NEW CASTLE COUNTY
VO-TECH SCHOOL DISTRICT

PAUL M. HODGSON
VOCATIONAL TECHNICAL HIGH SCHOOL

2575 Glasgow Avenue, Newark, DE 19702

PROJECT MANUAL

BSA+A PROJECT #22.011

Contract No. NCC2401D

Volume 4
Division 23

BID PACKAGE D – BUILDING ENVELOPE AND FIT OUT
ISSUE FOR BID – ADDENDUM #1

December 28, 2023

ABHA | BSA+A

PROJECT MANUAL

NEW CASTLE COUNTY VO-TECH SCHOOL DISTRICT

PAUL M. HODGSON VOCATIONAL-TECHNICAL HIGH SCHOOL

Contract No. NCC2401D

OWNER
New Castle County Vo-Tech School District
1417 Newport Rd
Wilmington, DE 19804
(302) 995.8000
fax (302) 995.1579

ARCHITECT
ABHA|BSA+A, LLC
1621 North Lincoln St.
Wilmington, DE 19801
(302) 658.6426
(302) 658.9300
Fax (302) 658.8431

CONSTRUCTION MANAGER
EDiS Company
110 South Poplar St., Suite 400
Wilmington, DE 19801
(302) 421.2973

CIVIL ENGINEER
Landmark Science & Engineering
200 Continental Dr., Suite 400
Newark, DE 19713
(302) 323.9377

STRUCTURAL ENGINEER
DCI Engineers
2 Mill Road, Suite 100
Wilmington, DE 19806
(302) 252.9200
Fax (302) 252.9201

MECHANICAL/ELECTRICAL/ PLUMBING ENGINEER
Gipe Associates, Inc.
8719 Brooks Drive
Easton, MD 21601
(410) 822.8688

FOOD SERVICE CONSULTANT
Corsi Associates, LLC
300 Smith St.
Farmingdale, NY 11735
(610) 888.1955

THEATER CONSULTANT
Stages Consultants, LLC
300 Raritan Ave 2nd Floor
Highland Park, NJ 08904
(732) 333.8003

ACOUSTICAL CONSULTANT
Acentech
620 W. Germantown Pike, Suite 210
Plymouth Meeting, PA 19462
(215) 245.8244

SECURITY/TECHNOLOGY CONSULTANT
Educational Systems Planning
2448 Holly Avenue, Suite 302
Annapolis, MD 21401
(410) 573.9148

ISSUE FOR BID
December 28, 2023

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SEALS PAGE

DESIGN PROFESSIONALS OF RECORD

Architect
ABHA|BSA+A, LLC
1621 North Lincoln St.
Wilmington, DE 19801
(302) 658.6426
(302) 658.9300

Civil Engineer
Landmark Science & Engineering
200 Continental Dr., Suite 400
Newark, DE 19713
(302) 323.9377

Structural Engineer
DCI Engineers
2 Mill Road, Suite 100
Wilmington, DE 19806
302-252-9200

MEP-FP Engineer
Gipe Associates
8719 Brooks Drive
Easton, MD 21601
(410) 822-8688

END OF SECTION

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The following previously issued Bid Package documentation is included by reference:
BPB Sitework and Utilities dated 25 May 23
BPB Addendum #1 dated 1 Aug 23
BPB Addendum #2 dated 7 Aug 23
BPB Addendum #3 dated 10 Aug 23
BPC Foundations and Structures 31 Aug 23
BPC Addendum #1 dated 29 Sept 23
BPC Addendum #2 dated 11 Oct 23
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COMMON WORK RESULTS FOR HVAC

PART 1. GENERAL

1.1. SUMMARY

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all mechanical work.

C. Unless otherwise specified, all submissions shall be made to, and acceptances and approvals made by the Architect and the Engineer.

D. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange piping, ductwork, equipment, and other work generally as shown on the contract drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with Submittals specified below. The right is reserved to make reasonable changes in location of equipment, piping, and ductwork, up to the time of rough-in or fabrication.

E. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.

F. Coordinate the work under Division 23 with the work of all other construction trades.

G. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the contract documents.

1.2. PERMITS AND FEES

A. Obtain all permits and pay taxes, fees and other costs in connection with the work. File necessary plans, prepare documents, give proper notices and obtain necessary approvals. Deliver inspection and approval certificates to Owner prior to final acceptance of the work.

B. Permits and fees shall comply with the Division 01, General Requirements of the specification.

1.3. EXAMINATION OF SITE

A. Examine the site, determine all conditions and circumstances under which the work must be done, and make all necessary allowances for same. No additional cost to the Owner will be permitted for contractors' failure to do so.

B. Examine and verify specific conditions described in individual specifications sections.

C. Verify that utility services are available, of the correct characteristics, and in the correct locations.

1.4. CONTRACTOR QUALIFICATION

A. Any Contractor or Subcontractor performing work under Division 23 shall be fully qualified and acceptable to the Architect/Engineer and Owner. Submit the following evidence when requested:

1. A list of not less than five comparable projects which the Contractor completed.

2. Letter of reference from not less than three registered professional engineers, general contractors or building owners.

3. Local and/or State License, where required.

4. Membership in trade or professional organizations where required.

B. A Contractor is any individual, partnership, or corporation, performing work by contract or subcontract on this project.

C. Acceptance of a Contractor or Subcontractor will not relieve the Contractor or subcontractor of any contractual requirements or his responsibility to supervise and coordinate the work, of various trades.

1.5. MATERIALS AND EQUIPMENT

A. Materials and equipment installed as a permanent part of the project shall be new, unless otherwise indicated or specified, and of the specified type and quality.

B. Where material or equipment is identified by proprietary name, model number and/or manufacturer, furnish named item, or its equal, subject to approval by Engineer. Substituted items shall be equal or better in quality and performance and must be suitable for available space, required arrangement, and application. Submit all data necessary to determine suitability of substituted items, for approval.

C. The suitability of named item only has been verified. Where more than one item is named, only the first named item has been verified as suitable. Substituted items, including items other than first named shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement and application. Contractor, by providing other than the first named manufacturer, assumes responsibility for all necessary adjustments and modifications necessary for a satisfactory installation. Adjustments and modifications shall include but not be limited to electrical, structural, support, and architectural work.

D. Substitution will not be permitted for specified items of material or equipment where noted.

E. All items of equipment furnished shall have a service record of at least five (5) years.

1.6. FIRE SAFE MATERIALS

A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA and ASTM standards for fire safety with smoke and fire hazard rating not exceeding flame spread of 25 and smoke developed of 50.

1.7. REFERENCED STANDARDS, CODES AND SPECIFICATIONS

A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.

B.	AABC	-	Associated Air Balance Council
C.	ABMA	-	American Boiler Manufacturers Association
D.	ACCA	-	Air Conditioning Contractors of America
E.	ADC	-	Air Diffusion Council
F.	AGA	-	American Gas Association
G.	AMCA	-	Air Movement and Control Association
H.	ANSI	-	American National Standards Institute
I.	ARI	-	Air Conditioning and Refrigeration Institute
J.	ASHRAE	-	American Society of Heating, Refrigerating and Air Conditioning Engineers
K.	ASME	-	American Society of Mechanical Engineers
L.	ASPE	-	American Society of Plumbing Engineers
M.	ASTM	-	American Society for Testing and Materials
N.	ASME CSD-1	-	American Society of Mechanical Engineers Controls and Safety Devices for Automatically Fired Boilers
O.	CAGI	-	Compressed Air and Gas Institute
P.	CS	-	Commercial Standard
Q.	CSA	-	Canadian Standards Association
R.	CSD	-	Control and Safety Devices
S.	DNREC	-	Delaware Department of Natural Resources
T.	FM	-	Factory Mutual

U. IBC - International Building Code

V. IBR - Institute of Boiler and Radiator Manufacturers

W. IEEE - Institute of Electrical and Electronics Engineers

X. MSSP - Manufacturers Standards Society of the Valve and Fittings Industry

Y. NEC - National Electrical Code

Z. NEMA - National Electrical Manufacturers Association

AA. NFPA - National Fire Protection Association

BB. NSF - National Sanitation Foundation

CC. SMACNA - Sheet Metal and Air Conditioning Contractors National Association

DD. UL - Underwriters' Laboratories

EE. State of Delaware Fire Protection Regulations.

FF. All mechanical equipment and materials shall comply with the codes and standards listed in the latest edition of ASHRAE HVAC Applications Handbook, Chapter entitled Codes and Standards.

1.8. SUBMITTALS, REVIEW AND ACCEPTANCE

A. Equipment, materials, installation, workmanship and arrangement of work are subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Architect to be in best interest of Owner.

B. After acceptance of Material and Equipment List, submit six (6) copies or more as required under General Conditions of complete descriptive data for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, installation instructions, and any other information necessary to indicate complete compliance with Contract Documents. Edit submittal data specifically for application to this project.

C. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and any electrical requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals.

D. Submittals will be reviewed for general compliance with design concept in accordance with contract documents, but dimensions, quantities, or other details will not be verified.

E. Identify submittals, indicating intended application, location and service of submitted

items. Refer to specification sections or paragraphs and drawings where applicable. Clearly indicate exact type, model number, style, size and special features of proposed item. Submittals of a general nature will not be acceptable. For substituted items, clearly list on the first page of the submittal all differences between the specified item and the proposed item. The contractor shall be responsible for corrective action and maintaining the specification requirements if differences have not been clearly indicated in the submittal.

F. Submit actual operating conditions or characteristics for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable. Call attention, in writing, to deviation from contract requirements.

G. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted. Use only final or corrected submittals and data prior to fabrication and/or installation.

H. For any submittal requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

I. For resubmissions, the Contractor must address in writing all of the Engineer’s comments on the original submission to verify compliance.

1.9. SHOP DRAWINGS

A. Prepare and submit shop drawings for all mechanical equipment, specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on contract drawings.

B. Submit data and shop drawings including but not limited to the list below, in addition to provisions of the paragraph above. Identify all shop drawings by the name of the item and system and the applicable specification paragraph number and drawing number.

C. Every submittal including, but not limited to the list below, shall be forwarded with its own transmittal as a separate, distinct shop drawing. Grouping of items/systems that are not related shall be unacceptable.

D. Items and Systems

1. Access Doors/Panels including layouts and locations

2. Airflow Monitoring Stations

3. Air Cooled Chillers

4. Air Curtains

5. Air Handling Units

6. Air Distribution Systems
7. Air Separators
8. Antifreeze Fluids
9. Antifreeze/Waste Oil Storage Tanks (Automotive Shop)
10. Automatic Air Vents
11. Automatic Temperature Control Systems and Equipment
12. Automatic Glycol Feed Systems & Pressure Tanks
13. Backwater Valves
14. Baseboard Radiation
15. Blender/Air Mixer
16. Boiler Accessories, Trim, Flow Switches
17. Boiler Breaching and Stacks
18. Boiler Burners
19. Boilers and Accessories
20. Carbon Dioxide Sensors
21. Carbon Monoxide System Hose Reels
22. Carbon Monoxide Makeup Air/Exhaust Systems
23. Carbon Monoxide Sensors
24. Ceiling Paddle Fans
25. Central Control and Monitoring Systems (CCMS) and Equipment
26. Chemical Feed Systems
27. Clothes Dryer Breeching/Ductwork
28. Combination Fire/Smoke Dampers
29. Condensate Pumps
30. Condensing Units
31. Coordinated Drawings

32. Differential Bypass Valves, Transmitters
33. Direct Buried Piping
34. Drip Pans
35. Dryer Duct Booster Fan
36. Duct Materials
37. Duct Mounted Hot Water Heating Coils
38. Duct Silencers
39. Dust Collection Systems including Dust Collector, Ductwork, Flexible Tubing
40. Electric Recessed Cabinet Convectors
41. Electric Unit Heaters
42. Electric Radiant Heat Panels
43. Energy Recovery Ventilators
44. Equipment Rails
45. Expansion Loops
46. Expansion Tanks and Accessories
47. Exterior Equipment/Duct Piping Supports
48. Exterior Pipe Roller Supports
49. Exterior Ductwork
50. Fan Coil Units
51. Fans
52. Freeze Protection Pumps
53. Filters
54. Filter Housings/Mixing Boxes
55. Finned Tube Radiation
56. Fire Stopping - Methods and Materials
57. Fire Dampers

58. Flow Measuring Stations
59. Flowmeter and Primary Elements (Flow Fittings)
60. Fume Hoods
61. Fume Hood Exhaust Fans
62. Paint Spray Booth Gas Furnaces
63. Gas Fired Domestic Water Heaters
64. Glycol Feed Systems
65. Grilles, Registers, Diffusers
66. Heating & Ventilating Units
67. Heat Pipes
68. Horizontal Electric Unit Heaters
69. Horizontal Hot Water Unit Heaters
70. Identification Systems
71. In-Line Circulators
72. Industrial Air Cleaners
73. Intake Hoods
74. Kitchen Hoods
75. Kitchen Make-up Air Units
76. Kitchen Ventilation System Units
77. Louvers
78. Material and Equipment Lists
79. Operations and Maintenance Manuals
80. Pete's Plugs
81. Pipe Enclosures
82. Pipe Guides and Anchors
83. Pipe Materials Including Itemized Schedules

84. Preliminary Testing and Balancing Reports
85. Pressure Relief Valves
86. Pressure Regulating Valves
87. Pressure Independent Control Valves
88. Pump Pressure Switches
89. Pumps
90. Radiant Heat Panels
91. Roof Curbs
92. Rooftop Units
93. Relief Hoods
94. Screen shots of ATC System Graphics
95. Single Zone VAV Units
96. Smoke Dampers
97. Smoke Removal Assist System
98. Split System Air Conditioning Units Ductless
99. Split System Heat Pumps, Ductless
100. Spray Booth Exhaust Fans
101. Static Pressure Gauges
102. Static Pressure Sensors
103. Strainers
104. Test Certificates
105. Thermal Insulation Materials Include Table Summaries
106. Thermometers and Gauges
107. Underground Pre-Fabricated Piping Systems
108. Unit Heaters
109. Variable Frequency Drive Motor Bearing Protective Rings

110. Variable Speed Drives

111. Vertical In-Line Pumps

112. Vertical Cabinet Unit Heaters

113. Vibration Isolation Materials

114. Waste Oil Tanks (Automotive Shops)

115. Water Heater Flue/Combustion Air Piping

116. Water Treatment Services

117. Weatherproof Assembly Components

118. Wiring Diagrams, Flow Diagrams and Operating Instructions

E. Contractor, additionally, shall submit for review any other shop drawings as required by the Architect. No item shall be delivered to the site, or installed, until the Contractor has received a submittal from the Engineer marked Reviewed or Comments Noted. After the proposed materials have been reviewed, no substitution will be permitted except where approved by the Architect.

F. For any shop drawing requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

1.10. SUPERVISION AND COORDINATION

A. Provide complete supervision, direction, scheduling, and coordination of all work under the Contract, including that of subcontractors.

B. Coordinate rough-in of all work and installation of sleeves, anchors, and supports for piping, ductwork, equipment, and other work performed under Division 23.

C. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction to allow for mechanical installations.

D. Coordinate electrical work required under Division 23 with that under Division 26. Coordinate all work under Division 23 with work under all other Divisions.

E. Supply services of an experienced (10 year minimum) and competent Project Manager to be in constant charge of work at site.

F. Where a discrepancy exists within the specifications or drawings or between the specifications and drawings, the more stringent (or costly) requirement shall apply until clarification can be obtained from the Engineer. Failure to clarify such discrepancies with the Engineer will not relieve the Contractor of the responsibility of conforming to the requirements of the Contract.

G. Failure of contractor to obtain a full and complete set of contract documents (either before or after bidding) will not relieve the contractor of the responsibility of complying with the intent of the contract documents.

H. Coordinate installation of large equipment requiring positioning before closing in building. Where required arrange for manufacturer to ship equipment in modules.

1.11. CUTTING AND PATCHING

A. Accomplish all cutting and patching necessary for the installation of work under Division 23. Damage resulting from this work to other work already in place, shall be repaired at Contractor's expense. Where cutting is required, perform work in neat and work¬manlike manner. Restore disturbed work to match and blend with existing construction and finish, using materials compatible with the original. Use mechanics skilled in the particular trades required.

B. Do not cut structural members without approval from the Architect or Engineer.

1.12. PENETRATION OF WATERPROOF CONSTRUCTION

A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls, and interior waterproof construction. Where such penetrations are necessary, furnish and install all necessary curbs, sleeves, flashings, fittings and caulking to make penetrations absolutely watertight.

B. Where pipes penetrate roofs, flash pipe with Stoneman Stormtite, Pate or approved equal, roof flashing assemblies with skirt and caulked counter flashing sleeve.

C. Furnish and install pitch pockets or weather tight curb assemblies where required.

D. Furnish and install roof drains, curbs, vent assemblies, and duct sleeves specifically designed for application to the particular roof construction, and install in accordance with the manufacturer's instructions. The Contractor shall be responsible for sleeve sizes and locations. All roof penetrations shall be installed in accordance with manufacturer’s instructions, the National Roofing Contractors Association, SMACNA, and as required by other divisions of these specifications.

1.13. CONCRETE AND MASONRY WORK

A. Furnish and install concrete and masonry work for equipment foundations, supports, pads, and other items required under Division 23. Perform work in accordance with requirements of other applicable Divisions of these specifications.

B. Concrete shall test not less than 3,000 psi compressive strength after 28 days.

C. Grout shall be non-shrink, high strength mortar, free of iron of chlorides and suitable for use in contact with all metals, without caps or other protective finishes. Apply in accordance with manufacturer's instructions and standard grouting practices.

1.14. EXCAVATION AND BACKFILLING

A. General

1. Perform all necessary excavation, or installation of work under Division 23, in whatever materials or conditions encountered, using suitable methods and equipment.

2. Accurately establish required lines and grades and properly locate the work.

3. Determine the locations of all existing utilities before commencing the work.

B. Excavation: (Refer also to other portions of the specifications)

1. Excavate only the required elevations. If excavation is carried below the foundation lines or other required limits, backfill the excess with concrete.

2. Keep banks of trenches as nearly vertical as possible, and provide sheeting and/or shoring as required for protection of work and safety of personnel. Follow local, State, OSHA Guidelines.

3. Keep excavations dry. Protect excavations from freezing.

C. Backfilling: (Refer also to other portions of the specifications)

1. Backfill excavations to the required elevations and restore surfaces to their original or required conditions.

2. Backfill shall be similar material, free from objectionable matter such as rubbish, roots, stumps, brush, rocks and other sharp objects. Unless otherwise indicated, suitable material from the excavation may be used for backfill.

3. Carefully place and mechanically tamp backfill in layers not exceeding 12 inches loose thickness. Compact to 95 percent minimum.

4. Do not backfill against frozen material. Do not use frozen material for backfill.

1.15. DRIVE GUARDS

A. Provide safety guards on all exposed belt drives, motor couplings, and other rotating machinery. Provide fully enclosed guards where machinery is exposed from more than one direction.

B. When available, guards shall be factory fabricated and furnished with the equipment. Otherwise fabricate guards of heavy gauge steel, rigidly braced, removable, and finish to match equipment served. Provide openings for tachometers. Guards shall meet local, State and O.S.H.A. requirements.

1.16. VIBRATION ISOLATION

A. Furnish and install vibration isolators, flexible connections, supports, anchors and/or foundations required to prevent transmission of vibration from equipment, piping or ductwork to building structure. See Division 23 Section, “Vibration Control for HVAC,

Plumbing and Fire Protection Equipment".

1.17. ALTERNATES

A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

1.18. REFRIGERANT SYSTEM CAPS

A. For all exterior grade and roof mounted equipment containing refrigerant install lockable caps on service valves to prevent tampering. Lockable caps shall be Model NPR as manufactured by Rector Seal or approved equal. Provide Model NPR Novent screwdriver tool with swiveling tip. Caps shall be suitable and specific for the refrigerant type utilized.

1.19. DEFINITIONS

A. Approve - to permit use of material, equipment or methods conditional upon compliance with contract documents requirements.

B. Furnish and install or provide means to supply, erect, install, and connect to complete for readiness for regular operation, the particular work referred to.

C. Contractor means the mechanical contractor and any of his subcontractors, vendors, suppliers, or fabricators.

D. Piping includes pipe, all fittings, valves, hangers, insulation, identification, and other accessories relative to such piping.

E. Ductwork includes duct material, fittings, hangers, insulation, sealant, identification and other accessories

F. Concealed means hidden from sight in chases, formed spaces, shafts, hung ceilings, or embedded in construction.

G. Exposed means not installed underground or concealed as defined above.

H. Invert Elevation means the elevation of the inside bottom of pipe.

I. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceiling, and unexcavated spaces.

J. Review - limited observation or checking to ascertain general conformance with design concept of the work and with information given in contract documents. Such action does not constitute a waiver or alteration of the contract requirements.

K. SCR: Silicon Controlled Rectifier: Solid state switching device to provide fast, infinitely variable proportional control.

L. ECM: Electronically Commutating Motor.

M. Building Line: Exterior wall of building.

1.20. MINIMUM EFFICIENCY REQUIREMENTS

A. All heating, ventilating, and air conditioning equipment shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.

B. All piping, ductwork, and equipment insulation shall comply with ASHRAE Standard 90.1, latest edition.

C. All service water/heating equipment shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.

D. All mechanical devices, controls, accessories, and components shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.

E. Department of Energy (DOE) compliance: Pump manufacturers shall comply with US Department of Energy (DOE) energy conservation standard for "clean water pumps" 1-200 horse power, less than 459 feet of head and greater than 25 gpm. These pumps shall be evaluated using the Pump Energy Index (PEI) of equal to or lesser than 1.0. the PEI number shall appear on the pump name plate and shall be available for the record at http://er.pumps.org.

F. Where Energy Star certification exists for equipment utilized on this project, the equipment must be Energy Star certified. Provide Energy Star certification with submittals.

1.21. SYSTEM INTEGRATION

A. For all HVAC equipment specified to be provided with packaged controls and interfaced with the automatic temperature control system, provide system integration between the equipment manufacturer and the automatic temperature control subcontractor.

B. HVAC equipment submittals requiring system integration as defined above must identify all required system integration points.

C. HVAC equipment manufacturers must coordinate with ATC subcontractor regarding system integration prior to submitting on the equipment.

D. A system integration meeting must be arranged by the Mechanical Contractor and include, but not be limited to the systems integrator for the HVAC equipment manufacturer and the ATC Subcontractor. This portion of systems integration must occur prior to HVAC equipment being delivered to the project.

E. Once the HVAC equipment is on site, a second systems integration meeting must be arranged by the Mechanical Contractor to coordinate the packaged controls with the ATC system. The HVAC equipment manufacturer's representative familiar with system integration and the ATC subcontractor familiar with programming must be present.

F. A final system integrations meeting shall occur once all equipment is in place and ready

for operation. The Mechanical Contractor, the HVAC equipment systems' integrator, and the ATC Subcontractor shall meet on site to jointly program, schedule, verify points, interlock devices, and fully set up all systems integration components.

G. All systems integration coordination, programming, and graphics must be completed prior to requesting commissioning and/or inspections by the Engineer of Record.

1.22. FUTURE ADDITIONS

A. Where future additions are indicated, size and install all piping to account for future additions. Furnish and install shut-off valves, flow meters, and balance valves in ceiling adjacent to future additions. Provide cap at the end of the piping. Arrange so that in the future the cap can be removed and shut-off valve opened to serve future addition without draining system.

1.23. COORDINATION WITH NEW CASTLE COUNTY VOCATIONAL TECHNICAL SCHOOL DISTRICT I.T. DEPARTMENT

A. All equipment that interfaces with the internet shall be coordinated with the New Castle County Vocational Technical School District I.T. Department to verify that the same is suitable for use on the New Castle County Vocational Technical School District IT infrastructure. Coordinate with the New Castle County Vocational Technical School District I.T. Department regarding the allowable frequency bands to avoid interference with the New Castle County Vocational Technical School District I.T. infrastructure.

1.24. VFD BYPASSES

A. When VFD's are specified with integral bypasses and the equipment manufacturer is not able to provide bypasses due to equipment space constraints, then the manufacturer must provide spare VFD's for each fan/pump.

PART 2. ELECTRICAL REQUIREMENTS

2.1. GENERAL MOTOR AND ELECTRICAL REQUIREMENTS

A. Furnish and install control and interlock wiring for the equipment furnished. In general, power wiring and motor starting equipment will be provided under Division 26. Carefully review the contract documents to coordinate the electrical work under Division 23 with the work under Division 26. Where the electrical requirements of the equipment furnished differ from the provisions made under Division 26, make the necessary allowances under Division 23. Where no electrical provisions are made under Division 26, include all necessary electrical work under Division 23.

B. All electrical work performed under Division 23 shall conform to the applicable requirements of Division 26 and conforming to the National Electrical Code. All wiring, conduit, etc., installed in ceiling plenums must be plenum rated per NFPA and the International Building Code.

C. Provide wiring diagrams with electrical characteristics and connection requirements.

D. Test Reports: Indicate test results verifying nominal efficiency and power factor for three

phase motors larger than five (5) horsepower.

E. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof covering. For extended outdoor storage, remove motors from equipment and store separately.

F. All motors shall be furnished with visible nameplate indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor and efficiency.

G. Motors located in exterior locations, wet air streams, air cooled condensers, and outdoors shall be totally enclosed weatherproof epoxy-treated type.

H. Nominal efficiency and power factor shall be as scheduled at full load and rated voltage when tested in accordance with IEEE 112.

I. Brake horsepower load requirement at specified duty shall not exceed 85 percent of nameplate horsepower times NEMA service factor for motors with 1.0 and 1.15 service factors.

J. All single phase motors shall be provided with thermal protection: Internal protection shall automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature ratings of motor insulation. Thermal protection device shall automatically reset when motor temperature returns to normal range, unless otherwise indicated.

K. Where a motor disconnect is indicated downstream of a variable frequency drive (VFD) provide interlock wiring from the auxiliary contacts on the disconnect to the VFD to de-energize when the disconnect is turned "off".

L. Where equipment under this Division is specified with integral disconnecting means, the same shall be a single disconnecting means for disconnecting all ungrounded main power supply conductors that is capable of being locked in the open ("off") position in accordance with the National Electrical Code and the local electrical inspector.

2.2. MOTORS AND CONTROLS

A. Motors and controls shall conform to the latest requirements of IEEE, NEMA, NFPA-70 and shall be UL listed. Motor sizes are specified with the driven equipment. Motor starting and control equipment is specified either with the motor which is controlled or in an electrical specification section. The Contractor is advised to consult all specification sections to determine responsibility for motors and controls.

B. Motors shall be designed, built and tested in accordance with the latest revision of NEMA Standard MG l.

C. Motors shall be suitable for use under the conditions and with the equipment to which applied, and designed for operation on the electrical systems specified or indicated.

1. Motor capacities shall be such that the horsepower rating and the rated full-load current will not be exceeded while operating under the specified operating

conditions. Under no condition shall the motor current exceed that indicated on the nameplates.

