller for heaters greater than 5 kW.
   4. Time-delay relay

5. Airflow Proving Switch
6. External disconnect mounted to structure.

D. Access panels for maintenance of coils shall be provided in ceiling and ductwork.

E. Coils shall be tested, adjusted, and safeties tested. Documentation shall be provided to EOR and APS.

End of Section 23 82 16 Air Heating Coils

SECTION 23 82 19 – FAN COIL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Hydronic Fan Coil Requirements
   2. Electric Heat for FCU Requirements
   3. Testing FCU Requirements

B. Legend:
   1. APS: Atlanta Public Schools
   2. ECM: Electronically Commutated Motor
   3. EOR: Engineer of Record
   4. SCR: Silicon-Controlled Rectifier
   5. T&P: Temperature and Pressure

1.2 HYDRONIC FAN COIL UNIT REQUIREMENTS

A. The following manufacturers are approved for use:
   1. Trane
   2. JCI
   3. Carrier
   4. Daikin
   5. Or approved by APS.

B. Fan motors shall be ECM motors with variable speed controllers and thermal overload protection.

C. Units shall have condensate overflow detection switch (float switch).

D. Secondary drain pans shall be installed beneath unit.

E. FCU shall have vibration isolation.

F. Coil fins shall be copper aluminum.

G. Manual air vents shall be installed at high point of coil.

H. T&P ports shall be installed on entering and leaving coil.

I. Circuit setter balancing valve to be installed on return side leaving control valve.

J. Strainer with full port ball valve for blowdown and hose end with cap shall be installed on supply side of coil.

K. Coil shall be connected to pipe with unions.
   1. Dielectric unions shall be used at connections of dissimilar metals.

L. A modulating control valve shall be installed where required.

M. 3-way or 2-way valves shall be installed based upon piping design.

N. Access panels for maintenance of coils shall be provided in ceiling and ductwork.
   1. Coils shall be isolated during system flush. Provide temporary coil by-pass.

O. Unit shall have filter box with leak free access door.

P. Controller shall be provided by manufacturer or Control Company.

1.3 ELECTRIC HEAT FOR FCU REQUIREMENTS

A. Heating elements shall be open-coil resistance wire of 80/20 nickel/chromium.

B. Electric coils shall be equipped with:
   1. High temperature coil protection
      a. Automatically reset, thermal-cutout, safety device that is serviceable through terminal box without removing heater from duct or casing.
      b. Secondary protections shall include load-carrying, manually reset or manually replaceable, thermal cutouts that is factory wired in series with each heater stage.
   2. Magnetic contactor
   3. Prefer SCR Controller or not preferred multistage controller for heaters greater than 5 kW.
   4. Time-delay relay
   5. Airflow Proving Switch

6. External disconnect mounted to structure.

C. Access panels for maintenance of coils shall be provided in ceiling.

1.4 TESTING FCU REQUIREMENTS

A. Fan coil unit shall be tested and documentation provided to APS and EOR.

End of Section 23 82 19 Fan Coil Units

SECTION 23 82 39 – UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. General Unit Heater Requirements
B. Legend
   1. APS: Atlanta Public Schools
   2. BMS: Building Management System
   3. UH: Unit Heater

1.2 GENERAL UNIT HEATER REQUIREMENTS

A. Unit heaters serving rest rooms corridors and stairwells shall be ceiling type with grille matching ceiling color or as determined by APS.
B. Unit heaters serving rest rooms & stairwells shall have an integral thermostat set to 60 °F.
C. Unit heaters serving mechanical and storage rooms shall have a thermostat on wall monitored by BMS.
   1. Integral thermostat shall be back-up and set to 60 °F.
D. Units shall be provided with thermal overload protection.
E. Disconnect switch shall be provided integral to unit or separately mounted on building structure.
F. All heaters shall be installed level and plumb.
G. Start-up shall be performed and documented.

End of Section 23 82 39 Unit Heaters