2. Motor sizes noted in the individual equipment specifications are minimum requirements only. It is the responsibility of the equipment manufacturers and of the Contractor to furnish motors, electrical circuits and equipment of ample capacity to operate the equipment without overloading, exceeding the rated full-load current, or overheating at full-load capacity under the most severe operating service of this equipment. Motors shall have sufficient torque to accelerate the total WR2 of the driven equipment to operating speed.

3. Motors shall be continuous duty type and shall operate quietly at all speeds and loads.

4. Motors shall be designed for operation on 60 hertz power service. Unless otherwise specified or shown, motors less than ½ horsepower shall be single phase, and motors ½ horsepower and larger shall be 3 phase unless otherwise noted.

5. Motors shall be mounted so that the motor can be removed without removing the entire driven unit.

D. Single phase motors, smaller than 1/20 horsepower shall be ball or sleeve bearing; drip-proof, totally enclosed or explosion proof, as specified; 120 volts; permanent-split capacitor or shaded pole type. These motors shall not be used for general power purposes, and shall only be provided as built-in components of such mechanical equipment as fans, unit heaters, humidifiers and damper controllers. When approved by the Engineer, deviations from the specifications will be permitted as follows:

1. Open motors may be installed as part of an assembly where enclosure within a cabinet provides protection against moisture.

2. Motors used in conjunction with low voltage control systems may have a voltage rating less than 115 volts.

E. Single phase motors, greater than 1/20 horsepower and less than ½ horsepower shall be ball bearing; drip-proof, totally enclosed or explosion proof, as specified, with Class A or B insulation, as standard with the motor manufacturer; 115 or 120/208/240 volts as required; capacitor start-induction run, permanent split capacitor, or repulsion start-induction run type with minimum efficiency of 70 percent and a minimum full load power of 77 percent.

F. Except as otherwise specified in the various specification sections, 3 phase motors 60 horsepower and smaller shall be NEMA design B squirrel cage induction type meeting the requirements of this paragraph. Motors shall be drip-proof, totally enclosed or explosion proof, as specified or indicated. Insulation shall be Class B or F, at 40 degrees C ambient temperature. Drip-proof motors shall have a 1.15 service factor and totally enclosed and explosion proof motors shall have a service factor of 1.00 or higher. Motors specified for operation at 480, 240, and 208 volts shall be nameplated 460, 230, 200 volts, respectively. Efficiencies and percent power factor at full load for three phase motors shall be not less than the values listed below for premium efficiency motors:

MOTOR NAMEPLATE	MINIMUM PERCENT EFFICIENCY AT NOMINAL SPEED AND RATED LOAD	MINIMUM PERCENT POWER FACTOR
1HP and above to	85.5 percent	84 percent
1-½ HP	86.5 percent	85 percent
2HP	86.5 percent	85 percent
3HP	89.5 percent	86 percent
5HP	89.5 percent	87 percent
7½ HP	91 percent	86 percent
10HP	91.7 percent	85 percent
15HP	93.0 percent	85 percent
20HP	93.0 percent	86 percent
25HP	93.6 percent	85 percent
50HP and above	94.5 percent	88 percent
60 HP	95.0 percent	90 percent
75HP	95.0 percent	90 percent
100 HP	95.4 percent	90 percent
125 HP	95.8 percent	95 percent
150 HP and above	96.0 percent	95 percent

G. Three phase motors ½ HP or greater shall be the Duty Master XE by Reliance Electric Company, Super-E Premium Efficiency of Baldor Motor and Drives, E-plus Efficient Standard Duty Motor of the Electric Motor Division of Gould, Inc., the MAC II High Efficiency motor of Westinghouse Electric Corp., the equivalent product of General Electric, or approved equal.

H. For motors serving equipment being controlled by a variable speed drive, motor shall be premium efficiency inverter duty rated.

I. Motor frames shall be NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast-iron or aluminum with steel inserts.

J. Control of each motor shall be manual or automatic as specified for each in the various mechanical sections. In general, and unless otherwise specified for a particular item in the various mechanical sections of the specifications, motor starters and controls shall be specified and provided under the various electrical sections of these specifications.

K. Provide manufacturer's warranty for all motors for minimum of 5 years including all labor and materials.

2.3. MOTOR INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install securely on firm foundation. Mount ball bearing motors to support shaft regardless of shaft position.

C. Check line voltage and phase and ensure agreement with nameplate. Check that proper thermal overloads have been installed prior to operating motors.

D. Use adjustable motor mounting bases for belt-driven motors.

E. Align pulleys and install belts.

F. Tension belts according to manufacturer's written instructions.

2.4. WIRING DIAGRAMS

A. The Contractor is responsible for obtaining and submitting wiring diagrams for all major items of equipment.

B. Wiring diagrams shall be provided with shop drawings for all equipment requiring electric power.

C. Provide wiring diagrams for all major mechanical items of equipment to electrical contractor and ATC subcontractor for coordination.

2.5. VARIABLE FREQUENCY DRIVE MOTOR BEARING PROTECTIVE RINGS:

A. For all motors driven by a variable frequency PWM drive include a maintenance free, circumferential, conductive micro fiber shaft grounding ring to discharge shaft currents. Grounding rings shall be manufactured by AEGIS SGR or approved equal.

B. Furnish units with two (2) year warranty.

C. Size and select Bearing Protective Rings per the manufacturer requirements based on the motor size, shaft diameter, and shaft shoulder length. For motors with slingers furnish and install NEMA /IEC kit as required.

D. Furnish and apply Colloidal silver shaft coating to all shafts with Bearing Protective Rings to improve shaft voltage discharge capability.

2.6. ENCLOSURES

A. Electrical enclosures including factory provided enclosures, field provided and installed enclosures, and automatic temperature control system enclosures shall be as follows:

1. Dry Interior Locations: NEMA 1.

2. Damp/Wet Locations, Including Exterior Locations: NEMA 3R.

3. Corrosive or Dusty Locations, Including Laboratories, All Tech Shops, Chemical Storage Rooms and Similar Space: NEMA 4X.

PART 3. EXECUTION

3.1. EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.

B. Install equipment according to approved submittal data. Portions of the work are shown only in diagrammatic form. Refer conflicts to Architect.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

D. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

E. Install equipment giving right of way to piping installed at required slope.

F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.

G. Do not install equipment, ductwork, or piping over electrical gear, electrical panels, motor controllers, and similar electrical equipment. Install equipment, ductwork, and piping to maintain clear space above and in front of all electrical components per the National Electric Code.

3.2. SUPPORTS, HANGERS AND FOUNDATIONS

A. Provide supports, hangers, braces, attachments and foundations required for the work. Support and set the work in a thoroughly substantial and workman-like manner without placing strains on materials, equipment, or building structure, submit shop drawings for approval. Coordinate all work with the requirements of the structural division.

B. Supports, hangers, braces, and attachments shall be standard manufactured items or fabricated structural steel shapes. All interior hangers shall be galvanized or steel with rust inhibiting paint. For un-insulated copper piping provide copper hanger to prevent contact of dissimilar metals. All exterior hangers shall be constructed of stainless steel utilizing stainless steel rods, nuts, washers, bolts, etc.

C. Concrete housekeeping pads and foundations shall be not less than 4 inches high (6 inches for high for chillers and boilers) and shall extend a minimum of 6 inches beyond equipment bases. Provide wire-mesh reinforcement; chamfer exposed edges and corners; and finish exposed surfaces smooth.

3.3. PROVISIONS FOR ACCESS

A. The contractor shall provide access panels and doors for all concealed equipment, valves, strainers, dampers, filters, controls, control devices, cleanouts, fire dampers, smoke dampers, damper operators, traps, and other devices requiring maintenance, service, adjustment, balancing or manual operation.

B. Where access doors are necessary, furnish and install manufactured painted steel door assemblies consisting of hinged door, key locks, and frame designed for the particular wall or ceiling construction. Properly locate each door. Door sizes shall be a minimum of 12 inches x 12 inches for hand access, 18 inches x 18 inches for shoulder access and 20 inches x 30 inches for full body access where required. Review locations and sizes with Architect prior to fabrication. Provide U.L. approved and labeled access doors where installed in fire rated walls or ceilings. Doors shall be Milcor Metal Access Doors as manufactured by Inland-Ryerson, Mifab, or approved equal.

1. Acoustical or Cement Plaster: Style B

2. Hard Finish Plaster: Style K or L

3. Masonry or Dry Wall: Style M

C. Where access is by means of liftout ceiling tiles or panels, mark each ceiling grid using small color-coded and numbered tabs. Provide a chart or index for identification. Place markers within ceiling grid not on ceiling tiles.

D. Access panels, doors, etc. described herein shall be furnished under the section of specifications providing the particular service and to be turned over to the pertinent trade for installation. Coordinate installation with installing contractor. All access doors shall be painted in baked enamel finish to match ceiling or wall finish. Label inside of access door as to what it serves.

E. Submit shop drawings indicating the proposed location of all access panels/doors. Access doors in finished spaces shall be coordinated with air devices, lighting and sprinklers to provide a neat and symmetrical appearance.

F. Where access doors are installed in wet locations (i.e. shower rooms, toilet rooms, kitchens, dishwasher rooms, and similar spaces, etc…) provide aluminum access doors/frames.

3.4. PAINTING AND FINISHES

A. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, nuts, bolts, washers, vibration isolators, etc. shall be stainless steel.

B. Clean surfaces prior to application of insulation, adhesives, coatings, paint, or other finishes.

C. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pretreatment.

D. Protect all finishes and restore any finishes damaged as a result of work under Division 23 to their original condition.

E. The preceding requirements apply to all work, whether exposed or concealed.

F. Remove all construction marking and writing from exposed equipment, ductwork, piping and building surfaces. Do not paint manufacturer's labels or tags.

G. All exposed ductwork, piping, equipment, etc. shall be painted. Colors shall be as stated in this division or as selected by the Architect and conform to ANSI Standards.

H. All exterior roof mounted ductwork, equipment, piping, breeching, and vents shall be painted to match roof in color as selected by Architect.

I. All exposed ductwork, piping, equipment, etc. in finished spaces shall be painted. Colors shall be as selected by the Architect and conform to ANSI Standards.

J. All exposed ductwork, piping, equipment, etc., in Mechanical Rooms, Boiler Rooms, Penthouses, Fire Pump Rooms, Mezzanines, and Storage where PVC jacketed shall not require painting. Label and identify and color code as specified.

3.5. CLEANING OF SYSTEMS

A. Thoroughly clean systems after satisfactory completion of pressure tests and before permanently connecting fixtures, equipment, traps, strainers, and other accessory items. Blow out and flush piping until interior surfaces are free of foreign matter.

B. Flush piping in re-circulating water systems to remove cutting oil, excess pipe joint compound, solder slag and other foreign materials. Do not use system pumps until after cleaning and flushing has been accomplished to the satisfaction of the Engineer. Employ chemical cleaners, including a non-foaming detergent, not harmful to system components. After cleaning operation, final flushing and refilling, the residual alkalinity shall not exceed 300 parts per million. Submit a certificate of completion to Engineer stating name of Service Company used.

C. Maintain strainers and dirt pockets in clean condition.

D. Clean fans, ductwork, enclosures, flues, registers, grilles, and diffusers at completion of work.

E. Install filters of equal efficiency to those specified in permanent air systems operated for temporary heating during construction. Replace with clean filters as specified prior to acceptance and after cleaning of system.

F. Pay for labor and materials required to locate and remove obstructions from systems that

are clogged with construction refuse after acceptance. Replace and repair work disturbed during removal of obstructions.

G. Leave systems clean, and in complete running order.

H. All HVAC piping/equipment strainers must be pulled and cleaned prior to substantial completion. In addition six (6) months after substantial completion all HVAC piping/equipment strainers must be pulled and cleaned a second time. Document and submit verification of strainer cleaning to Engineer, Owner, and Construction Manager.

3.6. COLOR SELECTION

A. Color of finishes shall be as selected by the Architect.

B. Submit color of factory-finished equipment for acceptance prior to ordering.

3.7. PROTECTION OF WORK

A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.

B. Cover temporary openings in piping, ductwork, and equipment to prevent the entrance of water, dirt, debris, or other foreign matter. Deliver pipes and tubes with factory applied end caps.

C. Cover or otherwise protect all finishes.

D. Replace damaged materials, devices, finishes and equipment.

E. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, where stored inside.

F. Provide moisture protection for ductwork in areas which are not under roof or where ductwork would be exposed to rainwater.

3.8. OPERATION OF EQUIPMENT

A. Clean all systems and equipment prior to initial operation for testing, balancing, or other purposes. Lubricate, adjust, and test all equipment in accordance with manufacturer's instructions. Do not operate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.

B. Where specified, or otherwise required, provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment. Where factory start-up of equipment is not specified, provide field start-up by qualified technician.

C. Submit factory start-up sheets or field start-ups sheets for all equipment prior to the commencement of testing and balancing work. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.

D. Do not use mechanical systems for temporary services or temporary conditioning during construction, unless approved by Owner in writing. Refer to Division 01 Section "Temporary Facilities and Controls" for temporary heating/cooling during construction.

E. Upon completion of work, clean and restore all equipment to new conditions; replace expendable items such as filters.

3.9. DEMONSTRATION AND TRAINING VIDEO RECORDINGS

A. General: Record demonstration and training video recordings. Record each training module separately.

1. At beginning of each training module, record each chart containing learning objective and lesson outline.

B. Video Recording Format: Provide high-quality color video recordings with menu navigation in format acceptable to Engineer

C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.

D. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed.

E. Transcript: Provide a transcript of the narration. Display images and running time captured from videotape opposite the corresponding narration segment.

3.10. IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS

A. Contractor shall submit for approval schematic piping diagrams of each piping system installed in the building. Diagrams shall indicate the location and the identification number of each valve in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under safety glass and hung in each Mechanical Room where directed. Contractor shall deliver the tracing or sepia from which the diagrams were reproduced to the Owner.

B. All valves shall be plainly tagged. For any bypass valves, install sign indicating valve position as “Normally Open” or “Normally Closed” as required.

C. All items of equipment, including motor starters, disconnects and ATC panels shall be furnished with white on black plastic permanent identification cards. Lettering shall be a minimum of ¼ inch high. Identification plates shall be secured, affixed to each piece of equipment, starters, disconnects, panels by screw or adhesive (tuff bond #TB2 or as approved equal).

D. Provide six (6) copies of operating and maintenance instructions for all principal items of equipment furnished. This material shall be bound as a volume of the Record and Information Booklet as hereinafter specified.

E. All lines piping and ductwork installed under this contract shall be stenciled with direction

of flow arrows and with stenciled letters naming each pipe and ductwork and service. Refer to Division 23 Section, "HVAC Piping, Fittings, Valves, Etc." and Division 23 Section, "HVAC Air Distribution". Color-code all direction of flow arrows and labels. In finished spaces omit labeling and direction of flow arrows. Paint in color as selected by Architect.

F. Submit list of wording, symbols, letter size, and color coding for mechanical identification. Submit samples of equipment identification cards, piping labels, ductwork labels, and valve tags to Engineer for review prior to installation.

G. Provide at least 24 hours of straight time instruction to the operating personnel. Time of instruction shall be designated by the Owner. Additional instruction time for the automatic temperature control (ATC) system is specified in Division 23 Section, "Instrumentation & Controls of HVAC & Plumbing Systems".

H. Contractor shall demonstrate Sequences of Operation of all equipment in presence of Owner's representative, Engineer, and ATC subcontractor.

3.11. WALL AND FLOOR PENETRATION

A. All penetrations of partitions, ceilings, roofs and floors by ducts, piping or conduit under Division 23 shall be sleeved, sealed, and caulked airtight for sound and air transfer control. Penetrations of mechanical room partitions, ceilings, and floors shall be as specified in Division 23 Section, "Vibration Control for HVAC, Plumbing and Fire Protection Equipment".

B. All penetration of fire rated assemblies shall be sleeved, sealed, caulked and protected to maintain the rating of the wall, roof, or floor. Fire Marshal approved U.L. assemblies shall be utilized. See Division 07 Section, "Fire Protection, HVAC & Plumbing Penetration Firestopping".

C. Where piping extends through exterior walls or below grade, provide waterproof pipe penetration seals, as specified in another division of these specifications.

D. Provide pipe escutcheons and duct flanges for sleeved pipes and ducts in finished areas.

E. Piping sleeves:

1. Galvanized steel pipe, standard weight where pipes are exposed and roofs and concrete and masonry walls. On exterior walls provide anchor flange welded to perimeter.

2. Twenty-two (22) gauge galvanized steel elsewhere.

F. Ductwork sleeves: 20 gauge galvanized steel.

G. Extend all floor sleeves through floor at least 3/4-inches above finished floor, caulk sleeve the entire depth and furnish and install floor plate.

H. Sleeves for penetrations in kitchen and food service areas shall finish .375 inches above floor or flush with wall surfaces and be neatly pointed up to fit snuggly against floor or wall material.

3.12. RECORD DRAWINGS

A. Upon completion of the mechanical installations, the Contractor shall deliver to the Architect one complete set of prints of the mechanical contract drawings which shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings.

B. Contractor shall incorporate all sketches, addendums, value engineering, change orders, etc., into record drawings prior to delivering to Architect.

3.13. WARRANTY

A. Contractor's attention is directed to warranty obligations contained in the GENERAL CONDITIONS.

B. The above shall not in any way void or abrogate equipment manufacturer’s guarantee or warranty. Certificates of equipment manufacturer’s warranties shall be included in the operations and maintenance manuals.

C. The Contractor guarantees for a two year period from the time of final acceptance by the Owner.

1. That the work contains no faulty or imperfect material or equipment or any imperfect, careless, or unskilled workmanship.

2. That all work, equipment, machines, devices, etc. shall be adequate for the use to which they are intended, and shall operate with ordinary care and attention in a satisfactory and efficient manner.

3. That the contractor will re-execute, correct, repair, or remove and replace with proper work, without cost to the Owner, any work found to be deficient. The contractor shall also make good all damages caused to their work or materials in the process of complying with this section. Contractor shall repair and/or replace any/all damage to finishes and furniture resulting from their corrective work.

4. That the entire work shall be water-tight and leak-proof.

3.14. LUBRICATION

A. All bearings, motors, and all equipment requiring lubrication shall be provided with accessible fittings for same. Before turning over the equipment to the Owner, the Contractor shall fully lubricate each item of equipment, shall provide one year's supply of lubricant for each, and shall provide Owner with complete written lubricating instructions, together with diagram locating the points requiring lubrication. Include this information in the Record and Information Booklet.

B. In general, all motors and equipment shall be provided with grease lubricated roller or ball bearings with Alemite or equal accessible or extended grease fittings and drain plugs.

3.15. OPERATIONS AND MAINTENANCE MANUALS

A. The Contractor shall have prepared six (6) hardcopies and one (1) electronic copy of the Operations and Maintenance Manuals and deliver these copies of the booklet to the Owner. The booklet shall be as specified herein. The booklet must be approved and will not be accepted as final until so stamped.

B. The booklet shall be bound in a three ring loose-leaf binder similar to National No. 3881 with the following title lettered on the front: Operations and Maintenance Manuals – New Hodgson Vocational Technical High School - HVAC. No sheets larger than 8-1/2 inches x 11 inches shall be used, except sheets that are neatly folded to 8-1/2 inches x 11 inches and used as a pull-out. Provide divider tabs and table of contents for organizing and separating information.

C. Electronic copies of the manual shall be saved on USB flash drives, and shall be in searchable PDF format with interactive index tabs. Approved electronic copies shall be stored in flash drive zipper cases in front of Volume 1 (if applicable) of hard copies of the manual.

D. Provide the following data in the booklet:

1. As first entry, an approved letter indicating the starting/ending time of Contractor's warranty period.

2. Maintenance operation and lubrication instructions on each piece of equipment furnished.

3. Complete catalog data on each piece of heating and air conditioning equipment furnished including approved shop drawing.

4. Manufacturer's extended limited warranties on equipment including but not limited to boiler breeching, variable frequency drives, air conditioning compressors, storage tanks, and chillers, boilers, pumps.

5. Chart form indicating frequency and type of routine maintenance for all mechanical equipment. The chart shall also indicate model number of equipment, location and service.

6. Provide sales and authorized service representatives names, address, and phone numbers of all equipment and subcontractors.

7. Provide supplier and subcontractor's names, address, and phone number.

8. Catalog data of all equipment, valves, etc. shall include wiring diagrams, parts list and assembly drawing.

9. Provide and install in locations as directed by the Owner, valve charts including valve tag number, valve type, valve model number, valve manufacturer, style, service and location. Each valve chart shall be enclosed in a durable polymer based frame with a cover safety glass.

10. Copy of the approved balancing report including duct leakage data.

11. Room design and actual differential pressure measurements.

12. ATC systems including as-built ATC drawings of systems including internal of all panels.

13. Access panel charts with index illustrating the location and purpose of access panels.

14. Approved Health Department, HVAC Inspector, Boiler Inspector, and Electrical Certificates.

15. Start-up reports for equipment.

16. Water treatment test reports.

17. Provide and install in locations as directed by Owner, filter charts, including filter type, size, model number, manufacturer, quantity and size for each filter utilized on the project. Filter charts shall be enclosed in a durable polymer based frame with a cover safety glass.

18. Insert color graphic with embedded parameters for ATC system into record and information booklet.

19. Filter charts indicating equipment served, size, and type of filter required.

20. Documentation of strainer pulling and cleaning.

21. Letter stating final concentration of glycol in hydronic systems**.**

22. Base mounted pump shaft alignment test results.

E. Electronic copies of the manual shall be saved on USB flash drives, and shall be in searchable PDF format with interactive index tabs. Approved electronic copies shall be stored in flash drive zipper cases in front of volume 1 (if applicable) of hard copies of the manual.

F. Submit Record and Information Booklets prior to anticipated date of substantial completion for Engineer review and approval. Substantial completion requires that Record and Information booklets be reviewed and approved.

3.16. INSTALLATION AND COORDINATION DRAWINGS

A. Prepare, submit, and use composite installation and coordination drawings to assure proper coordination and installation of work. Drawings shall include, but not be limited, to the following:

1. Complete Ductwork, Plumbing, Sprinkler and HVAC Piping Drawings showing coordination with lights, electrical equipment, HVAC equipment and structural amenities.

B. Draw plans to a scale not less than 3/8-inch equals one foot. Include plans, sections, and

elevations of proposed work, showing all equipment, piping and ductwork in areas involved. Fully dimension all work including lighting fixtures, conduits, pullboxes, panelboards, and other electrical work, walls, doors, ceilings, columns, beams, joists and other architectural and structural work.

C. Identify all equipment and devices on wiring diagrams and schematics. Where field connections are shown to factory-wired terminals, include manufacturer's literature showing internal wiring.

D. Refer to Division 01 Section “Project Management and Coordination” for additional requirements related to coordination drawings.

3.17. PIPING SYSTEMS TESTING

A. The entire new HVAC piping systems shall be tested hydrostatically before insulation covering is applied and proven tight under the following gauge pressures for a duration of twenty-four (24) hours. Testing to be witnessed by Owner's representative and documented in writing.

SYSTEM	TEST PRESSURE
Heating, Chilled, & Glycol Water Supply & Return Piping, Including Chemical Treatment Piping	100 psig
Direct Buried Heating Water Supply/Return Piping	1.5 times the design pressure
Refrigerant Piping including Relief Piping	600 psig with Nitrogen

B. Ductwork pressure testing shall be as specified in another division of these specifications.

C. Testing and acceptance thereof shall be in accordance with local requirements and shall meet approval of authority having jurisdiction. Submit certificates and approved permits and insert one (1) copy in the Operations and Maintenance Manuals.

D. Refrigerant piping shall be tested utilizing nitrogen per equipment manufacturer’s requirements.

E. All testing shall be witnessed by Construction Manager.

3.18. EQUIPMENT BY OTHERS

A. This Contractor shall make all system connections required to equipment furnished and installed under other divisions or furnished by the Owner. Connections shall be complete in all respects to render this equipment functional to its fullest intent.

B. It shall be the responsibility of the supplier of this equipment to furnish complete instructions for connections. Failure to do so will not relieve this contractor of any responsibility for improper equipment operation.

3.19. ADDITIONAL FILTERS AND BELTS

A. One complete set of additional filters and belts shall be turned over to the owner upon final acceptance of the building by the owner. Provide correspondence to the Engineer (copy) documenting that additional filters and belts have been turned over to Owner.

B. All filters and belts shall be tagged and identified for equipment served. Furnish filters in protection wrap.

3.20. STRAINER CLEANING

A. All equipment strainers must be pulled and cleaned at substantial completion. Document in writing and via digital photographs that all strainers have been pulled and cleaned.

B. One year after project substantial completion all strainers shall be pulled again and cleaned. Document in writing and via digital photographs that all strainers were pulled and clean at the one year after project substantial completion data.

C. Insert documentation that the strainers have been pulled and cleaned in the Record and Information Books.

D. Re-purge hydronic systems of all air after strainers are pulled and cleaned.

3.21. OUTAGES

A. Provide a minimum of fourteen (14) days notice to schedule outages. The Contractor shall include in their bid outages and/or work in occupied areas to occur on weekends, holidays, or at night. Coordinate and get approval of all outages with the Owner.

B. Submit Outage Request form, attached at end of this Section, to Owner for approval.

END OF SECTION

OUTAGE REQUEST

DATE APPLIED: _____ BY: _____

DATE FOR OUTAGE: _____ FIRM: _____

START OUTAGE-TIME: _____ DATE: _____

END OUTAGE -- TIME: _____ DATE: _____

AREAS AND ROOMS: _____

FLOOR(S): _____

AREA(S): _____

ROOM(S): _____

WORK TO BE PERFORMED: _____

SYSTEM(S): _____

REQUEST APPROVED BY: _____

(FOREMAN OR OTHER PERSON IN CHARGE)

(FOR OWNER'S USE ONLY):

APPROVED: _____

YES ____ NO ___ BY: _____ DATE: _____

DATE/TIME-AS REQUESTED: _____ OTHER : _____

OWNER'S PRESENCE REQUIRED: _____

YES: ____ NO: ___ NAME: _____

POINT OF CONTACT: _____ PHONE: _____

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DIVISION 23 SECTION 23 05 05
HVAC PIPING, FITTINGS & VALVES
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SECTION 23 05 05
HVAC PIPING, FITTINGS AND VALVES

PART 1. GENERAL

1.1. SUMMARY

A. The conditions of the contract and other general requirements apply to the work specified in this section. All work under this section shall also be subject to the requirements of Division 23 Section, Common Work Results for HVAC and Division 01, General Requirements.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SYSTEM DESCRIPTION CONDITIONS

A. Provide all labor and materials necessary to furnish and install all piping systems on this project as herein specified and/or shown on the drawings. Final connections to equipment furnished in other sections of the specifications shall be included under this section.

B. All piping and insulation installed in ceiling plenums must be plenum rated and comply with NFPA and International Building Code (IBC).

C. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

D. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.

E. Use non-conducting dielectric connections whenever jointing dissimilar metals in open systems.

F. Provide pipe hangers and supports in accordance with ASTM B31.9 and MSS SP69 unless indicated otherwise.

G. Use spring loaded "silent" check valves on discharge of all pumps.

H. Use 3/4 inch (20 mm) ball valves with cap and chain for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.

I. At all runout piping serving equipment, use swing joints with elbows to prevent excessive movement of piping due to expansion.

1.3. QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body.

B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulation. Provide certificate of compliance from authority having jurisdiction indicating approval of welders.

C. Welders Certification: In accordance with ASME Section 9.

D. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

1. All castings used for coupling housings, fittings, and valve bodies shall be date stamped for quality assurance and traceability.

E. Maintain one copy of each document on site.

1.4. DELIVERY, STORAGE AND HANDLING

A. Deliver, store, protect and handle products to site under as hereinbefore specified.

B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

C. Provide temporary protective coating on cast iron and steel valves.

D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed systems.

1.5. ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

1.6. EXTRA MATERIALS

A. Provide one (1) repacking kit for each size valve.

1.7. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. PIPE MATERIALS

A. All materials, unless otherwise specified, shall be new and of the best quality of their respective kinds, and shall conform to the requirements and ordinances of local, state and insurance authorities having jurisdiction.

1. Direct Buried Heating Water Supply & Return Piping (PEX) Below Grade:

a. General: All run-outs below grade to the finned tube elements shall be cross linked polyethylene (PEX) plastic as manufactured by Stadler Corporation, Vanguard, Heatway, Wirsbo, Heatlink, or approved equal.
b. Coordination: Coordinate thickening of slabs where required for adequate encasement of radiant heating piping components.
c. Tubing: ASTM F876 or ASTM F877 for service at 100 psig and 180 degrees F. Base material shall be high density polyethylene electronically cross-linked by means of high energy electron beam. All tubing shall contain an oxygen diffusion barrier per DIN 4726. Degree of cross-linking shall be 65 – 70 percent.
d. Fittings: Copper or brass compression type suitable for tubing and transitioning to above grade heating water pipe material. Fittings shall comply with ASTM F1807.
e. Warranty: Tubing shall be warranted against manufacturer's related tubing defects for 30 years.

2. Direct Buried Heating, Water Supply & Return Piping Outside of Building Below Grade (Field House):

a. General: All underground supply/return hot water lines shall be the XTRU-THERM PLUS type, as manufactured by Perma-Pipe, Thermacor, Rovanco, or approved equal. All straight sections, fittings, anchors and other accessories shall be factory fabricated to job dimensions and designed to minimize the number of filed welds. Each system layout shall be computer analyzed by the piping system manufacturer to determine stress on the carrier, pipe, and anticipated thermal movement of the service pipe. The system design shall be in strict conformance with ANSI B31.1 latest edition. Factory trained field technical assistance shall be provided for critical periods of installation; unloading, field joint instruction, and testing.
b. Service Piping: Internal piping shall be standard weight carbon steel. All joints shall be butt-welded for 2 ½ inches and greater, and socket or butt-welded for 2 inches and below. Where possible, straight sections shall be supplied in 40 foot random lengths with piping exposed at each end for field joint fabrication.
c. Accessories: End seals, gland seals and anchors shall be designed and factory fabricated to prevent the ingress of moisture into the system.
d. Insulation: Service pipe insulation shall be spray applied nominal 2 pound per cubic foot density, 0.16 K-factor, 90-95% closed cell content and compression strength of 40 psi polyurethane foam for straight sections and preformed polyurethane foam for all fittings. To ensure no voids are present, all insulation shall be inspected by one of the following three methods: visually checked prior to application of the protective jacket; infrared inspection of the entire length; or x-ray inspection of the entire length. The insulation shall be applied to the minimum thickness specified below. The insulation thickness shall not be less than indicated in these specifications.

Pipe Size (in.)	Insulation Thickness (in)
1	1

1½ -3	1.5
4 – 6	2
8 - 14	2.5
16 - 20	3
22 - 30	3.5

e. Protective Jacket: The outer jacket shall be High Density Polyethylene (HDPE) in accordance with ASTM D3350 minimum cell classification PE 3454444 C. The jacket shall be a minimum thickness of 150 mils. PVC jackets shall not be allowed.

f. Fittings: Fittings shall be factory prefabricated, coated, insulated and jacketed. Field insulation "kits" shall not be allowed. All fittings shall be epoxy coated, insulated and jacketed in accordance with the coating, insulating and jacketing section of these specifications.

g. Subassemblies: End Seals and anchors shall be factory prefabricated (no field welded split plates) and designed to prevent the ingress of moisture into the system. End Seals shall include a factory reinforcement plate 18" long at wall entry points. The plate shall be designed to withstand link seal compression.

h. Field Joint Insulation and Jacket Sealing Kits:

i. The Manufacturer shall supply polyurethane foam insulation, shipped in bulk 5 gallon containers with removable mold cover. Epoxy coating kits shall be included. ATP cable leak detection splice kits shall be included. Shrink Sleeves shall be one of two types:

1) All field joint wraps shall be a High Temperature Shrink Sleeve. No other type shrink sleeve is acceptable. The polyurethane foam shall be inspected for voids by removing the mold prior to the application of any shrink sleeve. The installer shall seal the field joint area with a heat shrinkable adhesive backed wrap with a minimum thickness of 0.067 inches, rated to a temperature of 176 degrees F (80 degrees C). Backfilling shall not begin until the heat shrink sleeve has cooled.

i. Backfill: A 4-inch layer of sand or fine gravel shall be placed and tamped in the trench to provide a uniform bedding for the pipe. The entire trench width shall be evenly backfilled with a similar material as the bedding in 6 inch compacted layers to a minimum height of 6 inches above the top of the insulated piping system. The remaining trench shall be evenly and continuously backfilled in uniform layers with suitable excavated soiled.

3. Heating & Chilled Water Supply & Return Piping, Chemical Treatment Piping, Glycol Piping, (Inside of Building):

a. Manufactures: Victaulic, Grinnell, or Sure-Joint.

b. Pipe: Schedule 40 Black steel pipe, ASTM A53
1-1/2 inch and smaller - Type F, ASTM A53 steel (CW) with threaded joints
2 inch and larger - Grade B, Type E, ASTM A53 steel (ERW) with welded, flanged or grooved joints.

c. Fittings & Joints: 2-1/2 inches & larger, schedule 40 wrought steel ASTM A234 Grade WPB or Std. B16.9 long radius welding; factory-fabricated from ASTM A53 pipe; or ASTM A536 ductile iron; 2 inches & smaller 125 lb. std. cast iron screwed, ASTM Standard B16.4; or Vic-Press precision, cold drawn, stainless steel with elastomer O-ring seals. Joints shall be threaded or AWS D1.1 welded. Victaulic, Appollo/Shurjoint, or approved equal grooved joints shall be acceptable.

d. Flanges: Wrought steel Class 150 welding neck. ASTM Standard B16.5.

e. Grooved Joint Couplings: Two ductile iron housings, pressure responsive elastomer gasket, and ASTM A449 zinc electroplated steel bolts and nuts. Couplings shall comply with ASTM F1476 Standard Specification for the Performance of Gasketed Mechanical Couplings for Use in Piping Applications.

i. Rigid Type: Coupling housings shall be cast with offsetting, angle-pattern bolt pads to provide joint rigidity and support and hanging in accordance with ASNI B31.1 and B31.9.

1) Victaulic Style 107H, Apollo/Shurjoint Z-07, Installation-Ready or approved equal, for direct stab installation without field disassembly, with grade EHP gasket, suitable for water service to +250 degrees F.

ii. Flexible Type: For use in locations where vibration attenuation and stress relief are required, and for the elimination of flexible connectors. Victaulic Installation-Ready Style 177 or Style 77, or approved equal.

iii. 14" and Larger: AGS Series, two segment coupling with lead-in chamfer on housing key and wide width FlushSeal gasket. Victaulic Style W07 (rigid) and Style W77 (flexible), Apollo/Shurjoint 7707/7707N, or approved equal.

iv. Flange adapters shall be suitable for direct connection to ANSI Class 125 or 150 flanged components. Victaulic Style 741/W741, Apollo/Shurjoint 7041, or approved equal.

v. Rolled form grooves only. Cut grooves are prohibited.

vi. Verify gasket compatibility on Chemical Treatment piping.

f. Gate Valves: 2-1/2 inches & larger - IBBM, 150 lb. OS&Y grooved end or flanged; 2 inches & smaller - 150 lb. Bronze body bronze trim. Basis of Design: Victaulic Series 771V or approved equal.

For valves 4 inch and larger located in mechanical equipment spaces 10 feet-0 inch or greater above finished floor, valve shall have chain wheel operators with chains extending to within 6 feet-0 inch above finished floor. Chain wheels and guides shall be galvanized.

g. Ball Valves: Shut-off valves 2 inches and smaller shall be ball valves. Ball valves shall be 600cwp, 150swp full port, with RPTFE seats, chrome plated ball and stem 2 ½ and larger, class 125 cast iron OS&Y IBBM gate valve, brass or bronze body, standard port, 2 piece body. Ball valves shall be VicPress end, threaded end or solder end as required to accommodate piping. Ball valves shall be as manufactured by Victaulic, Crane, Apollo, Nibco, Watts or engineer approved equal.

h. Globe Valves: 2-1/2 inches & larger – IBBM 125 lb.std. flanged, with No. 1 disc; 2 inches & smaller - bronze 150 lb. std. screw ends, with #1 disc.

i. Check Valves: 2-1/2 inches & larger – IBBM or stainless steel trim, 125 lb.std. grooved end or flanged spring-assisted swing check suitable for vertical or horizontal installation, with metal disc; 2 inch & smaller - 125 lb. std. screwed. Provide "silent" spring loaded check valves at all pump discharges. Victaulic Series 716/W715 or approved equal.

j. Balancing Valves: Victaulic Series 377/365, DeZurik Series 100, Fig. 118 or approved equal, ductile iron or cast iron construction, stainless steel bearings, nickel seats (3 inches and larger) non-lubricated, eccentric plug with EPDM, chlorobutyl rubber or Bunz-N resilient faced plugs suitable for 230 degrees F, semi-steel screwed with fig. 159, removable lever and open. nut for valves 3 inches and smaller. For valves 4-inch and larger, provide gear operators and grooved ends or flanged connections. Provide chain operated valves for sizes 4-inches and larger located 10 feet-0 inches or more above finished floor. Chains shall extend to within 6 inch-0 inches above finished floor. All valves shall have adjustable memory stop. Chain wheel and guide shall be galvanized.

k. Butterfly Valves: Victaulic Vic300 MasterSeal/ AGS-Vic300, DeZurik, Apollo 215L series, high performance, Milwaukee HP Valve, or Keystone K-Loc, type with infinite position lever (for 3-inches and smaller) and pressure-responsive seat or double seat type and memory stop. Provide gear operator on valves 4-inches and larger.

   i. Valve stem shall be stainless steel, and shall be offset from the disc centerline to provide complete 360 degree circumferential seating.

   ii. Valve shall be rated to +250 deg F in sizes through 12-inches.

   iii. Seat shall be elastomer, of a grade suitable for the intended service. The seat shall be pressure responsive in sizes through 12 inches.

   iv. For valves 4 inches and larger located 10 feet-0 inches or more above finished floor shall be provided with chain operators with chains extending to within 6 feet-0 inches above finished floor. Chain wheel and guide shall be galvanized.

l. Combination Shut-off/Balancing Valves:

Victaulic/ TA Hydronics, Taco Circuit Setter, Bell & Gossett Circuit Setter Plus, Flowset Accuset, Gerand, or as approved equal, 2-inch-3-inch 300 lb. rated Ametal (copper-alloy) body globe type or ball valve with bronze body/brass ball construction with glass and carbon filled TFE seats, in-line flow meter and balancing and shut-off valve with built in ball valve for flow adjustment. Valve shall have memory stop, calibrated nameplate, Schrader valve connections and preformed molded insulation. Valves shall be leaktight at full rated working pressure. Balance valve size shall be selected based on manufacturer's acceptable flow range and design flow rate. Pressure drop through combination shut off balance valves shall not exceed 5 feet of head at design flow rate. Where required for flow rates below 0.6 GPM, provide "reduced flow" combination shut-off balance valves sized so that the flow rate is within the manufacturer's recommended flow range.

Coil-Hook-up Connections: Victaulic Koil-Kits Series 799 or 79V or approved equal may be used at coil connections. The kit shall include a autoflow balancing valve, Series 78Y Strainer-Ball, Series 78U Union-

Port fitting, with Series 78T ball valve and required coil hoses. A Style 793 and/or 794 differential pressure controller shall be provided as required. A meter shall be provided by the valve manufacturer that shall remain with the building owner after commissioning.

m. Extended Valve Stems: Provide and install round collar type extended valve stems on all valves installed in insulated piping. Valve stem and collar shall be selected to suit insulation thickness and maintain valve handles outside of insulation.

n. Alternate:

i. At contractors option all HVAC water supply and return lines may be copper type L (ASTM Std. B88) with wrought copper fittings (ASTM Std. B 16.22) with brazed or 95-5 silver solder joints lead and antimony based solders are prohibited and all bronze valves may be used on piping 2 inches and less in size.

ii. At Contractors option, copper press fittings may be utilized as manufactured by Viega Pro Press/ Mega Press, Apollo Press/Apollo Power Press, or Mueller Streamline Co. Viega, ProPress, and Mueller Streamline Co. Pressure Seal Fittings: Bronze or copper shall conform to ASME B16.51, ICC LC 1002, and IAPMO PS 117. ProPress fittings ½-inch thru 4- inch for use with ASTM B88 copper tube type L and ½-inch up to 1-1/4-inch annealed copper tube. ProPress fittings shall have an EPDM sealing element and Smart Connect (SC) feature. 2-1/2-inch thru 4-inch shall have a 420 stainless steel grip ring, PBT separator ring, EPDM sealing element and leak detection feature.

4. Refrigeration Piping:

a. Concealed: Tube Size ¾ -inch & Smaller:
ASTM B280, copper tube; Type ACR, soft annealed temper fittings; cast copper-alloy fittings for flared copper tubes; flared joints. Fittings shall be ASME B16.22, wrought copper. Joints shall be brazed, AWS A5.8, BCUP silver/phosphorous/copper alloy with melting range 1190 to 1480 degrees F.

b. Concealed: Tube Size 7/8 inch through 4-1/8inches:
Copper tube, Type ACR, soft annealed temper; wrought-copper, brazed-joint fittings; brazed joints.

c. Exposed: Tube Size ¾ Inch and Smaller:
Copper pipe, Type ASTM B88, Type K with brazed wrought-copper fittings conforming to ASME B16.22. Filler metal shall be brazing type conform to AWS A5.8.

d. Exposed: Tube Sizes 7/8 Inch and Larger:
Copper pipe, Type ASTM B88, Type K with brazed wrought-copper fittings conforming to ASME B16-22. Filler metal shall be brazing type conforming to AWS A5.8.

e. Brazed Joints: Braze joints using American Welding Society (AWS) classification BCuP-4 for brazing filler metal.

f. Flexible connectors: 500-psig (3450-kPa) minimum operating pressure; stainless-steel core and high-tensile stainless-steel-braid covering; dehydrated, pressure tested, minimum 7 inches (180 mm) long.

g. Diaphragm Packless Valves:
500-psig (3450-kPa) working pressure and 275 degrees Fahrenheit (135 degrees C) working temperature; globe design with straight-through or angle pattern; forged-brass or bronze body and bonnet, phosphor bronze and stainless-steel diaphragms, rising stem and handwheel, stainless-steel spring, nylon seat disc, and with solder-end connections.

h. Packed-Angle Valves: 500-psig (3450-kPa) working pressure and 275 degrees Fahrenheit (135 degrees C) working temperature; forged-brass or bronze body, forged-brass seal caps with copper gasket, back seating, rising stem and seat, molded stem packing, and with solder-end connections.

i. Check Valves: Smaller than NPS 1 (DN 25): 400-psig (2760-kPa) operating pressure and 285 degrees Fahrenheit (141 deg Celsius) operating temperature; cast-brass body, with removable piston, polytetrafluoroethylene seat, and stainless-steel spring; globe design. Valve shall be straight-through pattern, with brazed-end connections.

j. Check Valves: NPS 1 (DN 25) and Larger: 400-psig (2760-kPa) operating pressure and 285 degrees Fahrenheit (141 deg Celsius) operating temperature; cast-bronze body, with cast-bronze or forged-brass bolted bonnet; floating piston with mechanically retained polytetrafluoroethylene seat disc. Valve shall be straight-through or angle pattern, with solder-end connections.

k. Service Valves: 500-psig (3450-kPa) pressure rating; forged-brass body with copper stubs, brass caps, removable valve core, integral ball check valve, and with brazed-end connections.

l. Solenoid Valves: Comply with ARI 760; 250 deg Fahrenheit (121 deg Celsius) temperature rating and 400-psig (2760-kPa) working pressure; forged brass, with polytetrafluoroethylene valve seat, 2-way, straight-through pattern, and brazed-end connections; manual operator; fitted with suitable NEMA 250 enclosure of type required by location, with 1/2-inch (16-GRC) conduit adapter and 24-V, normally closed holding coil.

m. Pressure-Regulating Valves:
Comply with ARI 770; pilot operated, forged brass or cast bronze, stainless-steel bottom spring, pressure-gage tapings, 24-V dc standard coil, and wrought-copper fittings for brazed-end connections; suitable for refrigerant specified.

n. Pressure Relief Valves: Straight-through or angle pattern, brass body and disc, neoprene seat, and factory sealed and ASME labeled for standard pressure setting.

5. Cooling Coil A/C Condensate Drain and Floor Drain Piping that is Collecting A/C Condensate Piping:

a. Pipe & Fittings: All A/C condensate drain piping, including floor drain piping that is collecting A/C condensate, shall be constructed of Type L copper tubing, with sweat fittings made with 95-5 solder. Washout plugs (cleanouts) shall be strategically located to allow periodic flush out of system. At a minimum, provide washout plugs at equipment connections and at direction changes of 90 degrees F or greater. Also install cleanout at all equipment traps for cleaning and service.

b. Provide backwater valve (ball float type) at connections of condensate piping to stormwater piping and air gap fitting. Backwater valve shall be Model Z1099 as manufactured by Zurn or approved equal. Backwater valve shall have drain coated cast iron body, plastic ball float, bronze backwater bushing and replaceable neoprene seat.

c. Exterior condensate pipe penetrations must exit exterior wall above flashing. Extend discharge away from exterior walls as detailed.

6. Dishwasher Condensate Hood Piping:

a. Pipe & Fittings: All dishwasher condensate hood drain piping shall be constructed of stainless steel piping with threaded joints. Washout plugs (cleanouts) shall be strategically located to allow periodic flush out of system. At a minimum, provide washout plugs at equipment connections and at direction changes of 90 degrees Fahrenheit of greater.

b. Prime and paint exposed dishwasher condensate hood drain piping in color as selected by Architect.

7. Gas Fired Condensing Boiler Condensate Piping

a. Piping shall be PVC pipe, ASTM D1785 schedule 40 with ASTM D2466 socket fittings for schedule 40. Join PVC pipe/fittings utilizing solvent cement ASTM D2564 with ASTM F656 primer.

B. Steel pipe shall be similar and equal to National Tube Company, Grinnell, Republic, or Bethlehem black or zinc-coated (galvanized) as hereinafter specified. Pipe shall be free from all defects which may affect the durability for the intended use. Each length of pipe shall be stamped with the manufacturer's name.

C. Copper pipe shall be Revere, Anaconda or Chase with approved solder fittings.

D. Welding fittings for steel pipe shall meet the requirements of ASTM Standard A-23 and shall be standard catalog products. Fittings fabricated by metering and notching pipe will not be accepted.

2.2. PIPE HANGERS, ROLLER SUPPORTS, ANCHORS, GUIDES, AND SADDLES

A. All hangers for metallic piping shall be adjustable, wrought clevis type, or adjustable malleable split ring swivel type, having rods with machine threads. Hangers shall be Grinnell Company's Figure 260, Victaulic, or Shurjoint for pipe ¾-inch and larger, and Figure 65 for pipe 2-inches and smaller, or approved equal Victaulic, Shurjoint, Carpenter Patterson, or approved equal. Adjustable pipe stanchion with U-bolt shall be Grinnell Company's Figure 191. Pipe roller supports shall be Grinnell's Figure 181 or Figure 271 Victaulic or Shurjoint. Exterior pipe hangers shall be galvanized or stainless steel construction. For copper piping in direct contact with the hanger, hanger construction shall be copper coated to prevent contact of dissimilar metals similar to Grinnell's Figure CT-65. Hanger spacing and rod sizes for steel and copper pipe shall not be less than the following:

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
3/4 & 1	6	5	3/8
1 - ½	6	8	3/8
2	8	8	3/8
2 – ½	10	9	½
3	12	10	½
4	14	12	5/8
5	14	12	5/8
6	16	14	3/4
8	18	16	7/8
10	20	18	7/8

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
12	20	18	7/8

B. Anchors, guides, and roller supports shall be installed in accordance with the contract drawings and manufacturer's recommendations to provide pipe support and control pipe movement for all piping systems. Anchors and guides shall be securely attached to the pipe support structure. Submit shop drawing for proposed pipe support structure for guides and anchors for approval of the Structural Engineer. Pipe alignment guides shall be Fig. 255 Grinnell, or as approved equal. Guides shall be sized to accommodate the pipe with insulation. Guides shall be steel factory, fabricated, with bolted two section outer cylinder and base for alignment of piping and two section guiding spider for bolting to pipe.

C. Hangers for pipe sizes ½ to 1 ½ inch (13 to 38 mm): Carbon steel, adjustable swivel, split ring.

D. Hangers for cold pipe sizes 2 inches (50 mm) and over: Carbon steel, adjustable, clevis.

E. Hangers for cold pipe sizes 2 to 4 inches (50 to 100 mm): Carbon steel, adjustable, clevis.

F. Hangers for cold pipe sizes 6 inches (150 mm) and over: adjustable steel yoke, cast iron roll, double hanger.

G. Multiple or Trapeze hangers: Steel channels with welded spacers and hanger rods.

H. Multiple or Trapeze hangers for hot pipe sizes 6 inches (150 mm) and over: Steel channels with welded spacers and hanger rod, cast iron roll.

I. Wall support for pipe sizes to 3 inches (76 mm): cast iron hook

J. Wall support for pipe sizes 4 inches (100 mm) and over: Welded steel bracket and wrought steel clamp.

K. Wall support for hot pipe sizes 6 inches (150 mm) and over: welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.

L. Vertical Support: Steel riser clamp.

M. Floor support for cold pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

N. Floor support for hot pipe sizes to 4 inches (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

O. Floor support for hot pipe sizes 6 inches (150 mm) and over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.

P. Copper pipe support: Carbon steel ring, adjustable, copper plated.

Q. Hanger rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

R. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

S. For exterior pipe supports provide stainless steel, supports, brackets, hardware and anchors.

T. For pipe hangers installed in corrosive environments such as chemical storage rooms, prep rooms…etc. the same shall (including hardware) shall be finished with on Electro-Galvanized Finish such as Galv-Krom® or approved equal.

2.3. HYDRONIC EXPANSION LOOPS

A. Provide hydronic flexible expansion loops of size and material noted on drawings as manufactured by Metroloop, Flexicraft, or approved equal. Flexible loops shall be designed to impart no thrust loads on the anchors. The loop shall consist of two flexible sections of hose and braid, two 90 degree elbows, and a 180 degree return. Loops shall be installed in a neutral, precompressed, or pre-extended condition as required for application. Loops are to be installed within four pipe diameters, both upstream and downstream, from a pipe guide.

B. Where indicated provided nested loops and support the 180 degrees return bend. Nested loops shall be sized to absorb the axial compression movement as scheduled on the contract drawings.

2.4. VALVES

A. Provide parts list and assembly drawings (exploded view) for all valves in shop drawing submittals. Provide valves of the same type by the same manufacturer.

B. Check valves in base mounted pump discharges shall be of the vertical type and shall be Victaulic Series 716/ W715, Miller "non-slam" check valves, Apollo, Shurjoint SJ-900, Grinnell, or approved equal suitable for service intended. Check valves in circulator discharges shall be horizontal type.

C. Provide at each base mounted pump a suction diffuser of size and type shown on drawings. Units shall consist of a ductile cast iron angle type body with inlet vanes, magnetic insert, and blowdown connection tapped gauge post, 125 psi ANSI flange and a combination stainless steel diffuser strainer with 5/32 or 3/16-inch diameter opening for pump protection. Unit shall be equipped with a disposable fine 20-mesh stainless steel start up strainer which shall be removable after 30 days. Flow direction shall be from inside the strainer to outside for ease of service and cleaning. The body shall fit the pump and

connecting pipe size. The unit shall be provided with a base support boss or an adjustable support foot to relieve piping strains from the pump suction. Suction diffuser shall be Victaulic 731 Series, Taco "SD" Series Catalog 300-4.1, Bell and Gossett Model FLG, Armstrong, Patterson, Apollo/Shurjoint 725F, or engineer approved equal.

D. Multi-purpose valve (non-slam check valve, throttling valve, shut-off valves and calibrated balancing valve) shall be provided at discharge side of constant speed pumps. The valve shall be of heavy-duty cast iron construction with standard ANSI flanged connections and rated for a maximum working pressure of 175 psig at 240°F. The valve shall be fitted with a stainless steel stem or stem sleeve and brass seat with "O" ring seal. Valve shall be Taco "Plus One" Number 300-4.2, Bell and Gossett 3DS Triple Duty Valve, Armstrong, Patterson, or as approved equal, and shall have check and plug valve features plus a memory stop with pointer and scale. Provide additional shut-off valve to allow servicing of check valve if a multipurpose valve is utilized in lieu of separate check, shut-off, and balance valve. Provide additional shut-off valve downstream of multi-purpose valve to allow servicing of multi-purpose check valve feature. Provide pre-manufactured, removable insulation covers for all multipurpose valves.

E. Triple Duty Valve Assembly: Assembly shall consist of a Victaulic Master Seal, Apollo/Shurjoint SJ-900, Grinnell, or approved equal butterfly valve with memory stop and a Series 779 Venturi-Check, rated for water service to 230 degrees Fahrenheit (110 degrees Celsius) and pressures to 300 psig (2065-kPa).

1. For 14” through 24” sizes, Victaulic AGS-Vic300, Apollo/Shurjoint SJ-300N-L/SJ-300N-W, Grinnell, or approved equal butterfly valve with Series W715 AGS check valve, rated for pressures to 230 psig (1575-kPa).

F. Do not install multipurpose valves or balance valves on the discharge of variable speed pumps.

2.5. STRAINERS

A. Strainers shall be of the basket or "Y" type and shall be heavy and durable, constructed of ductile iron to ASTM A536 or the best grade gray iron with the bottoms drilled and plugged. Bodies shall have arrows clearly cast on the sides to show flow direction. Strainers shall be equipped with easily removable covers and brass sediment baskets made of stainless steel or brass not less than #22 gauge in thickness. Total area of basket perforations shall be not less than four times the cross section of the entering pipe. Flow shall be into basket, and then out through the perforations. Strainers shall be suitable for water or the intended fluid. Strainers 2 inches and smaller shall have threaded or solder ends, 2 inches and larger shall have flanged ends.

B. Strainer screens shall be stainless steel with perforations and shall be 1/16-inch for pipe sizes 5 inches and less, 1/8-inch (40 percent open area) perforations for pipe sizes 6-inch and greater.

C. Provide valved and capped (with chain) blowdowns in each strainer. Blowdown valves shall be Apollo 78-100/200 series or as approved equal.

D. Strainers shall be manufactured by Victaulic Style 732/W732, Watts, Mueller, Armstrong, Yarway, Spirax/Sarco, Apollo/Shurjoint 726, or as approved equal.

2.6. UNIONS, FLANGES, AND COUPLINGS

A. Unions in steel pipe 2-inches and smaller shall be malleable iron with brass inserted seats designed for a working pressure of 150 psig.

B. Unions in copper pipe 2-inches and smaller shall be sweat fittings with bronze seats designed for a working pressure of 125 psig.

C. Unions in stainless steel pipe 2-inches and smaller shall be hexagonal threaded type stainless steel unions, with VicPress ends. Basis of Design: Victaulic Style P584.

D. Flanges for steel pipe over 2 inches shall be 150 psig, forged steel, slip on. Gaskets shall be 1/16 inch thick pre-formed neoprene.

E. Flanges for copper pipe over 2 inches shall be bronze. Gaskets shall be 1/16 inch thick preformed neoprene.

2.7. MANUAL AIR VENTS

A. Manual air vents shall be similar to the hereinafter specified gauge valves. Provide 1/4-inch size on ¾-inch pipe and smaller, ½ -inch size on 1-inch pipe and larger. Install at all high points of piping. Valves shall be Crane No. 88, or as approved equal, with threaded ends, bronze body, bronze or brass bonnet and bronze stem.

2.8. AUTOMATIC AIR VENTS

A. Provide at air separators, expansion tanks and where shown on the drawings, float actuated non-modulating high capacity air vent to purge free air from the system and provide a positive shut-off at pressures up to 150 psig at a maximum temperature of 250 degrees Fahrenheit. The high capacity air vent shall prevent air from entering the system if the system pressure drops below atmospheric pressure. The air vent shall be pilot operated for intermittent purging of free air up to pressures of 2 psig during normal system operation and diaphragm operated for full capacity purging of free air at pressures between 2 and 150 psig. The high capacity air vent shall be constructed of cast iron and fitted with components of type 313 stainless steel, brass, EPDM and silicone rubber. Pipe discharge to closest floor drains with Type K copper tubing. The high capacity vent shall be Model 107 by Bell and Gossett, Model 13w by Spirax Sarco, Taco, Spirotherm Spirotop, or as approved equal.

2.9. THERMOMETERS

A. Unless otherwise indicated, thermometers shall be ASTM E1, in a glass type, organic filled, 9-inch scale size, corrosion-resistant metal case, with "any-angle" mounting with positive locking device. Trerice Industrial Thermometers, Weksler Instruments, Ernst Gage Co., Miljoco, or approved equal. Insertion stem length shall suite the pipe size and configuration. Thermometer wells shall be brass with brass union hubs in copper and in ferrous piping. Where piping is insulated or otherwise covered, use wells with lagging extension. Where wells are installed in pipe tees at turns, increase pipe size so that well does not restrict flow. Accuracy shall be 2 percent.

B. Unless otherwise indicated, thermometer ranges shall be as follows:

1. Chilled water systems: 0 degrees F to 100 degrees Fahrenheit, 1 degrees Fahrenheit Division

2. Heating Water: 30 degrees Fahrenheit to 240 degrees Fahrenheit, 2 degrees Fahrenheit Division.

C. Provide heat conducting compound in wells.

2.10. PRESSURE GAUGES

A. Unless otherwise indicated, pressure gauges shall be the bronze bourdon tube type, 4-1/2-inch dial, stem mounting, cast aluminum adjustable pointer, 1 percent accuracy over middle half of scale range, 1-1/2 percent over balance: Trerice Model 600C; Weksler Instruments, Ernst Gage Co., Miljoco, or as approved equal.

B. Gauges shall have pressure, vacuum, compound, or retard ranges as required, select ranges so that the normal readings are at the approximate midpoint and maximum system pressures do not exceed full scale.

C. Furnish and install a gauge valve at each pressure gauge. Gauge valves shall be Crane Model No. 88, Needle Valve, Ernst Gage Co. FLG 200, Wexler Instrument Corp. Type BBV4, or approved equal, rated for pressure intended.

D. Gauge connections for pressure gauges, thermometers, or control instruments shall be made using tee fittings, except that gauge connections up to 1-inch size in steel may be using threaded extra heavy pipe couplings welded directly to the main, provided that the main is at least 2-inch size for 2-inch connections, 3-inch size for 3/4-inch connections, and 4-inch size for 1-inch connections. Minimum gauge connection shall be 2-inch ips.

E. Provide snubbers on all gauges. Snubbers shall be No. 872 by Trerice, RS1/RS6 by Wexler Instruments, Miljoco or as approved equal.

2.11. FLOW METER FITTINGS

A. Griswold or Bell & Gossett Venturi disturbed flow measurement quickset flow meter fittings shall be utilized for hydronic flow measurement. Units shall consist of a spun steel venturi welded into the pipe. Disturbed fluid shall be channeled through the throat of the venturi with a multi-point Piezo Ring. Accuracy shall be ± 1% PSID with no straight pipe run required.

2.12. PIPING SPECIALTIES

A. Furnish and install flexible pipe connections, as specified and/or shown on the drawings, at suction and discharge connections of all base mounted and vertical in-line pumps, connections to chillers, all vibrating equipment, and elsewhere as shown. Pump flexible connections shall be utilized at pumps. Refer to Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment for specifications.

B. Pressure relief valves shall be provided in the number and sizes required to relieve 110 percent of the full input to the systems. Valves shall be rated; and installed in accordance with ASME, and CSD-1 including all amendments. Pipe discharge full size to floor drain,

(with union) and support discharge pipe to prevent exerting any strain on relief valve body, piping to be Type-L copper. Water safety relief valves shall be Watts Series 740, Conbraco, Series 154A, Bell and Gossett, or approved equal. Provide pressure gauge adjacent to all safety relief valves.

C. Gas relief valve piping shall be sized and installed in accordance with the latest edition of ASME Boiler & Pressure Vessel Code, CSD-1 including amendments. Pipe material shall be as specified for gas piping. Gas relief valve piping material shall be the same as hereinbefore specified for gas piping.

2.13. ESCUTCHEONS

A. Provide chromium plated escutcheons properly fitted and secured with set screws on all exposed piping which passes through walls, floors or ceilings of finished spaces.

B. All escutcheon plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface. Plastic escutcheon plates will not be accepted.

2.14. DIELECTRIC CONNECTIONS (BRASS FITTINGS)

A. Furnish and install brass fittings, unions, waterway fittings, or flanges, at the following locations:

1. Where steel piping systems join copper piping.

2. Where copper tube connects to heat exchangers, expansion tanks, and other steel vessels.

3. Avoid the installation of steel nipples, cast iron or steel valves and specialties, or other ferrous components in predominately copper piping systems. Where such installation is necessary, isolate the component with brass fitting connections. Do not mix steel pipe and copper tube in the same run of pipe or in the same section of a piping system.

2.15. SLEEVES

A. Sleeves shall be provided around all pipes through walls, floors, ceilings, partitions, roof structure members or other building parts. Sleeves shall be standard weight galvanized iron pipe two sizes larger than the pipe or insulation so that pipe or insulation shall pass through masonry or concrete walls or floors. Provide 20 gauge galvanized steel sheet or galvanized pipe sleeves for all piping passing through frame walls.

B. Sleeves through floors shall be flush with the floor except for sleeves passing through Equipment Rooms which shall extend ¾-inch above the floor. Refer to Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment for mechanical equipment room penetrations additional requirements. Space between the pipe and sleeve shall be caulked. Escutcheon plates shall be constructed to conceal the ends of sleeves. Each trade shall be responsible for drilling existing floors and walls for necessary sleeve holes. Drilling methods and tools shall be as hereinbefore specified.

C. Sleeves through walls and floors shall be sealed with a waterproof caulking compound.

D. Firestop at sleeves that penetrate smoke barriers smoke partitions and/or rated walls/floors.

2.16. PRESSURE REDUCING VALVES

A. Provide pressure reducing valves as indicated, of size and capacity selected by the installer to maintain operating pressure on the system. Body shall be cast-iron or bronze construction, renewable stainless steel seat, non-corrosive disc, water tight cage assembly, adjustable pressure ranges and inlet strainer Watts Regulator Model 223-S, Armstrong, Bell and Gossett, Apollo 36LFPR, or as approved equal.

B. Provide pressure gauge adjacent to all pressure reducing valves to verify proper set point.

2.17. WATER PROOF PIPE PENETRATION SEALS

A. Provide and install waterproof pipe penetration seals at all pipes that enter the building below grade or through exterior wall.

B. Link seals are to be Metraflex Metraseals, Model MS, Linkseal, or approved equal, black EPDM seal material, glass reinforced plastic pressure plates, zinc plated nuts and bolts, seals are to be resistant to sunlight and ozone, pressure rated to make a hydrostatic seal of up to 20 psig and up to 40 feet of head, temperature rated from –40 degrees F to 250 degrees Fahrenheit.

2.18. TEST PLUGS

A. Where indicated, furnish and install P/T plugs or Pete's Plugs as manufactured by IMAC Systems or approved equal.

B. Description: Nickel-plated, brass-body test plug in NPS 2 (DN15) fitting. Test plugs shall be as manufactured by Trerice, Watts, Natural Meter, Apollo Brass Test Plugs, or approved equal. Test-station fitting made for insertion in piping tee fitting.

C. Body: Length as required to extend beyond insulation. Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS ¼ (DN 8) or NPS ½ (DN15) as required, ASME B1.20.1 pipe thread.

E. Pressure Rating: 500 psig minimum.

F. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

G. Core Inserts: One or two self-sealing valves, suitable for inserting 1/8 inch OD probe from dial-type thermometer or pressure gage. Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

H. Core Insert: Self-sealing valve, suitable for inserting 1/8 inch OD probe from dial-type thermometer or pressure gage.

I. Core Material for Air, Water, Oil, and Gas: 20 to 300 degrees F chlorosulfonated polyethylene synthetic rubber.

J. Test-Plug Cap: Gasketed and threaded cap, with retention chain or strap.

K. Test Kit: Pressure gage and adapter with probe, two bimetal dial thermometers, and carrying case.

L. Pressure Gage and Thermometer Ranges: approximately two times the system's operating conditions.

M. Self-closing valves with caps and retaining straps.

2.19. FLO-CONTROL VALVES

A. Furnish and install flo-control valves as shown on contract drawings to prevent gravity circulation in forced hot water systems. Flo-control valves shall be Bell & Gossett flo-control valves, TACO flo checks, or approved equal.

B. Flo-control valves shall be suitable for installation in vertical or horizontal piping. Disc shall be precision machined bronze. Valve seats shall be heavy wall brass. Flo-control valves shall be suitable for a maximum operating temperature of 275 degrees F and a maximum working pressure of 125 psig. Flow-control valves shall not be selected based on line size. Select flow-control valves at design flow rate to limit pressure drop to 6 Ft head.

C. Flo-control valves shall be constructed to allow cleaning without breaking pipe connections. Flo-control valves shall be installed with clearances from center line of valves to ceiling as required by manufacturer. Flo-control valves shall feature a manual open position for gravity circulation.

2.20. TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.

2. Pressure rating at least equal to pipes to be joined.

3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Plastic-to-Metal Transition Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Charlotte Pipe and Foundry Company.
b. Harvel Plastics, Inc.
c. Spears Manufacturing Company.

2. Description: PVC or CPVC one-piece fitting with manufacturer's Schedule 80

equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket end.

D. Plastic-to-Metal Transition Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Colonial Engineering, Inc.
b. NIBCO INC.
c. Spears Manufacturing Company.

2. Description: PVC or CPVC four-part union. Include brass threaded end, solvent-cement-joint plastic end, rubber O-ring, and union nut.

PART 3. EXECUTION

3.1. GENERAL PIPING INSTALLATION REQUIREMENTS

A. All pipes shall be cut accurately to measurements established at the building, and shall be worked into place without springing or forcing, properly clearing all windows, doors and other openings. Excessive cutting or other weakening of the building structure to facilitate piping installation will not be permitted. All pipes shall be so installed as to permit free expansion and contraction without causing damage. All horizontal mains shall pitch down in the direction of flow with a grade of not less than 1 inch in 40 feet. All open ends of pipe lines, equipment, etc., shall be properly capped or plugged during installation to keep dirt or other foreign material out of the system. All pipes shall be run parallel with the lines of the building and as close to walls, columns and ceilings as may be practical, with proper pitch. All piping shall be arranged so as not to interfere with removal of other equipment on devices not to block access to doors, windows, manholes, or other access openings. Flanges or unions, as applicable for the type of piping specified, shall be provided in the piping at connections to all items of equipment, coils, etc., and installed so that there will be no interference with the installation of the equipment, ducts, etc. All valves and specialties shall be placed to permit easy operation and access and all valves shall be regulated, packed and glands adjusted at the completion of the work before final acceptance. All piping shall be installed so as to avoid air or liquid pockets throughout the work. Ends of pipe shall be reamed so as to remove all burrs.

B. All piping shall be graded to convey entrained air to high points where automatic air vents shall be provided. The size of supply and return pipes for each piece of equipment shall in no case be smaller than the outlets in the equipment.

C. All piping shall be run to provide a minimum clearance of 2-inches between finished covering on such piping and all adjacent work. Group piping wherever practical at common elevations.

D. All valves, strainers, caps, and other fittings shall be readily accessible.

E. Drain valves with hose connections shall be provided at low points for drainage of piping systems. Blow down valves shall be provided at the ends of all mains and branches so as to properly clean by blowing down the lines throughout in the direction of normal flow.

F. Discharge lines from all relief valves shall be piped to within 4-inches of floor and extend to floor drains wherever floors are not pitched to drains. Pitch the relief valve piping away from the relief valve to issue that no fluid can be trapped in valve discharge. Support all relief valve piping to prevent exerting strain on the relief valve body. The end of the relief valve discharge piping shall not be threaded to prevent capping or plugging.

G. All branches from water mains shall be taken from the top of the supply mains at an angle of forty-five (45) degrees above the horizontal, unless otherwise directed. Branches feeding down shall be taken from the side or bottom of the main on water mains only. All connections shall be carefully made to insure unrestricted circulation, eliminate air pockets or trapped condensate, and permit the complete drainage of the system.

H. Cutoff valves shall be provided on each branch line from the mains on all heating/air conditioning lines.

I. Shut-off valves shall be installed at the inlet and outlet of each coil and piece of equipment to permit isolation for maintenance and repair. Units having multiple coils shall have separate valves for each coil.

J. Balancing valves shall be installed in all heating/air conditioning water branches and at all pumps, and where indicated on the drawings.

K. Unions shall be installed on all bypasses, ahead of all traps, at all connections to equipment, where shown on drawings or where required to facilitate removal of equipment whether shown or not.

L. Spring clamp plates (escutcheons) shall be provided where pipes are exposed in the building and run through walls, floors, or ceilings. Plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface.

M. If the size of any piping is not clearly evident in the drawings, the Contractor shall request instructions for the Engineer as to the proper sizing. Any changes resulting from the Contractor's failure to request clarification shall be at his expense. Where pipe size discrepancies or conflicts exist in the drawings, the larger pipe size shall govern.

N. Approved expansion loops shall be provided to permit free expansion and contraction of all piping systems.

O. Install all valves with stem upright or horizontal, not inverted.

P. Where pipe support members are welded to structural building framing, scrape, brush clean, weld and apply one coat of zinc rich primer.

Q. Provide clearance for installation of insulation and access to valves and fittings.

R. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

S. All water containing pipes shall be routed clear of combustion air dampers and louvers to prevent freezing condition when dampers are open.

T. Provide manual air vents at top of piping systems.

3.2. THERMOMETER AND PRESSURE GAGE INSTALLATION REQUIREMENTS.

A. Install thermometers and adjust vertical and tilted positions.

B. Install separable sockets in vertical position in piping tees where fixed thermometers are indicated.

1. Install with socket extending to one-third diameter of pipe.

2. Fill sockets with oil or graphite and secure caps.

C. Install pressure gages in piping tees with pressure-gage valve located on a pipe at most readable location.

D. Adjust faces of thermometer and gages to proper angle for best visibility.

E. Clean windows of thermometer and gages and clean factory-finished surfaces. Replace cracked and broken window, and repair scratched and marred surfaces with manufacturer's touch up paint.

3.3. VALVE INSTALLATION REQUIREMENTS

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

G. Install valves as indicated, according to manufacturer's written instructions.

H. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

I. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

J. Locate valves for easy access and provide separate support where necessary.

K. Install valves in horizontal piping with stem at or above the center of the pipe.

L. Install valves in a position to allow full stem movement.

M. For chain wheel operators, extend chains to 60 inches above finished floor elevation.

N. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

O. Install flow control valves with clearances from center line of valve to ceiling to allow servicing as required by manufacturer.

3.4. REFRIGERANT PIPING AND ACCESSORIES INSTALLATION REQUIREMENTS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise. All exposed piping shall be hard copper tubing with brazed joints. Refer to Architectural Contract Documents to determine exposed areas.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to units to allow service and maintenance.

G. Install piping free of sags and bends. Install VEE clevis hangers and VEE troughs on pipes less than ¾”inch in diameter.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified if valves or equipment requiring maintenance is concealed behind finished surfaces.

L. Install refrigerant piping in protective conduit where installed below ground.

M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

N. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.

2. Install horizontal suction lines with a uniform slope downward to compressor.

3. Install traps and double risers to entrain oil in vertical runs.

4. Liquid lines may be installed level.

O. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

P. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

Q. Identify refrigerant piping and valves.

R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section, “Common Work Results for HVAC”.

S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section, “Common Work Results for HVAC”.

T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section, “Common Work Results for HVAC”.

U. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6m) long.

2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6m) or longer.

3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6m) or longer, supported on a trapeze.

4. Spring hangers to support vertical runs.

5. Copper-clad hangers and supports for hangers and supports in direct contact with

copper pipe.

V. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS ½ (DN 15): Maximum span, 60 inches (1500mm); minimum rod size, ¼ inch (6.4mm).

2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500mm); minimum rod size, ¼ inch (6.4mm).

3. NPS 1 (DN 25): Maximum span, 72 inches (1800mm); minimum rod size, ¼ inch (6.4mm).

4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400mm); minimum rod size, 3/8 inch (9.5mm).

5. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400mm); minimum rod size, 3/8 inch (9.5mm).

6. NPS 2 (DN 50): Maximum span, 96 inches (2400mm); minimum rod size, 3/8 inch (9.5mm).

7. NPS 2-½ (DN 65): Maximum span, 108 inches (2700mm); minimum rod size, 3/8 inch (9.5mm).

8. NPS 3 (DN 80): Maximum span, 10 feet (3m); minimum rod size, 3/8 inch (9.5mm).

9. NPS 4 (DN 100): Maximum span, 12 feet (3.7m); minimum rod size, 1/2 inch (13mm).

W. For all interior refrigerant pipe/tubing that is less than 3/4inch in diameter, utilize VEE type clevis hanger Model 200 V and VEE type trough Model 200 VT; as manufactured by Carpenter and Patterson or approved equal. VEE trough materials shall be carbon steel with pre-galvanized finish. Install as required to maintain maximum hanger spacing requirements.

X. Support multifloor vertical runs at least at each floor.

Y. Furnish and install complete refrigerant piping systems between the indoor units and outdoor units, indoor units, and compressor units. Support piping in accordance with Division 23 Section, HVAC Piping, Fittings, Valves, Etc. Piping shall be sized as recommended by unit manufacturer taking into account length of vertical and horizontal runs, and refrigerant type. Provide and install dual sets of refrigerant piping on all units required to have dual independent circuits.

Z. Furnish and install all required piping accessories including, but not limited to, thermal expansion valves, Sporlan, or approved equal; Packless isolation valves at condenser and evaporator coil, Henry or approved equal, charging valve with chained seal cap, Henry or approved equal, sight glasses, Henry or approved equal; filter dryer with replaceable

cartridge, Sporlan, or approved equal, liquid line solenoid valve l20V/1/60 Hz., Sporlan, or approved equal. Contractor shall provide traps and double suction risers if required by equipment manufacturer. Pitch piping for proper oil return. Submit shop drawings on all components, and piping arrangements.

AA. All accessories shall be ARI rated. Furnish required nitrogen and refrigerant to fully test and charge system. Flood piping system with nitrogen when brazing.

BB. Refrigerant piping shall be Type 1 hard temper (ACR) copper tubing with wrought copper brazed fittings. Make joints with brazed wrought copper fittings.

CC. Refrigerant piping shall be cleaned, dehydrated and evacuated. Piping shall be evacuated and held to less than 2.5 mm Hg vacuum for a period of not less than 12 hours without appreciable pressure rise. Vacuum shall then be broken with refrigerant or dry nitrogen and re-evacuated to 2.5 mm Hg vacuum for an additional 12 hours. Piping test to be witnessed by Owner's representative and documented in writing. Submit results of tests to Architect/Engineer.

DD. All refrigerant/suction lines sets shall be fully insulated. Exterior pipe insulation shall be fully jacketed as specified in Division 23 Section, “HVAC Insulation”. Exposed interior pipe insulation shall be fully jacketed as specified in Division 23 Section, “HVAC Insulation”.

EE. Follow ASHRAE 15, latest edition procedures for charging and purging of systems and for disposal of refrigerant.

FF. Provide replaceable cartridge filter-driers, with isolation valves and valved bypass.

GG. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.

HH. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.

II. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.

JJ. Fully charge completed system with refrigerant after tested.

KK. Provide electrical connection to solenoid valves.

LL. Install liquid indicators in liquid line leaving condenser, in liquid line and on leaving side of liquid solenoid valves.

MM. Install strainers immediately upstream from each automatic valve, including expansion valves, solenoid valves, hot-gas bypass valves, and compressor suction valves.

NN. Install strainers in main liquid line where multiple expansion valves with integral strainers are used.

OO. Install moisture-liquid indicators in liquid lines between filter-dryers and thermostatic

expansion valves and in liquid line to receiver.

PP. Install flexible connectors at or near compressors where piping configuration does not absorb vibration.

QQ. Test and inspect refrigerant piping according to ASME B31.5, Chapter VI.

1. Test refrigerant piping and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure.

2. Test high- and low-pressure side piping of each system at not less than the lower of the design pressure or the setting of pressure relief device protecting high and low side of system.

    a. System shall maintain test pressure at the manifold gage throughout duration of test.
    b. Test joints and fittings by brushing a small amount of soap and glycerin solution over joint.
    c. Fill system with nitrogen to raise a test pressure of 150 psig (1035 kPa) or higher as required by authorities having jurisdiction.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

RR. Adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.

SS. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

TT. Adjust set-point temperature of the conditioned air or chilled-water controllers to the system design temperature.

UU. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.

2. Check compressor oil level above center of sight glass.

3. Open compressor suction and discharge valves.

4. Open refrigerant valves, except bypass valves that are used for other purposes.

5. Check compressor-motor alignment, and lubricate motors and bearings.

VV. Before installing copper tubing other than Type ACR, clean tubing and fittings with trichloroethylene.

WW. Replace core of filter-dryer after system has been adjusted and design flow rates and pressures are established.

XX. Charge system using the following procedures:

1. Install core in filter-dryer after leak test but before evacuation.

2. Evacuate entire refrigerant system with a vacuum pump to a vacuum of 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.

3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).

4. Charge system with a new filter-dryer core in charging line. Provide full-operating charge.

3.5. DIRECT BURIED HEATING SUPPLY/RETURN PIPING INSTALLATION REQUIREMENTS

A. Install piping and equipment as indicated, according to manufacturer's written instructions.

B. Provide conduit elbows where pipes penetrate flooring.

C. Install piping with bending radius not less than recommended by piping manufacturer.

D. Test and flush piping. Prepare written report of testing.

E. Locator Tape: Install detectable metallic tape above all direct buried piping.

F. The installing contractor shall handle the system in accordance with the directions furnished by the manufacturer and as approved by the architect and engineer. Manufacturer's field technical assistance (F.T.A.) shall be included and shall be required for the following "Critical" periods of the installation:

1. Unloading of all Trucks

2. Final Service Pipe Hydro Testing

3. Initial Field Joint Insulation and Jacketing

4. Initial Backfill

G. The field technical service representative shall provide a written report of instructions given and activities observed during the site visit(s). The technician shall be on site to monitor the progress of the installation for a minimum of five (5) days. Upon completion of the installation the manufacturer shall certify, in writing, to the contractor that the preinsulated piping system has been installed in accordance with installation manual and warranty requirements. The contractor shall provide the owners representative with a copy of the certification letter.

H. The contractor shall store, handle and place the pipe in strict accordance with the manufacturer's installation pamphlet.

I. In the event the contractor fails the final hydrostatic test the contractor shall be solely responsible for locating and repairing any leak(s).

J. The service piping shall be hydrostatically tested to 225 psig or 1½ times the operating

pressure, whichever is greater, for a period of two (2) hours, no pressure drop shall be allowed.

K. Field joint coating, insulation, leak detection assembly and jacketing shall be in strict accordance with the installation pamphlet and factory technicians written instructions.

3.6. PIPE JOINTS INSTALLATION REQUIREMENTS

A. Grooved Joints: Grooved joint shall be installed in accordance with the manufacturer's written recommendations. Grooved ends shall be clean and free from indentations, projections, or roll marks. The gasket shall be molded and produced by the coupling manufacturer of an elastomer suitable for the intended service. The coupling manufacturer's factory trained representative shall provide on-site training for the contractor's field personnel in the use of grooving tools and installation of product. The representative shall periodically visit the job site to ensure best practices in grooved product installation are being followed. (A distributor's representative is not considered qualified to conduct the training.)

B. Screwed Joints: All screwed joints shall be made with tapered threads properly cut. Screwed joints shall be made perfectly tight with a stiff mixture of graphite and oil, applied with a brush to the male threads on the fittings.

C. Brazed Joints and Copper Piping: Joints in copper piping shall conform to the following minimum standards.

1. The pipes shall be cut to a length making certain that the ends are square, using a fins hacksaw blade or tube cutter. The ends of all pipes shall be reamed and all burrs removed.

2. The outside end of the pipe and the cut end of the fitting shall be cleaned with steel wool, sand cloth, or steel wire brush. All dark spots shall be removed.

3. The flux shall be applied evenly and sparingly to the outside end of the pipe and the inside of the outer end of the fitting until all surfaces to be jointed are completely covered. The piping and fitting shall be slipped together and reworked several times to insure an even distribution of the flux.

4. The correct amount of brazing material per joint for each size pipe shall be used in accordance with the manufacturer's recommendations.

5. Brazed joints shall be made by using a direct flame from a torch.

6. On pipe sizes larger than ¼-inch, the fittings and valves in the pipe shall be moved or tapped with a hammer when the brazing material starts to melt to insure an even distribution of the brazing material.

7. The excess brazing material shall be removed while it is still in the plastic state leaving a fillet around the cup of the fitting.

8. Brazed joints shall be suitable for working pressure of 550 psig and for working temperature of not less than 250 degrees F. The type of brazing material and flux

used will be submitted for approval. Type 95-5 shall be the minimum standard.

9. Lead and antimony-based solders shall not be used for potable water systems. Brazing and silver solders are acceptable.

D. Where copper piping joins steel piping, approved bronze adapters shall be used.

E. Prohibited Connections: No direct weld or brazed connections without unions or flanges, shall be made to valves, strainers, apparatus, or related equipment. Right and left couplings, long threads, or caulking of pipe threads or gasket joints will not be permitted.

3.7. HANGERS, SUPPORTS, ANCHORS, GUIDES INSTALLATION REQUIREMENTS

A. General: All hangers shall be of an approved type arranged to maintain the required grading and pitching of lines to prevent vibration and to provide for expansion and contraction. Provide protection saddles between hangers and insulation on heating water insulated pipe. Saddles shall be Grinnells Figure 173/273 or approved equal. Provide approved spacers between saddles and pipe where flexible insulation is specified. Provide insulation protection shields for insulated piping without saddles. Shield shall be Grinnell Figure 167 or as approved equal.

B. Spacing: Regardless of spacing, hangers shall be provided at or near all changes in direction, both vertical and horizontal, for all piping.

C. Pipes to be supported off every joist/beam in the perpendicular direction or at 6 feet on center in the parallel direction. Piping 6 inches or greater shall have their own individual hangers.

D. Vertical Lines: Shall be supported at their bases, using either a suitable hanger placed in a horizontal line near the riser, or a base type fitting set on a pedestal, foundation or support. All vertical lines extending through more than one floor level shall be supported at each floor with a riser clamp. Riser clamp shall be Grinnell Co.'s Figure 261, or approved equal. All vertical drops to pump suction elbows shall be supported by floor posts.

E. Racks and Brackets: All horizontal piping on vertical walls shall be properly supported by suitable racks securely anchored into the wall construction. Where not practical to obtain ceiling anchorage, all piping near walls shall be supported by approved brackets securely anchored into the wall construction. Washer plates (Fib. 60, 60L) and other miscellaneous attachments, fasteners, etc., shall be Grinnell or as approved equal. All exterior hanger and bracket systems in their entirety shall be galvanized.

F. Pipe Hangers and supports shall be attached to the panel point at the top chord of bar joist or at a location approved by the structural engineer.

G. Select hangers and components for loads imposed. Secure rods with double nuts.

H. Support of horizontal piping shall allow for vertical adjustment after installation of piping.

I. Support overhead piping with clevis hangers.

J. Do not support all parallel piping from the same joist. Stagger all supports in accordance

with the structural engineer's recommendations.

K. Install guides on piping adjoining expansion fittings and loops.

L. Attach guides to pipe and secure to building structure.

M. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

N. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

O. Construct concrete anchors of poured in place concrete of dimensions indicated and include embedded fasteners.

P. Install pipe anchors according to expansion fitting manufacturer's written instructions if expansion fittings are indicated.

Q. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

R. Refer to structural documents for appropriate connection/attachment materials to building.

3.8. AIR VENTING INSTALLATION REQUIREMENTS

A. The top of each hydronic water supply and return piping and other points as indicated or where necessary for the removal of air from the system or equipment, shall be vented using an approved type of manual air vent.

B. In addition to manual air vents at high points of system, each item of water heat transfer equipment shall be manually vented using an approved type manual air vent. All air vents shall be accessible.

3.9. EXPANSION LOOPS AND SWING CONNECTION INSTALLATION REQUIREMENTS

A. Install expansion fittings according to manufacturer's written instructions.

B. Install expansion fittings in sizes matching pipe size in which they are installed.

C. Align expansion fittings to avoid end loading and torsional stress.

D. Install pipe bends and loops cold sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

E. Attach pipe bends and loops to anchors.

1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

F. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

G. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

H. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.10. PIPING IDENTIFICATION INSTALLATION REQUIREMENTS

A. All piping shall be identified with painted background marked with the name of the service with arrows to indicate flow direction. Color code and system identification shall comply with ANSI Standards and piping identification system shall comply with ASME A13.1-81., scheme for the identification of piping systems and ASHRAE Fundamentals Handbook, latest edition.

B. Markings shall be plain block letters, stenciled on pipes, and shall be located near each branch connection, near each valve, and at least every 10 feet on straight runs of pipe. Where pipes are adjacent to each other, markings shall be neatly lined up. All markings shall be located in such manner as to be easily legible from the floor. Pipe identification schedule shall be as follows:

OUTSIDE DIAMETER OF PIPE OR COVERING (INCHES)	LENGTH OF COLOR FIELD (INCHES)	SIZE OF LETTERS (INCHES)
½ to 1 ¼	8	½
1-½ to 2	8	¾
2 ½ to 6	12	1 ¼
8 to 10	24	2 ½
Over 10	32	3 ½

3.11. VALVE IDENTIFICATION REQUIREMENTS

A. All valves shall be tagged with a numbered tag.

B. The tags shall be made of 1-inch diameter brass tags fastened to the valve by means of brass chains. Numbers shall agree with valve numbers on diagrammatic herein before specified.

C. Provide a minimum of six (6) valve charts with valve numbers indicating valve type, size, manufacturer and service.

D. Additional valve charts shall be mounted behind glazed wooden frames and be hung in each mechanical equipment room including each air handling unit mechanical equipment room. Additional copies shall be provided in each copy of the O&M manuals.

3.12. CLEANING PIPING AND EQUIPMENT

A. All chilled water, condensate, heating water, HVAC, systems shall be cleaned by filling with a solution of one (1) pound of trisodium phosphate to each 50 gallons of water and circulating this solution for a period of six (6) hours during which time the system shall reach operating temperature. The systems shall then be flushed with fresh water and refilled with fresh water and/or where indicated antifreeze solution and purged of all air.

B. All glycol, condensate, chilled water, heating water, HVAC, piping system shall be flushed clean with fresh water. See Division 22 Sections, Plumbing Fixtures and Plumbing Equipment for domestic potable water cleaning and sterilization. Where indicated, hydronic systems shall be filled with 30 percent by volume antifreeze.

C. Any equipment, such as coils that have small tubing, shall be bypassed to prevent deposition of debris from the piping. Water balancing shall not be scheduled until the completion of the cleaning and treatment process.

D. All strainers shall be inspected and cleaned prior to testing and balancing. In addition, prior to substantial completion, contractor must inspect and clean all strainers.

3.13. PRESSURE SEAL FITTING INSTALLATION REQUIREMENTS

A. Viega, ProPress Pressure Seal bronze or copper fittings: Sealing element shall be verified for the intended use. Tube ends shall be cut on a right angle (square) to the tube. Tube ends shall be reamed and chamfered, all grease, oil or dirt shall be removed from the tube end with a clean rag. Visually examine the fitting sealing element to ensure there is no damage, and it is properly seated into the fitting. Utilizing a Viega Insertion Depth Inspection Gauge mark the tube wall, with a felt tip pen, at the appropriate location, or insert the tube fully into the fitting and mark the tube wall at the face of the fitting. Always examine the tube to ensure it is fully inserted into the fitting prior to pressing the joint. ProPress fittings ½-inch thru 4-inch shall be installed according to the most current edition of the Viega installation guidelines, using appropriate sized rigid ProPress tools. Installers shall attend a Viega ProPress installation training class.

B. After ProPress Pressure Seal fittings have been installed a “two step test” shall be followed. Pressurize the system with application appropriate test medium, water between 15 and 85 psi, or air/dry nitrogen between .5 and 45 psi. Check the pressure gauge for pressure loss. If the system does not hold pressure, walk the system and check for un-pressed fittings.

Should you identify an un-pressed fitting ensure the tube is fully inserted into the fitting, and properly marked, prior to pressing the joint. After appropriate repairs have been made, retest the system per specification requirements, not to exceed 600 psi with water.

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VIBRATION CONTROLS FOR HVAC, PLUMBING & FIRE PROTECTION EQUIPMENT
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SECTION 230548
VIBRATION CONTROLS FOR HVAC, PLUMBING AND FIRE PROTECTION EQUIPMENT

PART 1. RELATED DOCUMENTS

1.1. GENERAL

A. Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections apply to work of this section.

B. All work under this section shall also be subject to the requirements of Division 23 Section, Common Work Results for HVAC.

1.2. SUMMARY

A. Provide all labor and materials necessary to furnish and install vibration control systems on this project as herein specified and/or shown on the drawings.

B. Mount all mechanical equipment on suitable vibration isolators so as to prevent transmission of vibration into or through the building structure. Isolators shall be as manufactured by Mason Industries, Inc., Korfund, Inc., Amber Booth, Vibration Mounting and Controls, or approved equal, and shall be selected by the isolator manufacturer for each item of equipment in accordance with requirements hereinafter specified.

C. The equipment manufacturer shall supply all pump and motor bases, fan and motor bases, cradles, isolation pipe/duct hangers, spring and/or neoprene isolators, neoprene pads, flexible connectors, etc. as a coordinated package by a single manufacturer.

D. Select isolators for uniform static deflections according to distribution of weight; and for not less than the indicated isolation efficiency with the lowest rotational speed of equipment as the disturbing frequency.

E. Isolators and bases shall be stable during stopping and starting of equipment without transverse or eccentric movement of equipment, and shall be designed to resist horizontal forces of equipment which may operate unbalanced.

F. In general, select isolators on the basis of criteria as specified in the ASHRAE Applications Handbook, Latest Edition.

1.3. SUBMITTALS

A. Shop Drawings: Indicate inertia bases and locate vibration isolators, with static and dynamic load on each.

B. Product Data: Provide schedule of vibration isolator type with location and load on each.

C. Manufacturer’s Installation Instructions: Indicate special procedures and setting dimensions.

D. Manufacturer’s Certificate: Certify that isolators are properly installed and adjusted to meet or exceed specified requirements.

1.4. PROJECT RECORD DOCUMENTS

A. Record actual locations of hangers including attachment points.

1.5. COLOR CODING

A. All springs shall be color coded for load carrying capacity.

1.6. ALTERNATES

A. Refer to Division 01 Section, Alternates - Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. MANUFACTURERS

A. Isolators shall be the equivalent of the following types by Mason Industries, Inc., Korfund, Inc., Kinetic Noise Control, Inc., Vibro Acoustics or approved equal.

2.2. CORROSION PROTECTION FOR STEEL PARTS

A. Where steel parts are exposed to weather or humid environments provide hot-dipped galvanized coating of at least 2 ounces of zinc per square foot of surface. Coat springs with neoprene.

2.3. SPRING MOUNTS AND SOUND PADS

A. Provide all spring mounts with leveling devices, minimum .25 inch thick neoprene sound pads, and zinc chromate plated hardware.

B. All sound pads shall be size for minimum deflection of .05 inch; meet requirements for neoprene pad isolators.

2.4. SPRINGS

A. All springs shall have minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between .3 and .6 of maximum deflection.

2.5. NEOPRENE

A. Grade durometer 40, 50 OR 60 AND OIL RESISTANT.

2.6. FLOOR MOUNTED ISOLATORS:

A. Neoprene Isolation Pads: Provide pads at least ¼ " thick with cross-ribbed or waffle design. For concentrated loads provide steel bearing plates bonded or cold cemented to the pads. Neoprene isolation pads shall be Type Super W.

B. Neoprene Isolators: Rubber (neoprene)-in-shear mounting: Provide molded neoprene isolators having steel base plates with mounting holes and, at the top, steel mounting plates

with mounting holes or threaded inserts. Provide elements of type and size coded with molded letters or color-coded for capacity identification. Embed metal parts completely in neoprene. Double deflection neoprene mountings shall have a minimum static deflection of 0.35". Bolt holes shall be provided for these areas where bolting is required. On equipment such as small vent sets and close coupled pumps, steel rails shall be used above the mounting to compensate for the over-hang. Mountings shall be type ND or rails type DNR.

2.7. SPRING ISOLATORS

A. General: Provide spring isolators or protected spring isolators that are adjustable and laterally stable with free-standing springs of horizontal stiffness at minimum 80 percent of the vertical (axial) stiffness. For machine-attached and floor-attached restraining elements, separate from metal-to-metal contact by neoprene cushions 1/8-inch thick minimum. Provide neoprene acoustic friction pads at least ¼ inch thick.

B. Spring Isolator: Spring type isolators shall be free standing and laterally stable without any housing and complete with ¼ " neoprene acoustical friction pads between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflections, compressed spring height and solid spring height. Mountings shall be type SLF as manufactured by Mason Industries, Inc. or as approved equal.

C. Restrained Spring Isolator: Equipment with operating weight different from the installed weight such as chillers, boilers, etc. and equipment exposed to the wind such as air cooled chillers, fans, and roof mounted condensing units, shall be mounted on spring mountings as described above, but a housing shall be used that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection and mounts shall be located between the supporting steel and roof or the grillage and dunnage as shown on the drawings. The installed and operating heights shall be the same. A minimum clearance of ½" shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operations. Mounting shall be type SLR.

2.8. SUSPENSION ISOLATORS

A. General: Provide hangers with suspension isolators encased in open steel brackets. Isolate hanger rods from isolator steel brackets with neoprene-lined opening.

B. Suspension Neoprene Isolators: Provide double-deflection elements with minimum 3/8 inch deflection.

C. Suspension Spring Isolators: Vibration hangers shall contain a steel spring and 0.3" deflection neoprene element in series. The neoprene element shall be molded with a rod isolation bushing that passes through the hanger box. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing thru a 30° arc before contacting the hole and short circuiting the spring. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include a scale drawing of the hanger showing the 30° capability. Hangers shall be type 30N.

D. Precompressed Suspension Spring Isolators: Vibration hangers shall be as described in "C" above, but they shall be precompressed to the rated deflection so as to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a scale drawing of the hanger showing the 30° capability. Hangers shall be type PC30N.

E. Ductwork Suspension Spring Isolators: Vibration hangers shall contain a steel spring located in a neoprene cup manufactured with a grommet to prevent short circuiting of the hanger rod. The cup shall contain a steel washer designed to properly distribute the load on the neoprene and prevent its extrusion. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing thru a 30° arc before contacting the hole and short circuiting the spring. Spring shall have a minimum additional travel to solid equal to 50% of the rated deflection. Hangers shall be provided with an eye bolt on the spring end and provision to attach the housing to the flat iron duct straps. Submittals shall include a scale drawing of the hanger showing the 30° capability. Hangers shall be type W30.

2.9. THRUST RESTRAINTS

A. Adjustable spring thrust restraints, able to resist the thrust force with at least 25 percent unused capacity. The operating spring deflection shall be not less than 50 percent of the static deflection of the isolation supporting the machinery. The spring element shall be contained within a steel frame and designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of ¼" movement at start and stop. The assembly shall be furnished with one rod and angle bracket for attachment to both the equipment and ductwork or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrically on either side of the unit. Horizontal thrust restraints shall be type WB.

2.10. INERTIA BASES

A. Structural Bases: Vibration isolator manufacturer shall furnish integral structural steel bases. Bases shall be rectangular in shape for all equipment other than centrifugal refrigeration machines and pump bases which may be "T" or "L" shaped. Pump bases for split case pumps shall include supports for suction and discharge base ells. All perimeter members shall be beams with a minimum depth equal to 1/10th of the longest dimension of the base. Beam depth need not exceed 14" provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of one inch- bases shall be type WF.

B. Structural Rails: Vibration isolator manufacturer shall provide steel members welded to height saving brackets to cradle machines having legs or bases that do not require a complete supplementary base. Members shall be sufficiently rigid to prevent strains in the equipment. Inverted saddles shall be type ICS.

C. Concrete Bases: Vibration isolator manufacturer shall furnish rectangular structural beam or channel concrete forms for floating foundations. Bases for split case pumps shall be large enough to provide support for suction and discharge base ells. The base depth need

not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity. In general, bases shall be a minimum of 1/12th of the longest dimension of the base, but not less than 6". Forms shall include minimum concrete reinforcement consisting of half inch bars or angles welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom, or additional steel as is required by the structural conditions. Forms shall be furnished with steel members to hold anchor-bolt sleeves when the anchor bolts fall in concrete locations. Height saving brackets shall be employed in all mounting locations to maintain a 1" clearance below the base. Concrete shall be 3,000 psi concrete. Mass of concrete inertia bases shall be minimum of 2 times weight of isolated equipment. Bases shall be type K.

2.11. FLEXIBLE CONNECTORS FOR PIPING

A. General: Straight or elbow flexible connectors rated for temperatures, pressures, and fluids to be conveyed. Provide flexible connectors with the strength 4 times operating pressure at highest system operating temperature. Provide elbow flexible connectors with a permanently set angle.

B. Elastomeric Flexible Connectors: Flexible neoprene connectors shall be manufactured of multiple plys of nylon tire cord fabric and neoprene both molded and cured in hydraulic rubber presses. No steel wire or rings shall be used as pressure reinforcement. Straight connectors shall have two spheres. Connectors up to and including 1 ½ " diameter may have threaded ends. Connectors 2" and larger shall be manufactured with floating galvanized flanges recessed to lock the connector's raised face neoprene flanges. Hoses shall be installed on the equipment side of the shut-off valves. Connectors shall be rated a minimum of 150 psi at 220°F. Flanged equipment shall be directly connected to neoprene elbows in the size range 2 ½ " through 12" if the piping makes a 90o turn at the equipment. All straight through connections shall be made with twin-spheres properly pre-extended as recommended by the manufacturer to prevent additional elongation under pressure. 12" and larger sizes operating above 100 psi shall employ control cables with end fittings isolated by means of ½ " thick bridge bearing neoprene washer bushings designed for a maximum of 1000 psi.

C. Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies.

D. Elbows shall be Mason-Flex type MFNEC, straight connectors Mason-Flex type MFTFU or MFTNC, and control cable assemblies type ACC.

E. Metal Flexible Connectors: Fabricated of Grade E phosphor bronze, monel or corrugated stainless steel tube covered with comparable bronze or stainless steel braid restraining and pressure cover. Sizes 3" and larger shall be flanged. Sizes 2 ½ " and smaller shall have male nipples. Lengths shall be as indicated:

Nominal Diameter (Inches)	Length (Inches)
½ "	12"

3/4"	12"
1 ½ "	12"
1 ½ "	12"
2"	12"
2 ½ "	12"
3"	18"
4"	18"
5"	24"
6"	24"
8"	24"
10"	24"
12"	36"

F. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Hoses shall be type BSS.

2.12. NEOPRENE PAD ISOLATORS

A. Rubber or neoprene waffle pads.

1. 30 durometer

2. Minimum 2 inch (13mm) thick

3. Maximum loading 40 psi (275 kPa)

4. Height of ribs shall not exceed 0.7 times width.

B. Configuration: ½ inch (13mm) thick waffle pads bonded each side of ¼ inch (6 mm) thick steel plate.

2.13. RUBBER MOUNTS

A. Molded rubber designed for 0.6 inches (13 mm) deflection with threaded insert.

PART 3. EXECUTION

3.1. GENERAL PROVISIONS

A. Install vibration-and-noise isolation materials and equipment as indicated and in accordance with machinery manufacturer's instructions.

B. Where neoprene elements of vibration isolator may be subjected to high pipe temperatures above 160°F, provide metal heat shields or thermal isolators.

C. A minimum of 4" thick reinforced concrete housekeeping pads shall be provided under all floor mounted equipment. A minimum of 6" thick reinforced concrete housekeeping pads shall be provided under all chillers and boilers. Rest subbases on structural floor and reinforce with steel rods interconnected with floor reinforcing bars by tie bars hooked at both ends. Provide at least one (1) inch clearance between subbases and inertia bases, steel bases, and steel saddles with machinery in operation.

D. All vibration isolators exposed to weather or humid environment shall be hot dipped galvanized with springs coated with neoprene in accordance with paragraph hereinbefore described.

E. Concrete inertia bases shall be a minimum of two (2) times the weight supported. Clearance between the underside of the inertia base and the housekeeping pad below shall not be less than 1 inch. Concrete shall be 3000 psi. Install inertia bases in accordance with the recommendations of the machinery manufacturer and the inertia base manufacturer.

F. Anchor Bolts and Grout: Secure machinery to foundations and inertia bases with anchor bolts. Grout equipment with baseplates, the full area under baseplates with premixed non-shrinking grout. After grout has set, remove wedges, shims, and jack bolts and fill spaces with grout.

G. Common Machinery Foundations: Mount electrical motors on the same foundations as driven machinery. Support piping connections, strainers, valves, and risers on the same foundation as the pumps.

H. Vertical Stops: For machinery affected by wind pressure or having an operational weight different from installed weight, provide resilient vertical limit stops which prevent spring extension when weight is removed. Provide vertical stops for machinery containing liquid, such as water chillers, and boilers. Spring isolated or protected spring isolated machinery must rock and move freely within limits of stops or seismic restraint devices.

I. Thrust Restraints: Where required, provide pairs of thrust restraints, symmetrically installed on both sides of the steady state line of thrust.

J. Machinery: Provide vibration isolators, flexible connectors and seismic snubbers in accordance with manufacturer's recommendations. Machinery with spring isolators or protected spring isolators shall rock or move freely within limits of stops or seismic snubber restraints.

K. Stability: Isolators shall be stable during starting and stopping of machinery without traverse and eccentric movement of machinery that would damage or adversely affect the machinery or attachments.

L. Lateral Motion: The installed vibration isolation systems for each piece of floor or ceiling mounted machinery shall have a maximum lateral motion under machinery start up and

shut down conditions of not more than ¼ -inch. Restrain motions in excess by approved spring mountings.

M. Unbalanced Machinery: Provide foundation suspension systems specifically designed to resist horizontal forces for machinery with large unbalanced horizontal forces. Vibration isolator systems shall conform to the machinery manufacturer's recommendations.

N. Nonrotating Machinery: Mount nonrotating machinery in systems which includes rotating or vibrating machinery on isolators having the same deflection as the hangers and supports for the pipe connected to.

O. Roof and Upper Floor Mounted Machinery: On the roof or upper floors, mount machinery on isolators with vertical stops. Rest isolators on beams or structures designed and installed in accordance with the SMACNA ASMM Plate 61.

P. Vibration isolation ceiling hangers shall be installed so that the hanger rods do not touch the sides of the isolator housing, thereby seriously degrading the vibration isolation performance. Vibration isolation ceiling hangers shall be located so that the hanger housing may rotate 360 degrees without touching any object.

Q. Electrical Connections: Provide flexible conduit or multiple conductor cable connections for machinery with sufficient extra length to permit 2 inch minimum displacement in any direction without damage.

R. Systems Not To Be Vibration Isolated: Do not provide vibration isolation for electrical raceways and conduits or for fire protection, storm, sanitary, and domestic water piping systems which do not include pumps or other vibrating, rotating, or pulsating equipment including control and pressure reducing valves.

S. Install in accordance with manufacturer’s instructions.

T. Install isolation for motor driven equipment.

U. Bases:

1. Set steel bases for one inch (25mm) clearance between housekeeping pad and base.

2. Set concrete inertia bases for 2 inch (50mm) clearance between housekeeping pad and base.

3. Adjust equipment level.

V. Install spring hangers without binding.

W. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.

X. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.

Y. Connect wiring to isolated equipment with flexible hanging loop.

3.2. MEDIUM AND HIGH PRESSURE DUCTWORK ISOLATION (4 INCH WATER COLUMN AND ABOVE)

A. Provide vibration isolation for medium and high pressure ductwork operating with over four (4) inches water column. The isolator deflections shall be equal to or greater than the static deflection of the vibration isolators provided for the connected machinery as follows:

All discharge runs for a distance of 50' from the connection equipment (fans, exhausters and blowers) shall be isolated from the building structure. Spring deflections shall be a minimum of 0.75".

B. Ductwork Hanger and Support Installation: Provide ductwork with vibration isolation hangers and supports where located in mechanical equipment rooms. Connect ductwork to equipment with flexible duct connectors. Segment ductwork with flexible duct connectors.

C. Duct Risers: Provide duct riser supports within shafts with suitable bearing plates and two layers of ¼ " thick ribbed or waffled neoprene pad loaded to not more than 50 psi. Separate isolation pads with ¼ " steel plate.

D. Supports at Base of Duct Risers: For duct isolation supports at the base of risers, provide two layers of ¼ " thick heavy-duty neoprene pad separated by ¼ " thick steel plate. Use bearing plates sized to provide a pad loading of not more than 500 psi. Weld the stanchion between the duct and isolation support to the pipe, and weld or bolt to the isolation support. Bolt isolation support to the floor slab with resilient sleeves and washers. Where supplementary steel is required to support ducts, provide a maximum deflection of ¼ " at the midspan of this steel under the supported load. Rigidly support duct from the supplementary steel and the supplementary steel isolators.

E. Duct Anchors: Attach each end of the duct anchor to an omni-directional isolator which in turn shall be rigidly fastened to the steel framing or structural concrete as indicated. Vertical restraints shall be provided by similar material arranged to prevent vertical travel in either direction. The load on the isolation material shall not exceed 500 psi.

3.3. PIPE ISOLATION

A. Horizontal Pipe Isolation:

1. Precompressed Suspension Spring Isolators:

a. For the first three pipe hangers in the main lines near the mechanical equipment provide precompressed suspension spring isolators. Floor supported piping shall rest on trained spring isolators. All precompressed suspension spring isolators hangers or the first three trained spring isolators mounts as noted above, will have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceiling under occupied spaces, the first three hangers shall have 0.75" deflection for pipe sizes up to and including 3", 1.5" deflection for pipe sizes up to

and including 6" and 2.5" deflection thereafter. All other hangers and mounts will have a minimum steel spring deflection of 0.75". Hangers shall be located as close to the overhead supports as practical.

2. Combination Spring and Neoprene Suspension Hanger:

a. For horizontal runs in other than those hereinbefore specified provide suspension spring hangers (combination spring and neoprene) with .75" minimum steel spring deflection.
b. Chilled Water, Hot Water Piping:
i. For the first 20 feet of the branch connection of the main supply and return piping at each floor.
ii. For all piping over 2" diameter.

B. Floor-Supported Piping:

1. Floor supports for piping in equipment rooms and adjacent to isolated equipment shall use vibration isolators as described hereinbefore and selected to the guidelines of hangers.

2. The first three adjacent floor supports shall be the restrained spring type with a blocking feature that prevents load transfer to equipment flanges as the piping is filled and drained.

3. Where piping is subject to larger thermal movement a slide plate shall be installed on the top of the isolator. Slide plate shall be teflon, graphite or steel.

4. Provide a thermal barrier where neoprene products are installed directly beneath steam or hot water lines.

C. Pipe Risers: Provide pipe riser supports with bearing plates and two layers of ¼ " thick ribbed or waffled neoprene pad loaded to not more than 50 psi. Separate isolation pads with ¼ " steel plate. Weld pipe riser clamps at anchor points to the pipe and to pairs of vertical acoustical pipe anchor mountings which shall be rigidly fastened to the steel framing.

D. Supports at Base of Pipe Risers: Piping isolation supports at the base of risers shall be two layers of ½" thick heavy-duty neoprene pad separated by ¼ " thick steel plate. Use bearing plates sized to provide a pad loading of not more than 500 psi. Weld the stanchion between the pipe and isolation support to the pipe and weld or bolt to the isolation support. Bolt isolation support to the floor slab with resilient sleeves and washers. Where supplementary steel is required to support piping, provide a maximum deflection of 0.08 inches at the mid-span of this steel under the load. Rigidly support piping from the supplementary steel with the supplementary steel isolated from the building structure with isolators.

E. Pipe Anchors: Attach each end of the pipe anchor to an omni-directional pipe isolator which in turn shall be rigidly fastened to the steel framing or structural concrete. Provide a telescoping pipe isolator of two sizes of steel tubing separated by a minimum ½ " thick pad of heavy-duty neoprene or heavy-duty neoprene and canvas. Provide vertical restraints by similar material to prevent vertical travel in either direction. The load on the isolation material shall not exceed 500 psi.

3.4. FLEXIBLE PIPE CONNECTORS

A. Provide flexible connectors in accordance with manufacturers instructions where piping systems serving vibration isolated equipment and as shown on the drawings. Flexible connectors shall be installed near the connection to the equipment. Where liquid pulsation dampening is required, flexible connectors with spherical configuration may be used. Provide restraints for pipe connectors at pumps to prevent connector failure upon pump start-up.

B. Provide flexible connectors at connections of dry pipe air compressors, shop air compressors, dental air compressors, and dental vacuum pumps to piping systems**.**

3.5. ISOLATION FOR SPECIFIC EQUIPMENT

A. The vibration isolator manufacture shall provide isolators for all pieces of equipment provided for the job. Isolator shall be selected by the isolator manufacturer on the basis of criteria as specified in the ASHRAE Applications Handbook, latest edition, unless a more stringent requirement is indicated on the drawings.

B. Pumps/Air Compressors/Vacuum Pumps:

1. All base mounted pumps, domestic booster pumps, air compressors, and vacuum pumps shall be mounted on concrete inertia bases supported on stable steel springs in series with ribbed neoprene pads selected for not less than 1.5 inch static deflection under full operating load. Mason Industries type SLF or as approved equal.

2. Floor support of the initial pipe elbows at the pump discharge and suction diffuser at the pump intake shall be made from the isolated inertia base, not from the equipment room floor. Mason Industries Type K or as approved equal.

3. Provide flexible pipe connections at pump suction and discharge. Mason Industries Type BSS or MFTNC/MFTFU with control rods type ACC or as approved equal.

4. Provide discharge and suction vibration isolators at all in-line pumps.

C. Air Handling Units/Heating Ventilating Units/Make-up Air Units, Energy Recovery Ventilators, and Industrial Air Cleaners:

1. All air handling units, H & V units, make-up air units, energy recovery ventilators, and industrial air cleaners units shall be supported on stable steel springs in series with ribbed neoprene pads selected for not less than 2.0" deflection under full operating load. Mason Industries type SLF springs or as approved equal. Following the manufacturer's specific installation instructions for specific equipment is acceptable.

D. Fans:

1. Fans up to 22" wheel diameter shall be mounted stable steel springs in series with ribbed neoprene pads selected for not less than 1.0" static deflection (Mason

Industries Type SLF or equivalent).

2. Fans with wheel diameters 24" and greater shall be mounted on unhoused stable steel springs in series with ribbed neoprene pads and structural rails selected for not less than 1.5" static deflection (Mason Industries Type SLF or equivalent and structural rails Type ICS with thrust restraint provisions) and rails shall be Type ICS.

3. All fans suspended from the ceiling, joists or roof structure, including outside air fans, return fans, relief air, ventilation fans, and exhaust fans, shall be suspended using hangers incorporating steel springs in series with neoprene, selected for not less than 2.0" static deflection under full load (Mason Industries Type 30N or equivalent).

E. Chillers: Chillers shall be mounted on restrained spring isolator with vertical limit stops for not less than 1 inch static deflection under full operating load. Isolators shall be Mason Industries Type SLR or as approved equal. All exterior isolators for chillers shall be hot dipped galvanized including all hardware. Provide neoprene coated springs.

F. Condensing Units: All condensing units shall be supported on stable steel springs in series with ribbed neoprene pads and structural rails selected for not less than 1.0" deflection under full operating load. All exterior isolators for condensing units shall be hot dipped galvanized including all hardware. Mason Industries Type SLF springs or as approved equal. Provide neoprene coated springs.

G. All horizontal, vertical, and recessed unit heaters and fan coil units shall be suspended using hangers incorporating steel springs in series with neoprene selected for not less than 1" static deflection under full load (Mason Industries Type 30N or equivalent).

H. Ductless Units: Indoor ductless units shall be supported with rubber grommet type suspension isolators. Outdoor ductless units or water cooled ductless units shall be supported on ribbed neoprene pads resting on roof curbs (roof application) or concrete pad.

I. Dust Collector: Dust Collector shall be mounted or restrained spring isolators with vertical limit stops for not less than 1 inch static deflection under full operating load. All springs shall be neoprene coated with hot dipped galvanized hardware. Isolators shall be Mason Industries Type SLR or approved equal.

3.6. MANUFACTURER'S FIELD SERVICES

A. Inspect isolated equipment after installation and submit report. Include static deflections.

END OF SECTION

DIVISION 23 SECTION 23 05 93
TESTING, ADJUSTING & BALANCING FOR HVAC & PLUMBING
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SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC AND PLUMBING

PART 1. GENERAL

1.1. GENERAL

A. This section covers performance testing, adjusting and balancing of heating, ventilating, air conditioning and domestic re-circulating systems as specified in Division 23 Section, Heating, Ventilating, and Air Conditioning Equipment and in Division 22 Sections, Plumbing Fixtures and Plumbing Equipment.

B. For Common Work Results of HVAC, See Division 23. See Division 01 for General Requirements.

C. The mechanical contractor shall select and employ an impartial, independent balancing agency to provide testing and balancing services for the heating, ventilating and air conditioning (HVAC) systems, plumbing systems, and other specified systems of this project.

D. The work included in this section consists of furnishing labor, instruments, and tools required in testing, adjusting and balancing the HVAC and plumbing systems, as described in these specifications or shown on accompanying drawings. Services shall include checking equipment performance, taking the specified measurements, and recording and reporting the results. Where balance valves and/or flow meter fittings are not indicated utilize ultrasonic flow meter to record fluid flow rates in gallons per minute.

1. Perform all work required to prepare the building HVAC and Plumbing systems for testing, adjusting, and balancing indicated by the Contract Documents as follows:

    a. Verify the air systems are ready for balancing.
    b. Verify the hydronic systems are ready for balancing.
    c. Verify the control systems are ready for balancing.
    d. Notify appropriate parties the system is ready for balancing.

2. Scope of work.

    a. Testing, adjusting, and balancing (TAB) of the HVAC systems, Plumbing Systems, and related ancillary equipment will be performed by an independent, third party, AABC Certified Agency, selected and employed directly by the Contractor. The preparation and corrections necessary for the testing and balancing of these systems, as described herein, are the responsibility of the Contractor.
    b. As part of the project Construction Contract, the Contractor shall make any changes or replacements to the sheaves, belts, dampers, valves, or other components required for correct balance as advised by the TAB Agency, at no additional cost to the Owner.
    c. The Contractor shall provide and coordinate the services of qualified, responsible subcontractors, suppliers and personnel as required to correct, repair, and/or replace any and all deficient items or conditions found

during the course of this project, including the testing, adjusting, and balancing period.

d. In order that all systems may be properly tested, adjusted and balanced as required herein by these Specifications, the Contractor shall operate the systems at their expense for the length of time necessary to properly verify their completion and readiness for TAB, and the entire duration required for the TAB process.

e. Project Contract completion schedules shall allow for sufficient time to permit the completion of TAB services prior to Owner occupancy. The Contractor shall allow adequate time for the testing and balancing activities of the Owner-provided services during the construction period and prior to Substantial Completion, as defined in the AIA General Conditions and Supplementing Condition of this Construction Document.

f. The Drawings and Specifications indicate valves, dampers, and miscellaneous adjustment devices to be adjusted to obtain optimum operating conditions. It is the responsibility of the Contractor to install these devices in a manner that will leave them accessible and readily adjustable. Should any such device not be readily accessible, the Contractor shall provide access, as requested by the TAB Agency. Any malfunction encountered by TAB personnel and reported to the Contractor shall be corrected by the Contractor immediately so that the balancing work can proceed with a minimum of delays.

g. The scope of work, as defined herein, is to advise the Contractor of the coordination, adjustment, and system modifications that will be required under the project work to complete Owner requirements for final TAB. The Contractor's original bid shall allow for the costs of all work which may be required in the TAB phases, and which may be necessary for the completion of the TAB work as defined by the TAB Agency.

3. Submittals. The TAB Agency shall submit an agenda that will include:

a. Field observation reports.
b. An overview of system TAB procedures.
c. System testing which will include where ducts will be traversed, which instrumentation will be used, how correction factors for grille and diffuser will be obtained, how measurements will be verified at maximum and minimum, and how control components will be verified.
d. Report forms with each system's components identified and numbered.

E. The items requiring testing, adjusting, and balancing include, but are not limited to, the following:

<u>Air Systems</u>:

1. Air Flow Monitoring Stations

2. Air Handling Units

3. Air Curtains

4. Carbon Monoxide Makeup Air/Exhaust Fans/Hose Reels

5. Ceiling Paddle Fans
6. Coils (Air Temperatures & Static Pressure Drops)
7. Chiller Condenser Fans
8. Diffusers, Registers and Grilles
9. Dryer Duct Booster Fans
10. Duct Smoke Detectors
11. Ductless Split System Units (Indoor and Outdoor Units)
12. Dust Collection Equipment (Including all Drops, Floor Sweeps, and Equipment)
13. Energy Recovery Ventilators
14. Electric Unit Heaters
15. Electric Heating Coils
16. Exhaust Fans
17. Fans
18. Fan Coil Units
19. Fume Hood Systems including Fume Hoods & Fans
20. Fire Dampers and Combination Fire/Smoke Dampers
21. Heat Recovery Systems
22. Heat Pumps
23. Heating and Ventilating Units
24. Heat Pipes
25. Industrial Ventilation Systems
26. Industrial Air Cleaners
27. Intake Hoods
28. Kitchen Hoods
29. Kitchen Make-up Air Units
30. Make-up Air Units

31. Outside Air Intakes
32. Pressure Independent Control Valves
33. Power Relief Fans
34. Radiant Heat Panels
35. Relief Fans
36. Relief Hoods
37. Return Fans
38. Rooftop Air Handling Units
39. Single Zone VAV Units
40. Paint Spray and Mixing Booths (Exhaust Fans/Makeup Air Units)
41. Static Pressure Sensors
42. Supply Fan AHU
43. Unit Heaters
44. Ventilation Fans
45. Welding Makeup Air Units/Exhaust Fans/Arms
46. Zone Branch and Main Ducts

Hydronic Systems:

1. Air Handling Units
2. Automatic Glycol Feeders
3. Boilers
4. Chillers
5. Carbon Monoxide Makeup Air Units
6. Coils
7. Condensate Pumps
8. Condensate overflow safety switches
9. Differential Pressure Bypass Valves

10. Domestic Booster Pumps
11. Domestic Re-circulating Systems and Water Heater
12. Elevator Pit Sump Pumps
13. Emergency Fixture Mixing Valves
14. Energy Recovery Ventilators
15. Fan Coil Units
16. Finned Tube Radiators
17. Flow Measuring Stations
18. Flow Meter Fittings
19. Flow Switches
20. Freeze Protection Pumps
21. Heating and Ventilating Units
22. High/Low Mixing Valves (Domestic Water)
23. In-line Pumps
24. Kitchen Ventilation Systems
25. Make-up Air Units/Outside Air Units
26. Minimum Flow Bypass Valves.
27. Pumps
28. Single Zone VAV Units
29. System Mains and Branches
30. Thermostatic Mixing Valves
31. Unit Heaters
32. Welding Area Makeup Air/Exhaust Fans/ARMS

1.2. ALTERNATES

A. Refer to Division 01 Section, Alternates for description of work under this section affected by alternates.

1.3. GENERAL COMMISSIONING REQUIREMENTS

A. Refer to Division 01 Section, "General Commissioning Requirements" for description of work under this Division affected by General Commissioning.

1.4. PRELIMINARY EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:

1. Systems are started and operating in a safe and normal condition.

2. Temperature control systems are installed complete and operable.

3. Proper thermal overload protection is in place for electrical equipment.

4. Final filters are clean and in place. If required, install temporary media in addition to final filters.

5. Duct systems are clean of debris.

6. Fans are rotating correctly.

7. Fire dampers, smoke dampers, and volume dampers are in place and open.

8. Air coil fins are cleaned and combed.

9. Access doors are closed and duct end caps are in place.

10. Air outlets are installed and connected.

11. Duct system leakage is minimized.

12. Hydronic systems are flushed, filled, and vented.

13. Pumps are rotating correctly.

14. Proper strainer baskets are clean and in place.

15. Service and balance valves are open.

B. Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.

C. Beginning of work means acceptance of exiting conditions.

1.5. QUALIFICATIONS OF THE BALANCE AGENCY

A. The balancing agency shall be a member of the Associated Air Balance Council (AABC).

B. The certified test and balance engineer shall be responsible for supervision and certification for the total work herein specified.

C. All final reports shall be signed by the certified test and balance engineer.

D. All personnel used on the project will be employees of an AABC Certified Agency. All work will be performed under the direct supervision of the AABC Certified Test and Balance Engineer (TBE). All work will be performed with AABC Certified Test and Balance Technicians (TBT) Resumes including education, experience, and certification of each person on the project shall be submitted.

E. Warranty. The AABC Agency shall submit a National Project Performance Guaranty.

1.6. PERSONNEL

A. All personnel used on the project will be employees of an AABC Certified Agency. All work will be performed under the direct supervision of the AABC Certified Test and Balance Engineer (TBE). All work will be performed with AABC Certified Test and Balance Technicians (TBT). Resumes including education, experience, and certification of each person on the project shall be submitted as informational submittals.

1.7. WARRANTY

A. The AABC Agency shall submit a National Project Performance Guaranty.

1.8. PRE-BALANCING CONFERENCE

A. Convene a conference one week prior to commencing work of this Section with all appropriate individuals.

1.9. STANDARDS

A. The balancing agency shall perform the services specified herein in accordance with the Associated Air Balance Council's National Standards, including revisions, to the date of the contract.

B. All terms in this specification shall have their meaning defined as stated in the National Standards.

C. ADC: Test Code for grilles, registers, and diffusers.

D. ASHRAE III: Practice for measurement, testing, adjusting and balancing of building heating, ventilation, air conditioning, and refrigeration systems.

E. NEBB: Procedure standards for testing, adjusting, and balancing of environmental systems.

F. SMACNA: HVAC systems testing, adjusting, and balancing.

G. AABC: Associated Air Balance Council

1.10. COORDINATION

A. It will be necessary for the balancing agency to perform its services in close coordination

with the mechanical contractor.

B. The plans and specifications have indicated meters, valves, dampers, and other devices for the purpose of adjusting the system to obtain optimum operating conditions. It will be the responsibility of the mechanical contractor to install these devices in a manner that will leave them accessible and readily adjustable. The balancing agency shall provide guidance if there is a questionable arrangement of a control or balancing device.

C. The construction manager, mechanical contractor, temperature control contractor and suppliers of the HVAC equipment shall all cooperate with the balancing agency to provide all necessary data on the design and proper application of the system components.

D. For heat pumps, the manufacturer's start-up agency and Test and Balance Engineer shall assist each other with obtaining proper flow rates and refrigerant pressures.

1.11. INSTALLATION TOLERANCE

A. Unless otherwise indicated, all air devices shall be adjusted to within plus or minus 10 percent of design. All fans shall be adjusted to within plus or minus 5 percent of design. All pumps and Hydronic equipment shall be adjusted to within plus or minus 5 percent of design.

1.12. RESPONSIBILITIES OF THE TAB AGENCY

A. Liaison and Early Inspection. The following reviews, observations, and tests shall be performed by the TAB Agency:

1. Review the mechanical drawings and specifications for balanceability and provide commentary. Verify proper types and locations of all Test and Balance devices.

2. During construction, review all approved HVAC submittals such as control diagrams, air handling devices, hydronic devices, and other components that pertain to TAB work and balanceability. Assist the commissioning agent with all Functional Performance Testing.

3. Perform construction observations and submit a written report:

   a. On the ductwork prior to insulation and/or ceiling cover-up.
   b. On the piping prior to insulation and/or ceiling cover-up.

4. Witness duct pressure test as defined in the specifications, and submit a written report.

5. Perform a pre-balance site review, and submit a written report.

6. During the balancing process, abnormalities and malfunctions of equipment or components may be discovered by the TAB personnel. The Construction Inspector, Architect, Engineer, and Owner shall be advised in writing so that the condition(s) can be corrected by the Contractor. The written document need not be formal, but shall be understandable and legible. The TAB Agency shall not instruct or direct the Contractor in any of the work, but will make reports to the appropriate

parties.

B. Final Air Balance. When systems are complete and ready for operation, the TAB Agency will perform a final air balance for all air systems and record the results. The volume of air for the supply, return, exhaust, and outside air equipment and terminals will be tested and balanced within the tolerances of the AABC Standard, or as specified, whichever is more stringent. Air handling unit and fan volumes shall be adjusted by changing fan speed. Air distribution device volumes shall be adjusted using the duct dampers and not the grille face. Air distribution devices shall be balanced with air patterns as specified. Duct volume dampers shall be adjusted to provide air volume to branch ducts where such dampers are shown. The general scope of balancing by the TAB Agency will include, but is not limited to, the following:

1. Filters: Check air filters and filter media. Balance systems with essentially clean filters and filter media.

2. Fan Speed: Measure and record RPM for each fan. Provide Controls Contractor with drive parameters for variable speed drives.

3. Voltage and Amperage Readings: Measure and record the final operating voltage and amperage for each motor.

4. Static Pressure Profile: Static pressure profiles shall be measured and recorded across each supply fan, cooling coil, heating coil, heat of rejection equipment fans, return air fan, air handling unit filter, exhaust fan, and at the furthest air device or terminal unit from the air handler supplying that device.

5. Equipment Air Flow: Adjust and record supply, return, outside and exhaust air CFM and temperatures, as applicable, at each fan and coil.

6. Coil Temperatures: Set controls for full cooling and for full heating loads. Read and record entering and leaving dry bulb and wet bulb (cooling only) temperatures at each cooling coil, heating coil, and HVAC terminal unit. At the time of reading, record water flow and entering and leaving water temperatures and pressure drops. In variable flow systems, adjust the air and water flow to design for all the above readings.

7. Zone Air Flow: Adjust each HVAC terminal unit and each air-handling unit for design CFM.

8. Outlet Air Flow: Adjust each supply diffuser, register and grille, and each exhaust inlet to within the tolerance per the AABC Standard.

9. Pitot Tube Traverses: For use in future troubleshooting by maintenance personnel, all main supply, return, outside air, and exhaust ducts shall have air velocity and volume measured and recorded by the Pitot tube traverse method shown in the AABC Standard. Locations of these traverse test stations shall be described on the sheet containing the data. All Pitot tube traverses shall be clearly identified on the outside of the duct insulation with the traverse identified and duct size. Submit half scale drawings showing the locations of all duct traverses.

C. Final Water Balance. When systems are complete and ready for operation, the TAB Agency will perform a final water balance for each hydronic HVAC system. The general scope of balancing by the TAB Agency will include, but not be limited to, the following:

1. Adjusted System Tests: Adjust balancing valves at each coil and heat exchanger for design flow per the AABC Standard. Adjust balancing valves at pumps to obtain design water flow. Record pressure rise across pumps, and obtain GPM flow from the pump curve. Permanently mark the balanced position for each valve. If discharge valves on the pumps are used for balancing, record the head being restricted by the valves. Test and record autoflow valve differential pressures and adjust pump speed to optimize and minimize autflow differential pressure.

2. Temperature Readings: Read and record entering and leaving water temperature at each water coil, converter, heat rejection equipment and heat exchanger at design flow. Adjust as necessary to secure design operating conditions. Provide final readings at all thermometer well locations.

3. Pressure Readings: Water pressure shall be recorded at all gauge connections. Pressure readings at coils and pumps shall be related to coil and pump curves in terms of GPM flow and through flow measuring stations, where provided and installed, at each hydronic unit. The flow of water through all water coils shall be adjusted by balancing valves until the rated pressure drop across each coil is obtained and total water flow is verified by flow measuring station. For coils equipped with three-way valves, the rated pressure drop shall first be adjusted through the coils. The bypass valve shall then be adjusted on each coil until the pressure drop between supply and return connections is the same as with the flow through the coil.

4. Voltage and Amperage Readings: Read and record the final operating voltage and amperage for each pump motor.

5. Pump Speed: Measure and record RPM for each pump. Provide Controls Contractor with drive parameters for variable speed pumps.

D. Testing of Temperature Control Systems as applicable to the project.

1. Air Handling Units

a. Start each air handling unit; verify and document:
- Dampers modulate properly and in the correct sequence.
- Fan(s) VFD ramps to design speed or proper controlled speed.
- All fire/smoke and/or smoke dampers go to their “system on” position.
- All coil valves operate in response to the controlled temperature.
- All interlocked fans and/or devices energize.
- All alarms and safeties are operational and will alarm or shut down the unit.
- All operating scenarios are tested; e.g.: economizer cycle, minimum/maximum airflows, outside airflows at unit minimum/maximum volume, and special sequences.
- All end switches and positioners are properly set.

- All pressure controllers respond to increases or decreases in system pressure.
- All temperature and pressure sensors are calibrated.
- Airflow monitors report the correct airflow and control devices respond correctly to a change in airflow; e.g.: outside air control.
- Reset control sequences operate in response to changes in system temperatures, flows, or pressures.
- Correct operation of fan sequences when multiple fans are installed.
- Emergency mode operation; e.g.: power outage, freeze protection.
- Test all static pressure sensors and controls and calibrate the same.

b. Shut down each air handling unit; verify and document:
- Dampers respond properly (open, close, or modulate), and in the correct sequence.
- All fan systems ramp down and stop.
- Correct operation of fan sequences when multiple fans are installed.
- Emergency mode operation; e.g.: freeze protection.
- Interlocked devices turn off.
- System starts for setback temperature control.
- System starts on a temporary occupancy override.
- All fire/smoke and/or smoke dampers go to their "system off" position.
- All coil/heat exchanger valves go to their specified position.
- All alarms and safeties remain operational.

2. Fan Systems

a. Start each fan or fan system; verify and document:
- Interlocks and lockouts operate in accordance with the sequence.
- Fan(s) VFD ramps to design speed or proper controlled speed.
- All alarms and safeties are operational and will alarm or shut down the fan.
- Dampers modulate properly and in the correct sequence.
- All fire/smoke and/or smoke dampers go to their "system on" position.
- All interlocked fans and/or devices energize.
- All end switches and positioners are properly set.
- All pressure controllers respond to increases or decreases in system pressure.
- All temperature and pressure sensors are calibrated.
- Airflow monitors report the correct airflow and that control devices respond correctly to a change in airflow; e.g.: outside air control.
- Correct operation of fan sequences when multiple fans are installed.
- Emergency mode operation; e.g.: power outage, freeze protection.

b. Shut down each fan or fan system; verify and document:
- Dampers respond properly (open, close, or modulate) and in the correct sequence.
- All fan systems ramp down and stop.

- Correct operation of fan sequences when multiple fans are installed.
- Emergency mode operation; e.g.: purge air.
- Interlocked devices turn off.
- All fire/smoke and/or smoke dampers go to their "system off" position.
- All alarms and safeties remain operational.

3. Hydronic Systems

a. Start hydronic systems; verify and document:
- Valves modulate properly and in the correct sequence.
- Pump(s) VFD ramps to design speed or proper controlled speed.
- All isolation valves go to their "system on" position.
- All coil valves operate in response to the controlled temperature.
- All interlocked devices energize.
- All alarms and safeties are operational and will alarm or shut down the system.
- All operating scenarios are tested; e.g.: minimum/maximum water flows, minimum/maximum pressure, and special sequences.
- All end switches and positioners are properly set.
- All pressure controllers respond to increases or decreases in system pressure.
- All temperature and pressure sensors are calibrated.
- Flow meters report the correct water flow and that control devices respond correctly to a change in water flow.
- Reset control sequences operate in response to changes in system temperatures, flows or pressures.
- Differential pressure across all pressure independent control valves and venturi flow meters.
- Correct operation of pump and/or boilers/chillers sequences when multiples are installed.
- Emergency mode operation; e.g.: power outage, freeze protection.
- The controls have time delay strategy to avoid excessive cycling of pumps and coils.

b. Shut down hydronic systems; verify and document:
- Valves modulate properly and in the correct sequence.
- Pump(s) VFD ramps down to off position.
- All isolation valves go to their "system off" position.
- All coil valves go to their normal off position.
- All interlocked devices de-energize.
- All alarms and safeties remain operational.
- Correct shutdown of pump and/or boiler/chiller sequences when multiples are installed.
- Emergency mode operation; e.g.: freeze operation.

4. Component Calibration

All temperature, airflow, fluid flow, pressure, and flow measuring components

shall be measured and compared to the control system readout; verify and document:

- The air temperature sensors for each coil, heat exchanger. If the temperature is not reading within tolerance, the sensor will be reported to the control contractor for calibration.
- The room temperature, relative humidity, and $C0_2$ sensors. If the sensors are not reading within tolerance, the sensors shall be reported to the control contractor for calibration.
- The water temperature sensors for each coil, boiler, chiller. If the temperature is not reading within tolerance, the sensors shall be reported to the control contractor for calibration.
- All air and water pressure sensor readouts. If the pressure is not reading within tolerance, the sensor shall be reported to the control contractor for calibration.
- All flow measuring device readouts. If the flow readout is not recording within tolerance, the sensor shall be reported to the control contractor for calibration.

5. Point Verification

- Point verification for the digital control system documents that every point is operational and the setpoint, flow, temperature, or pressure is reporting correctly to the graphic interface. Verify and document all points.

6. Dynamic Testing

- Dynamic testing involves making a change of value at the sensor in order to observe the system's reaction and how it regains the original setpoint. Verify and document the system's response.

1.13. REPORTS

A. The report shall be a complete record of the HVAC system performance, including conditions of operation, items outstanding, and any deviations found during the process. The final report also provides a reference of actual operating conditions for the owner and/or operations personnel. The report summary is a project narrative describing the outcome of the testing and balancing and shall include a list of items that document all system variations deviating from design tolerances. Information can also be included that suggests possible resolutions.

B. All measurements and recorded readings that appear in the reports shall be certified by the Agency's Test and Balance Engineer.

C. Submit reports on forms approved by the Engineer. Hard and/or electronic copies of the final report shall be submitted in accordance with the Contract Requirements. The report shall indicate a summary of actual operating data and any abnormal operating conditions. The report shall contain all required information as described within this specification, including the information formatted and shown in the AABC Standard.

D. For phased projects, submit a final, complete, and comprehensive TAB report with index for all phases.

E. When the Engineer reviews TAB reports and provides comments, address each comment in writing for all re-submitted TAB reports.

1.14. TAB FINAL ACCEPTANCE INSPECTION

A. At the time of TAB final acceptance inspection, the TAB agency shall recheck, in the presence of the Owner's representative, specific and random selections of data recorded in the certified test and balance report.

B. Points and areas for recheck shall be selected by the Owner's representative.

C. Measurements shall be verified at the same test conditions as the submitted and approved test and balance agenda.

D. Selections for verification shall not exceed 10% of the total number tabulated in the report, except where special air systems require a complete recheck for safety reasons.

E. If 10% of the random verification tests demonstrate a measured flow deviation of 10%, or more from that recorded in the certified test and balance report, the report shall be automatically rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, a new certified test and balance submitted, and a new inspection test made. There shall be no additional cost to the Owner for this work.

F. Final acceptance shall occur after successful completion of the TAB verification process.

1.15. RESPONSIBILITIES OF THE MECHANICAL CONTRACTOR

A. The mechanical contractor shall sufficiently complete the installation and start all HVAC and plumbing systems to insure they are working properly and shall perform all other items as described hereinafter to assist the balancing agency in performing the testing and balancing of the HVAC system.

B. Record equipment manufacturer's standard start-up information and submit to Engineer for review. Testing and balancing work shall not commence on any equipment until start-up reports have been completed, reviewed by Engineer, and forwarded to Testing and Balancing Agency.

C. The Contractor shall:

1. Have the building, air conditioning systems, heating systems, and plumbing systems in complete operational readiness for TAB work to begin.

2. The Contractor shall allow sufficient time for the TAB Agency to perform their contracted work within the construction schedule. The Contractor shall complete work by systems or floors, whichever is the most efficient for testing systems. After award of the contract and the completion of the construction schedule by the Contractor, a TAB coordination meeting shall be held with the TAB Agency, the Contractor and primary subcontractors, including but not limited to mechanical,

electrical, and building automation subcontractors to develop a testing schedule for the project. The Contractor shall submit copies of the proposed schedule to the TAB Agency two weeks prior to this meeting.

3. Promptly correct deficiencies of materials and workmanship identified as delaying completion of TAB work.

4. Be responsible for any added costs to the Owner resulting from the Contractor's failure to have the building air conditioning systems and plumbing systems ready for TAB when scheduled, or from the Contractor's failure to correct deficiencies promptly.

D. Facility Operational Readiness

1. Complete operational readiness of the building requires that the building envelope be complete. This includes the installation of doors, windows, and ceilings to obtain simulated or projected operating conditions.

E. Air Distribution Systems

1. Verify installation for conformity to design.

2. Terminate all supply, return, outside air, exhaust air, relief air, ventilation air ducts, and pressure test them for leakage. Test pressure and leakage rate shall be as specified in Division 23 Section, HVAC Air Distribution System under Leakage Tests. Pressure testing shall be performed by mechanical contractor and witnessed by Test and Balance Engineer.

3. Ensure that all splitters, extractors, volume dampers, fire dampers, and smoke damper are properly located and functional. Dampers serving requirements of minimum and maximum outside - return - relief, and exhaust air shall provide tight closure and full opening, with a smooth and free operation.

4. Verify that all supply - return - exhaust and transfer grilles; registers, and diffusers are installed, operational, and sealed tightly.

5. Ensure that air-handling systems, units, and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., are blanked and/or sealed to eliminate excessive bypass or leakage of air.

6. Ensure that all fans are operating and free of vibration. All fans and drives shall be checked for proper fan rotation and belt tension. Overload protection shall be of proper size and rating. A record of motor current and voltage shall be made to verify that the motors do not exceed nameplate rating. Record thermal overload ratings for all motors in the Test and Balance Report.

7. Make any necessary changes to the sheaves, belts, and dampers, as required by the balancing agency, at no additional cost to the owner.

8. Install clean filters.

9. Coils shall be clean with fins straightened, bearings shall be properly greased, belts shall be aligned and tightened, and the system shall be completely operational. The Contractor shall verify that all systems are operating within the design pressure limits of the piping and ductwork.

10. All supply, return, exhaust, and relief fans shall be operating and verified for: freedom from vibration, proper fan rotation and belt tension; heater elements in motor starters to be of proper size and rating, as the as per the starter manufacturer. Record motor amperage and voltage on each phase at start-up, verifying they do not exceed nameplate ratings.

11. Controls commissioning shall be complete.

12. For heat pumps, condensing units provide refrigerant suction and discharge pressure to Test and Balance Engineer for inclusion in the final TAB Report.

F. Water Circulating Systems

1. Verify installation for conformity to design.

2. Check all pumps to verify pump alignment and rotation.

3. Ensure that systems are clean, with the proper strainer screens installed for normal operation.

4. Check all pump motors for current on each phase and voltage, to ensure that motors do not exceed nameplate rating.

5. Provide thermal overload protection of proper size per the starter manufacturer and rating. Record thermal overload ratings for all motors. Insert data in Test and Balance Report.

6. Ensure that all water circulating systems shall be full and free of air; that expansion tanks are set for proper water level; and that all air vents were installed at high points of systems and are operating.

7. All piping shall be terminated and pressure tested for leakage as required by the specification. All valves shall be set to their full open position, bypass stop valves shall be closed, and mixing valves shall be set to full-flow through the the system's components. After the system is flushed and checked for proper operation, all strainers shall be removed and cleaned. The Contractor shall repeat the operation until circulating water is clean. The start-up strainers shall then be removed and hung adjacent to the pumps.

8. Chemicals shall be added to closed systems to treat piping and inhibit corrosion. The system static pressure shall be adequate to completely fill the system without operating the pumps.

9. The operating parameters of the heat exchangers, coils, pumps, and control devices shall be capable of obtaining design requirements.

10. Proper balancing devices shall be installed in the designated locations. These devices include but are not limited to flow meters, pressure taps, thermometer wells, and balancing valves.

G. Notification of System Readiness

1. After completion of the work, the Contractor shall notify the Owner and TAB Agency, in writing, certifying that the work has been accomplished and that the building, air conditioning, and plumbing systems are ready for testing, adjusting, and balancing. The Contractor shall include a copy of the tabulated data of the start-up reports.

2. The Contractor shall notify the TAB Agency of the readiness for balancing and forward copies of the Contractor's certification and the tabulated data.

3. Should the TAB Agency be notified as described above and the inspection reveal the TAB services notification to have been premature, all costs of the inspection by the TAB Agency shall be reimbursed by the Contractor.

1.16. CONTRACTOR SUPPLIED ITEMS

A. As a requirement of the TAB contract, the Contractor's Project Manager shall compile and provide the TAB Agency the following:

1. One set of mechanical specifications.

2. All pertinent change orders.

3. All Request(s) for Information (RFI).

4. One complete set of MEP Drawings.

5. One copy of approved submittal data on equipment installed and controls submittal with sequences of operation.

6. All HVAC Control Communications software with the appropriate licenses and hardware interfaces.

1.17. RESPONSIBILITIES OF THE TEMPERATURE CONTROL CONTRACTOR

A. The temperature control contractor shall complete the installation of the temperature control system, and operate and test all control systems to ensure they are functioning properly as designed. The temperature control contractor shall assist the balancing agency in testing and balancing the HVAC systems, as described hereinafter.

1. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water reset, freeze stats, high and low temperature thermostats, safeties, and duct smoke detectors.

2. Verify that all controlling instruments are calibrated and set for design operating

conditions.

3. Calibrate temperature sensors after installation, and before the temperature sensors control verification tests are performed. The balancing agency shall prove the accuracy of final settings by taking temperature readings. The readings shall be in a typical conditional space for each separately controlled zone.

4. The temperature control contractor shall allow sufficient time in the project to provide assistance and instruction to the balancing agency in the proper use and setting of control components such as, but not limited to, computers, static pressure controllers, or any other device that may need set points changed so that the testing and balancing work can be performed.

5. The Control Contractor shall schedule a meeting with the Mechanical Contractor, TAB Agency, and Owner's representative for a pre-submittal review to establish that their interpretation of the control sequence is correct.

6. The Control Contractor shall verify that all controlling instruments are calibrated and set for design operating conditions, with the exception of components that require input from the TAB Agency. A default shall be set for such components. The Control Contractor shall cooperate with the TAB Agency and provide all software and interfaces necessary to communicate with the system.

7. The Automatic Temperature Control Contractor shall thoroughly check all controls, sensors, operators, and sequences before notifying the TAB Agency that the Energy Management System is operational. The Energy Management System Contractor shall provide technical support in the form of technicians and necessary computers to the TAB Agency for a complete check of those systems.

8. The Fire Alarm (FA) Contractor shall thoroughly check all detection devices, sequences, interlocks, and other components before notifying the TAB Agency that the system is operational, including the Fireman's Override Panel. The FA Contractor shall provide all documentation that identifies all fire and smoke detection devices, all smoke zones, and all alarm and event chart devices. The FA Contractor shall certify to the Contractor that the systems are totally operational prior to the start of TAB.

B. All control sequences, software, equipment, and components shall be started-up by a qualified technician. Start-up report shall be submitted to Engineer prior to the commencement of testing and balancing work. Testing and balancing shall not commence until start-up reports are completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.

1.18. NOTIFICATION FOR TESTING AND BALANCING WORK TO BEGIN

A. The mechanical contractor shall notify the balancing agency in writing when all heating, ventilating, and air conditioning and plumbing systems are complete and ready for testing and balancing. The mechanical contractor shall attest that he has completed all items as herein described.

B. The following must be completed prior to start of system balancing:

1. All duct work and associated grilles/registers/diffusers installed and completed.

2. Piping systems completed, flushed and filled.

3. Equipment properly started by qualified personnel or start-up technicians.

4. Ceiling tiles installed.

5. Automation system (temperature controls) installed and completed for both air and water systems.

6. All equipment controlled in automatic ("Auto") mode.

7. Access granted to the balancing contractor to the automation/controls system provided.

C. Mechanical Contractor shall notify the Construction Manager of the start date of this portion of the work.

1.19. DEFICIENCIES

A. Any deficiencies in the installation or performance of a system or component observed by the TAB agency shall be brought to the attention of the appropriate responsible person.

B. The work necessary to correct items on the deficiency listing shall be performed and verified by the affected Contractor before the TAB Agency returns to retest. Unresolved deficiencies shall be noted in the final report.

C. TAB Agency shall notify Construction Manager of all deficiencies found during initial survey.

1.20. ADJUSTING

A. Ensure recorded data represents actual measured observed conditions.

B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring all sensors to specified settings.

E. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

F. Check and adjust systems approximately six months after final acceptance and submit report.

G. Permanently mark the locations of all duct traverses on the exterior surface of the duct

insulation. For exterior ductwork, the duct traverse locations must be identified with waterproof labels.

PART 2. PRODUCTS (NOT APPLICABLE)

PART 3. EXECUTION

3.1. GENERAL

A. Perform all testing and balancing in complete accordance with AABC National Standards for Field Measurements and Instrumentation.

B. Furnish all test instruments and equipment. All instruments must have been calibrated within twelve (12) months prior to use and shall be checked for accuracy prior to and during the work. Submit certificate for calibration of all equipment utilized on project with date of calibration clearly identified.

C. Review all systems designs and equipment, manufacturers' data, and be completely familiar with the work before proceeding.

D. Report all malfunctions or deficiencies to the contractor so that corrective action can be taken. Test and Balance Report shall not be submitted for review until all malfunctions or deficiencies are corrected. Repeat tests where required until design conditions are achieved.

E. Where systems or equipment cannot be balanced or adjusted to design conditions, determine the cause and submit a complete report to the Engineer.

F. Retest or rebalance the system as required during the warranty period.

G. Test and balance all systems under adequate load condition. If, in the opinion of the Engineer, there is insufficient load to properly test and balance the systems, perform sufficient preliminary balancing and adjustment to permit operation of the systems until such time as final testing and balancing can be done. Provide in writing the future date when systems shall be tested under sufficient load.

H. At project completion provide a complete set of ½ scale drawings indicating the locations of all duct traverses.

3.2. EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC/plumbing system and equipment controls.

E. Examine ceiling plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems – Duct Design". Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens and indicated perforations.

L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

M. Examine system pumps to ensure absence of entrained air in the suction piping.

N. Examine operating safety interlocks and controls on HVAC equipment.

O. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3. AIR SYSTEM PROCEDURES

A. The balancing agency shall perform the following testing and balancing functions in accordance with the Associated Air Balance Council's National Standards:

1. Fan Speeds - Test and adjust fan RPM to achieve design CFM requirements.

2. Current and Voltage - Measure and record motor current and voltage. Check and record thermal overload ratings for all motors.

3. Pitot-Tube Traverse - Perform a Pitot-tube traverse of main supply, return and exhaust ducts to obtain total CFM. If a Pitot-tube traverse is not practical, the summation of the outlets or inlets may be used. An explanation why a traverse was not made must appear on the appropriate data sheet.

4. Outside Air - Test and adjust system minimum outside air by Pitot-tube traverse. If a Pitot-tube traverse is not practical, the percentage of outside air may be determined by calculations from the return air, outside air, and mixed air temperatures. Make allowances for heat of compression and motor heat where applicable.

5. Static Pressure - Test and record system static pressures, including suction and discharge static pressure of each fan. Record hood static pressure at kitchen hood exhaust taps, kiln hoods, canopy hoods, spray booths, fume hoods and similar equipment. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make fan RPM allowances for 50 percent loading of filters.

6. Air Temperature - Take wet-bulb and dry-bulb air temperatures on the entering and leaving side of each cooling coil and/or heat recovery coil. Dry-bulb temperature shall be taken on the entering and leaving side of each heating coil.

7. Zone Ducts - Adjust zone ducts to within design CFM requirements. At least one zone balancing damper shall be completely open.

8. Main Ducts - Adjust main ducts to within design CFM requirements and traverse for total CFM quantities.

9. Branch Ducts - Adjust branch ducts to within design CFM requirements. Multi-diffuser branch ducts shall have at least one outlet or inlet volume damper completely open.

10. Magnahelic Gauges - Static pressure at static pressure tips for Magnahelic gauges shall be recorded in Test and Balance Reports.

11. Tolerances - Test and balance each diffuser, grille, and register to within 10 percent of design requirements. Test and balance all fans to within 5 percent of design requirements.

12. Identification - Identify the location and area of each grille, diffuser, and register. This information shall be recorded on air outlet data sheets.

13. Description - Record the size, type, and manufacturer of each diffuser, grille, and register on air outlet data sheets.

14. Minimizing Drafts - Adjust all diffusers, grilles, and registers to minimize drafts in all areas.

15. Test and Balance Engineer shall witness and record all leakage testing of ductwork. Leakage test data shall be included in final Test and Balance Reports.

16. Where modulating dampers are provided, take measurements and balance at extreme conditions.

17. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

18. For heat pumps or condensing units assist start-up organization or manufacturer's representative with start-up. Record air flow rates, water flow rates and electrical characteristics prior to refrigerant pressure measurement and settings.

19. For all equipment specified with condensate overflow safety switches/floats test operation of such device and record results. Verify interlock with ATC system.

20. Outside air and exhaust/relief air measurements must be measured and submitted in all modes of operation including the following:

    a. Min-Min Outside Air/Exhaust/Relief air mode (square footage outside air).
    b. Min-Max Outside Air/Exhaust/Relief air mode (square footage and people outside air).
    c. Maximum outside air/exhaust/relief mode (full 100% economizer mode).

21. For all outside air modes of operation record and submit full static pressure profiles, amperage, BHP, air flow rates, external static pressure, and internal static pressure. Verify airflow rates with air flow monitoring stations and record results.

3.4. WATER SYSTEM PROCEDURES

A. The various water circulating systems shall be filled, purged of air, and put into operation before hydronic balancing by the mechanical contractor.

B. The flow of water through all coils shall be adjusted by manipulating balancing valves until the rated pressure drop through the coil or metering device is obtained. Perform balancing by measurement of temperature differential in conjunction with air balancing.

C. The balancing agency shall perform the following testing and balancing functions in accordance with the AABC National Standards.

D. All Hydronic equipment, domestic re-circulating pumps, and HVAC pumps shall be Tested and Balanced as described below:

1. Water Treatment - Examine the water in the system and determine if the water has been treated and cleaned. If it has not, request the mechanical contractor to clean and treat the water prior to TAB work

2. Strainers - Request that the mechanical contractor clean all strainers.

3. Air Vents - Check all air vents at the high points of the water system and determine

if they are installed and operating.

4. Valves - Set all balancing valves to the full-open position for balancing.

5. Pumps - Adjust all pumps and domestic hot water re-circulating water pumps to meet design GPM requirements. Check pumps for proper operation. Pumps shall be free of vibration and cavitation. Measure and record operating current and voltage. Check and record thermal overloads installed on all pumps. Record in Test and Balance Report.

6. Tolerances - Proceed to balance all coils, pumps, balance valves chillers, boilers, to within 5 percent of design requirements.

7. Marking - Mark all settings and record all data after completing the flow readings and coil adjustments.

8. Where available pump capacity (due to diversity) is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

9. Test and verify proper operation of oil sensors at elevator pit sump pump and report results.

10. Test all A/C condensate pumps for proper operation.

11. Test condensate overflow safety switches.

E. Chillers:

1. Verify that chillers have been started by others and are in operation. Test and adjust chiller water flows to achieve maximum or design GPM.

2. Current and Voltage - Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure compressor motor is not in or above the service factor.

3. Test and record temperature profiles of chillers.

4. Description of liquid sufficient to obtain physical properties.

5. Power input to controls and auxiliary components in KW.

6. Dry bulb temperature of air entering condenser (degrees F).

7. Condenser fans motor power consumption in KW.

8. Condenser fans rotating speed in rpm.

9. Test operation of flow switches.

F. Boilers:

1. Verify that boilers have been filled and started by others, and are in operation.

2. Current and Voltage - As applicable, test and record motor voltage and amperage, and compare data with the nameplate limits to ensure motor is not in or above the service factor.

3. Test and adjust water flow through water boilers.

4. Test and record temperature and pressure profiles of boilers.

5. Test flame failure alarms and low water cut-off alarms.

6. Test condensate block alarm.

7. Test Flow Switches.

G. Coils:

1. Tolerances - Test, adjust, and balance all hydronic coils within 5 percent of design requirements.

2. Verification - Verify the type, location, final pressure drop and GPM of each coil. This information shall be recorded on coil data sheets.

3.5. DOMESTIC HOT WATER RE-CIRCULATING SYSTEMS PROCEDURES

A. The domestic hot water re-circulating system shall be tested and balanced as indicated on the contract documents including:

1. Balance of circuit setters to design quantities indicated on contract documents.

2. Balance of re-circulating pumps to meet design GPM requirements.

B. Domestic Water Heaters/Generators:

1. Verify that all domestic water heaters have been filled and started by others and are in operation. Where heat pump water heaters are specified, test in electric only mode, heat pump mode, and simultaneous mode.

2. Test and record outlet temperature of water heater at approximate design recovery.

3. Current and Voltage: As applicable, test and record voltage and amperage, compare data with nameplate limits to ensure water heater elements or burners do not exceed nameplate data.

4. Test discharge temperature and flow rate at all lavatory/hand sink mixing valves. Also measure time period for fixtures to obtain hot water.

3.6. FUME HOOD TESTING AND BALANCING

A. General: The testing and balancing agency shall perform all required testing and balancing

as previously described in "Air Balancing Procedures" for the fume hood exhaust fans.

B. Fume Hood Air Volume and Face Velocity: The testing and balancing agency shall conduct a performance test to determine the hood air volume and face velocity as described below for each fume hood.

1. Test the operation of the sash. Use one hand to grip the sash at the extreme right side and raise and lower the sash. Repeat at the extreme left side. The sash should glide smoothly and freely and hold at any height without creeping. If the hood has a vertical moving sash, set it in the full open or in the "as used" position. If the hood has a combination sash, close the vertical sash and position the horizontal sash to get the maximum face opening or set it in the "as used" position. "As used" position of all fume hoods shall be 18 inches above the work surface, unless otherwise noted.

2. Traverse the exhaust duct using a manometer or anemometer to determine total volume of air through the hood. Calculate the total air volume in cubic feet per minute by multiplying the area of the duct by the average duct velocity (Q=AV). Take static pressures in the exhaust duct at the collar and compare with design static pressure loss through the fume hood. Record the readings. Any holes drilled for testing must be sealed as specified by the engineer or equipment manufacturer.

3. Divide the hood face into a grid using the vertical and horizontal dimensions to get equal areas over the cross section of the sash opening. Establish the center of each area. The maximum distance between the centers should not exceed 6 inches. Make a sketch showing area centers.

4. Traverse the sash opening using an anemometer to take a velocity reading at each center point. Record the readings. The hood fails the test if the minimum reading at any point on the traverse is less than 80percent of the average face velocity.

5. Calculate the average face velocity in feet per minute. Compare the average face velocity with design specifications.

6. Calculate the volume of exhaust air in cubic feet per minute at the hood face by multiplying the square feet of the sash opening by the calculated average face velocity (Q-AV).

7. Compare with the air volume taken at the exhaust duct traverse point. Record hood static pressure at location of Magnahelic gauge static pressure tip and record in TAB Report.

8. Place a certificate showing test results on the fume hood.

C. Smoke Test Procedures: The testing and balancing agency shall conduct a smoke test to determine each fume hood’s performance as described below:

1. Make a complete traverse of the hood face with either titanium tetrachloride on a cotton swab, a smoke candle or a smoke tube. Determine that a positive air flow is entering the hood over the entire face. Use a smoke tube, a smoke candle, or swab a stripe of titanium tetrachloride on pieces of tape to produce the necessary

amount of smoke. Direct the smoke at the following test locations:

a. Along both sides, the top and the work surface of the hood about 6 inches behind and parallel to the hood face.
b. Along the back panel and the baffle of the hood.
c. Around any equipment in the hood.

2. Verify that all smoke is carried to the back of the hood and exhausted. The hood fails the test if visible smoke flows out the front of the hood. Reverse air flows or dead air spaces are not permitted.

3. With the sash open, ignite a smoke candle within the hood enclosure to observe the exhaust capacity of the hood. All smoke should flow quickly and directly to the back of the hood and be exhausted. Set the candle on the work surface and close the sash. With the sash closed, the hood must have enough air to dilute and exhaust the smoke. The hood fails the test if visible smoke flows out the front of the hood. Reverse air flows or dead air spaces are not permitted.

4. Place a pan of hot water in the center of the work area and add enough chunks of dry ice to the hot water to form a large volume of heavy white smoke. All smoke should flow directly to the back of the hood and be exhausted. The hood fails the test if visible smoke flows out the front of the hood. Reverse airflows or dead air spaces are not permitted.

5. The Test and Balancing Agency shall provide all equipment necessary for smoke test including:

a. Smoke tubes
b. Dry ice
c. Titanium tetrachloride
d. Cotton swabs

6. Results of smoke test to be included in Test and Balance Report.

7. Record all visual testing of fume hoods on a digital recording device and forward digital file to Engineer/Owner with final Test and Balance Report.

3.7. KITCHEN HOOD TESTING AND BALANCING PROCEDURES

A. The kitchen hood exhaust and make-up air quantities shall be tested and balanced to the indicated design quantities (CFM). The air flow of each shall be determined by the use of pitot tube traverse and/or a short ridge velgrid.

B. The kitchen hood should then be tested for adequate capture using a 30 second smoke bomb. The cooking equipment below the hood should be turned on and brought up to normal operating temperature. All grease filters should be in place. The kitchen make-up air unit and exhaust fans shall be on. The hood static pressure should be recorded and documented in the Test and Balance Report and the hood shall be tested and must provide 100 percent capture. If the hood does not prove 100 percent capture, the source of the problem shall be determined and the test repeated. Record results of tests within TAB report.

3.8. FIRE AND SMOKE TESTING PROCEDURES

A. The TAB agency shall test fire/smoke damper to assure operation. It shall verify that an access door has been installed for each fire and smoke damper. For fire dampers, the TAB agency shall open the access door, disconnect the fusible link, and allow the damper to close. Operation should be smooth and the damper must close completely. The TAB agency shall then reset the damper. For the smoke damper, the TAB agency shall open the access door, activate the damper, and observe operation. The damper must close quickly and completely. The TAB agency shall then reset the damper and observe its complete opening. Record results of tests within TAB report.

3.9. LIFE SAFETY CONTROLS TESTING PROCEDURES

A. The TAB agency shall test and record life safety control operation on the HVAC equipment. It shall verify the installation of required smoke detectors in air handling equipment (AHE), and shall verify operation of the smoke detector by activating the smoke detector and observing air handler shutdown. With the controls and alarm contractors, the TAB agency shall verify the operation of interconnected systems such as the AHU smoke detector's activation of the fire alarm system and the alarm system's activation of the life safety control sequences. Record results of tests within TAB report.

3.10. VERIFICATION OF TEMPERATURE CONTROL

A. The balancing agency shall be assisted by the temperature control contractor in verifying the operation and calibration of all temperature control systems. The following tests shall be conducted:

1. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water reset.

2. Verify that all controlling instruments are calibrated and set for design operating conditions.

3. Verify the accuracy of the final settings by taking temperature readings. The readings shall be in a typical conditioned space for each separately controlled zone.

4. Test and calibrate all air flow monitoring stations for proper air flow.

5. Test and calibrate all static pressure sensors for proper set point and control.

6. Test and calibrate all differential pressure sensors. Record set point in Record and Information Books.

3.11. TEST AND BALANCE REPORTS

A. The test and balance report shall be complete with logs, data, and records as required herein. All logs, data, and records shall be typed on white bond paper and bound. The report shall be certified accurate and complete by the balancing agency's certified test and balance engineer.

B. Six (6) hardcopies and one (1) electronic copy of the test and balance report are required and shall be submitted to the Engineer. If, in the opinion of the Engineer, test results or portions thereof are incomplete or inconclusive, repeat necessary portions of the work to the satisfaction of the Engineer.

C. The report shall contain the following general data in a format selected by the balancing agency:

1. Project Number
2. Contract Number
3. Project Title
4. Project Location
5. Project Architect
6. Project Mechanical Engineer
7. Test & Balance Agency
8. Test & Balance Engineer
9. Construction Manager
10. Mechanical Contractor
11. Commissioning Agent
12. Dates tests were performed
13. Certification
14. Duct Leakage Tests
15. Phone Numbers of all Individuals Listed Above

D. The test and balance report shall be recorded on report forms conforming to the recommended forms in the AABC National Standards.

E. The test and balance report shall include a table of contents with numbered pages.

3.12. TEST REPORT FORMS

A. Air Moving Equipment and Fan Test Forms - Submit fan curve showing design and operating points of operation. Also, record the following on each air-handling equipment test form:

1. Manufacturer, model number, serial number, arrangement.

2. All design and manufacturer-rated data.

3. Total actual CFM by traverse if practical. If not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.

4. Suction and discharge static pressure of each fan, as applicable. Include pressure drops across coils, dampers, filters, mixing boxes, and similar devices.

5. Outside-air, return-air, and exhaust air total CFM.

6. Actual operating current, voltage and brake horsepower of each fan motor. For packaged equipment, this includes supply fans, relief air fans, and condenser fans.

7. Final RPM of each fan.

8. Fan and motor sheave manufacturer, model, size, number of grooves, bore, and center distance.

9. Belt size, quantity and make.

10. Static-pressure controls final operating set points (if applicable).

11. Total and external static pressure.

12. Room differential static pressures.

B. Pump Test Forms - Submit pump curve showing design, operating, and no-flow points of operation. Also, record the following items on each pump test form:

1. Manufacturer, size, model, service and serial number.

2. All design and manufacturer's rated data.

3. Pump operating suction and discharge pressure and final total dynamic head.

4. No flow (pump discharge valve closed) suction and discharge pressure and corresponding total dynamic head. This procedure is to determine actual impeller size. Record impeller size.

5. Rated and actual operating current, voltage, and brake horsepower of each pump motor.

6. Total operating head pressure.

7. Shutoff, discharge and suction pressures.

8. Shutoff, total head pressure.

C. Chiller and Boiler Test Forms - Record the following items on each chiller and boiler test form:

1. Manufacturer model number, serial numbers.
2. All design and manufacturer's rated data.
3. Service and location.
4. Actual pressure drop and related GPM primary side.
5. Actual pressure drop and related GPM, secondary side.
6. Primary side entering and leaving temperatures.
7. Secondary side entering and leaving temperatures.
8. Temperature control settings.
9. Electrical characteristics.
10. For air cooled chillers condenser fan speed and kw.
11. Where applicable, electric heat trace operation for chilled water piping located outside.
12. Test operation of flow switches.

D. Heating and Cooling-Coil Test Forms - Record the following items on each test form:

1. Manufacturer, location, service.
2. All design and manufacturer's rated data.
3. Rated and actual water pressure drop through each coil and related GPM.
4. Rated and actual static pressure drop across each coil.
5. Rated and actual entering and leaving water temperatures across each coil.
6. Wet-bulb and dry-bulb temperatures entering and leaving each cooling coil; dry-bulb temperatures entering and leaving each heating coil.
7. Air flow (Design and Actual).
8. For DX-coil, provide design and actual saturated suction temperature.
9. For DX-Coil, provide design and actual discharge pressures.

E. Air Monitoring Station Test Forms:

1. Identification /location.
2. Manufacturer.

3. Systems.
4. Size and Model Number.
5. Area.
6. Design Velocity.
7. Design Airflow.
8. Test Velocity.
9. Test Airflow.
10. Static Pressure Drop and Velocity Pressure.
11. Station Calibrated Setting.

F. Flow Measuring Station Test Forms:

1. Identification/location.
2. Manufacturer.
3. Size and Model Number.
4. Design and Actual Flow Rate.
5. Design and Actual Pressure Drop.
6. ATC flow rate versus field measured flow rate.

G. Electric Unit Heater Test Forms:

1. Manufacturer.
2. Identification/number.
3. Location.
4. Model number.
5. Design kW and actual kW.
6. Phase, voltage, amperage.
7. Test voltage (each phase).
8. Test amperage (each phase).
9. Air flow, specified and actual.

10. Temperature rise, specified and actual.

H. Electric Motors Test Forms: (Applies to all motors, including pumps, fans and HVAC equipment)

1. Manufacturer.

2. Model/Frame.

3. HP/BHP.

4. Phase, voltage, amperage; nameplate, actual, no load.

5. RPM.

6. Service factor.

7. Starter size, rating, heater elements.

8. Sheave Make/Size/Bore.

9. Thermal overload settings

I. V-Belt Drive Test Forms:

1. Identification/location.

2. Required driven RPM.

3. Driven sheave, diameter and RPM.

4. Belt, size and quantity.

5. Motor sheave diameter and RPM.

6. Center to center distance, maximum, minimum, and actual.

J. Duct Traverse Test Forms:

1. System zone/branch.

2. Duct size.

3. Area.

4. Design velocity.

5. Design air flow.

6. Test velocity.

7. Test airflow.

8. Duct static pressure.

9. Air temperature.

10. Air correction factor.

K. Duct Leakage Test Forms:

1. Description of ductwork under test.

2. Duct design operating pressure.

3. Duct design test static pressure.

4. Duct capacity, air flow.

5. Maximum allowable leakage duct capacity times leak factor.

6. Test apparatus.

   a. Blower.
   b. Orifice, tube size.
   c. Orifice size.
   d. Calibrated.

7. Test static pressure.

8. Test orifice differential pressure.

9. Leakage.

L. Air Distribution Test Forms:

1. Air terminal number.

2. Room number/location.

3. Terminal type.

4. Terminal size.

5. Area factor.

6. Design velocity.

7. Design air flow.

8. Test (final) velocity.

9. Test (final) air flow.

10. Percent of design air flow.

M. Dust Collector Test Forms: - Submit fan curve showing design and operating points of operation. Also, record the following on each dust collector test form:

1. Manufacturer, model number, serial number, arrangement.
2. All design and manufacturer-rated data.
3. Total actual CFM by traverse if practical. If not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.
4. Suction and discharge static pressure of each dust collector, as applicable. Include pressure drops across filters and similar devices.
5. Actual operating current, voltage and brake horsepower of each dust collector fan motor.
6. Final RPM of each fan.
7. Duct collector fan and motor sheave manufacturer, model, size, number of grooves, bore, and center distance.
8. Belt size, quantity and make.
9. Total and external static pressure.

N. Ductless Unit Test Forms:

1. Manufacturer
2. Type, air conditioning, heat pump
3. Identification number
4. Location
5. All design and manufacturer's rated data.
6. Rated and actual entering and leaving dry bulb temperatures.
7. Rated and actual entering and leaving wet bulb temperatures.
8. Air flow (design and actual)
9. Provide actual saturated suction temperature.
10. Actual operating current, voltage and brake horsepower of each fan motor.
11. Final fan RPM.

O. Energy Recovery Ventilators Test Forms: Submit fan curve showing design and operating

points of operation. Also, record the following on each air-handling equipment test form:

1. Manufacturer, model number, serial number, arrangement.

2. All design and manufacturer-rated data.

3. Total actual CFM by traverse if practical. If not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.

4. Suction and discharge static pressure of each fan, as applicable. Include pressure drops across coils, filters, energy wheels, and similar devices.

5. Outside-air, and exhaust air total CFM.

6. Actual operating current, voltage and brake horsepower of each fan motor.

7. Final RPM of each fan.

8. Fan and motor sheave manufacturer, model, size, number of grooves, bore, and center distance.

9. Belt size, quantity and make.

10. Total and external static pressure.

11. Rated and actual static pressure drop across each energy wheel.

12. Wet-bulb and dry-bulb temperatures entering and leaving each cooling coil, heat pipe and energy wheel. Dry-bulb temperatures entering and leaving each heating coil.

13. Record carbon dioxide set points and actual readings for exhaust air stream at each ERV and global CO2 sensor.

14. Record the supply fan and exhaust fan maximum hertz/speed and minimum hertz/speed. Provide measurements to ATC subcontractor for fan tracking control.

15. Test minimum air flow rate and maximum air flow rate. Submit amperage, air flow rates, RPM, hertz, and static pressure profile in all modes of operation.

P. Finned Tube Test Forms - Record the following items on each test form:

1. Manufacturer, location, service.

2. All design and manufacturer's rated data.

3. Rated and actual water pressure drop through each piece of finned tube and related GPM.

4. Rated and actual entering and leaving water temperatures across each section of

finned tube.

5. Entering and leaving air temperatures across each finned tube element.

Q. Fan Coil Unit Data Test Forms:

1. Manufacturer.
2. Type.
3. Identification/number.
4. Location.
5. Model number.
6. Size.
7. Water Pressure drops (all coils).
8. Static pressure
9. Test amperage
10. Entering coil conditions (wet bulb and dry bulb).
11. Leaving coil conditions (wet bulb and dry bulb).
12. Water flow rates (all coils)
13. Test voltage.
14. Supply return and outside air flow rates.

R. Kitchen Make-up Air Unit Test Forms

1. Manufacturer model number, serial numbers.
2. All design and manufacturer's rated data.
3. Design and actual fluid pressure and related GPM.
4. Electrical characteristics, design, and actual.
5. Fan speed, static pressure voltage, amp draw.
6. Wet Bulb and dry Bulb temperatures entering, leaving coils design, actual.
7. Air flow rate/RPM at maximum flow and minimum flow.
8. Interlocked exhaust fan air flow rate/RPM at maximum flow and minimum flow.

9. Temperatures entering and leaving the heat pipe, design, and actual.

10. Where applicable entering/leaving temperatures at evaporator coils, hot gas re-heat coils, design, and actual.

11. Record the supply fan and exhaust fan maximum hertz/speed and minimum hertz/speed. Provide measurements to ATC subcontractor for fan tracking control.

S. Elevator Sump Pump Test Forms:

1. Manufacturer, Model Number, and Serial Number.

2. Motor Horsepower – Design/Actual

3. Voltage/Phase/Hz/Amps

4. Verify ATC interlocks.

5. Test high water condition.

T. Air Cooled Condensing Unit/Heat Pump Test Forms:

1. Manufacturer

2. Model Number

3. Location

4. Size/Capacity

5. Fan RPM (Min and Max)

6. Compressor and Condenser/Heat Pump Fan Electrical Characteristics

7. Condenser/Heat Pump Fan RPM

8. Amp Draw of all Components

9. Refrigerant Suction/Discharge Pressures

10. Thermal Overload Sizes

U. High/Low Mixing Valve Test Forms

1. Manufacturer, Model Number, Series, Arrangement

2. All manufacturer data.

3. Verify all strainers are clean.

4. Leaving temperature actual and design.

V. Thermostatic Mixing Valve Test Forms

1. Manufacturer, Model Number, Series, Arrangement
2. All manufacturer data.
3. Verify all strainers are clean.
4. Leaving temperature actual and design.

W. Water Heater Test Forms

1. Manufacturer, Model Number, Series
2. All manufacturers' data.
3. Verify all safeties.
4. Record leaving water temperature actual and design.
5. Verify operation in all modes of operation.
6. Record electrical characteristics

X. Condensate Over Flow Switches/Floats Test Forms

1. Manufacturer
2. Type
3. Location
4. Equipment shut down verification
5. ATC interlock verification

Y. Ceiling Paddle Fans Test Forms (Record the following on each ceiling paddle fan)

1. Manufacturer, Model Number, Serial Number
2. Voltage, Phase, Amps, Hertz
3. Fan RPM
4. Test and record fan rotation speed in both directions.

Z. Electric Radiant Heat Panels Test Forms:

1. Manufacturer.
2. Identification/number.

3. Location.

4. Model number.

5. Design kW and actual kW.

6. Phase, voltage, amperage.

7. Test voltage (each phase).

8. Test amperage (each phase).

9. Air flow, specified and actual.

10. Temperature rise, specified and actual.

AA. Single Zone VAV Unit Test Forms: Submit fan curve showing design and operating points of operation. Also, record the following on each air-handling equipment test form:

1. Manufacturer, model number, serial number, arrangement.

2. All design and manufacturer-rated data.

3. Total actual CFM by traverse if practical. If not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.

4. Suction and discharge static pressure of each fan, as applicable. Include pressure drops across coils, filters, energy wheels, and similar devices.

5. Outside-air, and exhaust air total CFM.

6. Actual operating current, voltage and brake horsepower of each fan motor.

7. Final RPM of each fan.

8. Fan and motor sheave manufacturer, model, size, number of grooves, bore, and center distance.

9. Belt size, quantity and make.

10. Total and external static pressure.

11. Rated and actual static pressure drop across each energy wheel.

12. Wet-bulb and dry-bulb temperatures entering and leaving each cooling coil, heat pipe and energy wheel. Dry-bulb temperatures entering and leaving each heating coil.

13. For DX-coil, provide design and actual saturated suction temperature.

14. Record carbon dioxide set points and actual readings for exhaust air stream at each single zone VAV unit and global CO2 sensor.

15. Entering and leaving air temperatures at hot gas re-heat coils.

16. Record the supply fan and exhaust fan maximum hertz/speed, and minimum hertz/speed. Provide measurements to ATC subcontractor for fan tracking control.

17. Test minimum air flow rate, maximum air flow rate and economizer air flow rate.

18. Submit amperage, air flow rates, RPM, hertz, and static pressure profile in all modes of operation.

BB. Hydronic Unit Heater Test Forms:

1. Manufacturer.

2. Model/Serial #.

3. Location.

4. Design air flow rate and actual air flow rate.

5. Design entering/leaving water temperature and actual entering/leaving water temperature.

6. Design fluid pressure drop and actual fluid pressure drop.

7. Design heating capacity and actual heating capacity in BTU/hr.

8. Actual entering/leaving air temperature.

CC. Carbon Monoxide Ventilation System Unit Test Forms

1. Manufacturer model number, serial numbers.

2. All design and manufacturer’s rated data.

3. Design and actual fluid pressure and related GPM.

4. Electrical characteristics, design, and actual.

5. Fan speed, static pressure voltage, amp draw.

6. Wet Bulb and dry Bulb temperatures entering, leaving coil design, actual.

7. Air flow rate/RPM at maximum flow and minimum flow.

8. Interlocked exhaust fan air flow rate/RPM at maximum flow and minimum flow.

9. Temperatures entering and leaving the heat pipe, design, and actual.

10. Where applicable entering/leaving temperatures at hot gas re-heat coils, design, and actual.

11. Record the supply fan and exhaust fan maximum hertz/speed and minimum hertz/speed. Provide measurements to ATC subcontractor for fan tracking control.

DD. Welding Area/Paint Spray Booth Make-up Air Unit Test Forms

1. Manufacturer model number, serial numbers.

2. All design and manufacturer's rated data.

3. Design and actual fluid pressure and related GPM.

4. Electrical characteristics, design, and actual.

5. Fan speed, static pressure voltage, amp draw.

6. Wet Bulb and dry Bulb temperatures entering, leaving coil design, actual.

7. Air flow rate/RPM at maximum flow and minimum flow.

8. Interlocked exhaust fan air flow rate/RPM at maximum flow and minimum flow.

9. Temperatures entering and leaving the heat pipe, design, and actual.

10. Where applicable entering/leaving temperatures at hot gas re-heat coils, design, and actual.

11. Record the supply fan and exhaust fan maximum hertz/speed and minimum hertz/speed. Provide measurements to ATC subcontractor for fan tracking control.

12. For paint spray booth, entering/leaving temperature at the gas fired makeup air unit.

EE. Packaged Automatic Glycol Feeder Test Forms:

1. Manufacturer, model number, serial number.

2. All design and actual measured data.

3. Pump discharge pressure.

4. Rated and actual voltage, current.

5. Pressure switch set point pressure.

6. Test all safeties and alarms.

FF. Heating and Ventilating Unit Test Forms: Submit fan curve showing design and operating points of operation. Also, record the following on each air handling equipment test form:

1. Manufacturer, model number, serial number, arrangement.

2. All design and manufacturer-rated data.

3. Total actual CFM by traverse if practical. If not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.

4. Suction and discharge static pressure of each fan, as applicable. Include pressure drops across coils, filters, energy wheels, and similar devices.

5. Outside-air, and exhaust air total CFM.

6. Actual operating current, voltage and brake horsepower of each fan motor.

7. Final RPM of each fan.

8. Fan and motor sheave manufacturer, model, size, number of grooves, bore, and center distance.

9. Belt size, quantity and make.

10. Total and external static pressure.

11. Rated and actual static pressure drop across each energy wheel.

12. Wet-bulb and dry-bulb temperatures entering and leaving energy wheel. Dry-bulb temperatures entering and leaving each heating coil.

13. Test minimum air flow rate and maximum air flow rate. Submit amperage, air flow rates, RPM, hertz, and static pressure profile in all modes of operation.

GG. Rooftop VAV Unit Test Forms: Submit fan curve showing design and operating points of operation. Also, record the following on each air-handling equipment test form:

1. Manufacturer, model number, serial number, arrangement.

2. All design and manufacturer-rated data.

3. Total actual CFM by traverse if practical. If not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.

4. Suction and discharge static pressure of each fan, as applicable. Include pressure drops across coils, filters, and similar devices.

5. Outside-air, and exhaust air total CFM.

6. Actual operating current, voltage and brake horsepower of each fan motor.

7. Final RPM of each fan.

8. Fan and motor sheave manufacturer, model, size, number of grooves, bore, and center distance.

9. Belt size, quantity and make.

10. Total and external static pressure.

11. Wet-bulb and dry-bulb temperatures entering and leaving each cooling coil. Dry-bulb temperatures entering and leaving each gas furnace.

12. Record the supply fan and exhaust fan maximum hertz/speed, and minimum hertz/speed. Provide measurements to ATC subcontractor for fan tracking control.

13. Test minimum outside air flow rate, maximum outside air flow rate, and economizer air flow rate.

HH. Kitchen Hood Test Forms:

1. Manufacturer.

2. Identification/type of hood.

3. Location.

4. Total exhaust air flow rate in CFM.

5. Exhaust duct traverse size and location.

6. Filter face velocities.

7. Exhaust duct static pressure in inches w.g.

8. Results of smoke testing.

9. Total make-up air unit airflow rate in CFM.

II. Industrial Air Cleaner Test Forms:

1. Manufacturer/Model #/Serial #.

2. Location.

3. Total air flow rate in CFM.

4. Filter/component pressure drops.

5. Electrical characteristics including current, volts, amps, and BHP.

END OF SECTION

DIVISION 23 SECTION 23 06 00
HEATING, VENTILATING, AND AIR CONDITIONING EQUIPMENT
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SECTION 23 06 00
HEATING, VENTILATING, AND AIR CONDITIONING EQUIPMENT

PART 1. GENERAL

1.1. GENERAL

A. The Conditions of the Contract and other General Requirements apply to the work specified in this section. All work under this section shall also be subject to the requirements of Division 23 Section, Common Work Results for HVAC and Division 01 Section General Requirements.

1.2. DESCRIPTION

A. The work to be performed shall include all labor, materials and equipment necessary to furnish and install complete, all mechanical equipment as shown on drawings, hereinafter specified or reasonably implied, and leaving the same in satisfactory operation condition. It is the intent that systems be installed complete with all items necessary to accomplish this purpose.

1.3. SUBMITTALS

A. Shop Drawings: Indicate assembly, equipment dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.

B. Product Data:

1. Provide literature which indicates dimensions, weights, capacities, ratings, performance, gages and finishes of materials, and electrical characteristics and connection requirements.

2. Provide data of filter media, filter performance data, filter assembly, and filters frames.

3. Provide fan and pump curves with specified operating point clearly plotted.

4. Submit sound power level data for both fan outlet and casing radiation at rated capacity. Submit sound power levels by octave band or sound pressure levels by octave band for all equipment.

5. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

6. For fume hood exhaust fans provide nozzle velocity of exhaust fan, total exhaust flow, and discharge plume height.

1.4. OPERATION AND MAINTENANCE DATA

A. Maintenance Data: Include instructions for lubrication, filter replacement, motor and

drive replacement, spare parts lists, and wiring diagrams.

1.5. DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect, and handle products to site under provisions of General Requirements.

B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.

C. Store all equipment in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

D. Comply with manufacturer's installation instructions for rigging, unloading and transporting equipment.

E. Protect all motors, shafts, and bearings from weather and construction dust.

1.6. ENVIRONMENTAL REQUIREMENTS

A. Do not operate any equipment for any purpose, temporary or permanent, until ductwork/piping is clean, filters/strainers are in place, bearings lubricated, and equipment has been test run under observation.

1.7. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates.

1.8. EXTRA MATERIALS

A. Provide one set of seals for each type and model of pump provided on the project.

B. Furnish a spare quantity of lime chips for each condensate neutralizer.

1.9. SHORT CIRCUIT CURRENT RATINGS

A. Unless otherwise noted, all HVAC equipment shall include a nameplate that identifies the short circuit current rating (SCCR). Unless otherwise noted the SCCR rating for all HVAC equipment shall be a minimum of 65 KA.

1.10. PACKAGED EQUIPMENT BACNET CARDS

A. For all packaged units, furnish and install Bacnet cards for interface to the automatic temperature control system. Map over all Bacnet points and alarms and show on ATC system graphics. All alarms must be identified on ATC graphic.

PART 2. PRODUCTS

2.1. 100% OUTSIDE AIR DOUBLE WALL INDOOR CENTRAL STATION HEATING AND VENTILATING UNITS (WELDING OR CARBON MONOXIDE MAKE-UP AIR UNITS) (MAU-1, 2, & 3)

A. Provide and install central station heating and ventilating units as shown and scheduled on the plans. The units shall be installed in a neat and workmanship like manner in strict accordance with specifications. Air Handling units shall be Trane IAQ Modular Climate Changers, JCI/York Airpack, Carrier, Daikin, Venmar, or approved Equal. Provide components as detailed on the contract drawings.

B. General

1. Central station heating and ventilating units heating/ventilating units, and make-up air units shall be certified in accordance with the Air Conditioning and Refrigeration Institute (ARI) Standards 430 for Central Station Air Handling unit and 410 for coils.

2. Units shall be provided with nominal 1-inch deflection spring isolators, as required, or as recommended by the unit manufacturer.

3. The units shall be furnished complete with double wall insulated casings, centrifugal fans, coils as scheduled, insulated drain pan, motor, drive belt guard, and accessories as required. Coils shall not exceed specified face velocities.

4. Adequate space around all sides of the air handling unit shall be provided for proper service and maintenance.

5. All units shall be horizontal draw through medium pressure units. Construct casing section located upstream of supply fan for operation at a minimum 4 inches W.G. negative static pressure and downstream section for operation at a minimum of 6 inches water gauge positive static pressure.

6. All units shall be factory primed and finished in colors as selected by Engineer.

7. Provide unit mounting legs to support all sections of unit and raise unit for proper trapping. Unit mounting devices not constructed of galvanized steel shall be chemically cleaned, coated with rust inhibiting primer, and finished with rust inhibiting enamel. Contractor shall be responsible for all steel supports and hangers for hung units.

8. Fan discharge arrangements shall be coordinated with ductwork layout to minimize “system effect” per AMCA-Publication 201-90.

9. Provide 6-inch high unit mounting legs or base rail to support all sections of unit and raise unit for proper trapping. Unit mounting devices shall be galvanized steel and a minimum of 10 gauge. Unit mounting devices not constructed of galvanized steel shall be chemically cleaned, coated with rust inhibiting primer and finished with rust inhibiting enamel. Contractor shall be responsible for all steel supports and hangers for hung unit.

10. All heating coil capacities shall be based on scheduled percentage of propylene glycol.

11. Fan motors shall be inverter duty rated when utilized with variable frequency drives.

C. Construction

1. Unit casing shall be constructed of minimum 18 gauge galvanized metal, formed and reinforced to provide a rigid assembly. Formed panels shall be removable to provide easy access to internal components. Each of the sectionalized modules and accessories shall be factory assembled. Removal of side panels shall not affect the structural integrity of the unit.

2. All exterior panels and structural frames shall be constructed of G90-U galvanized steel. Casings not constructed of G90-U galvanized steel, casings with welds on exterior surfaces, or casings with welds on interior surfaces the have burned through to exterior surfaces shall be chemically cleaned, coated with rust inhibiting primer, and finished with rust inhibiting enamel in order to prevent premature corrosion and microbial growth.

3. Seal and gasket all joints between exterior panels and structural frames with closed-cell foam gasketing for air seal and acoustical break.

4. Casing shall have full size removal access doors as shown on drawings. Access doors shall have 2-inch double wall construction. Provide automotive style neoprene gasketing around full perimeter of access doors to prevent air leakage. Provide “ventlock” style non-corrosive alloy latches operable from the inside or outside of unit. If access doors open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement.

5. Insulate casing sections with 2-inch thick 1 ½ pound per cubic foot density fiber glass insulation or equivalent. Provide double wall casing construction and encase insulation between solid exterior and double wall interior casing panels such that no insulation is exposed to airstream. Foil facing on insulation is not acceptable as alternate to double wall construction. Insulation shall comply with NFPA 90A.

6. Coils sections with two or more coils shall have a 4-inch spacer between each adjacent coil.

7. Fan sections with internally mounted motors shall be provided with a standard full size access door allowing easy access to the fan/motor assembly. Units with externally mounted motors shall be provided with an expanded metal belt guard with hole for tachometer.

D. Fans

1. Units shall be provided with double width double inlet, centrifugal-type wheels. Fans shall be Standard or Class II (as required by total static pressure) forward

curved wheels or air foil type as scheduled. Every fan shall be rated in accordance with AMCA Standards and the fan section shall be certified in accordance with ARI Standard 430. Fan shafts shall be selected to operate well below the first critical speed and each shaft shall be factory coated after assembly with an anti-corrosion coating. After the pre-balanced fan is installed in the air handler the entire fan section shall be run to assure smooth and trouble free operation.

2. Fan bearings shall be self-aligning, pillow block or flanged-type regreasble ball bearings and shall be supplied for an average life (L50) or 200,000 hours. All bearings shall be factory-lubricated and equipped with standard hydraulic grease fittings and extended lube lines. Provide dust caps on all hydraulic grease fittings.

3. Mount fans on isolation bases. Internally mount motors on same isolation bases and internally isolate fans and motors with spring isolators. Install flexible canvas ducts between fan and casings to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A.

4. Fan section shall have full height, double wall, hinged, removable access doors for inspection and maintenance of internal components.

5. Weigh fan and motor assembly at AHU manufacturer's factory for isolator selection. Statically and dynamically balance fan section assemblies. Fan section assemblies include fan wheels, shafts, bearings, drives, belts, isolation bases and isolators. Allow isolators to free float when performing fan balance. Measure vibration at each fan shaft bearing in horizontal, vertical and axial directions. Balance at design RPM's as scheduled on drawings.

E. Motors and Drives

1. Fan motors shall be externally mounted or as indicated on contract drawings. Air handling units with internal motors shall be provided with additional cooling capacity to compensate for motor heat added to airstream. Total cooling capacity, as scheduled, shall be increased by 2500 btuh per motor horsepower for units with internally mounted motors.

2. Units shall be provided with the motor efficiencies as specified in Division 23.

3. Motors shall be open NEMA Design B, rigid base, open drip proof, with Class B insulation.

4. Fan drives shall be selected for a 1.5 service factor and anti-static belts shall be furnished. One additional set of belts shall be provided for each air handling unit and delivered to the Owner's representative at the completion of the project.

5. Fan sections shall be equipped with double width double inlet, centrifugal type wheels.

6. Drives shall be variable pitch and suitable for adjustment within plus or minus 15 percent of specified RPM but not to exceed the maximum RPM of the unit.

F. Coils

1. Heating and Pre-heat coils shall be furnished to meet the performance requirements set forth in the schedule. All coils shall have performance certified in accordance with ARI Standard 410. Coils shall be arranged in the unit for horizontal air flow and selected for a maximum face velocity as scheduled. Install coils such that headers and return bends are enclosed by unit casings. Low temperature coils (40 degrees F EPT) shall be properly circulated to prevent laminar flow at part load conditions.

2. Coil casing shall be constructed of heavy gauge galvanized metal with aluminum die-formed corrugated fins and guide channels to create turbulent wiping behind the tube. The fins shall have drawn collars, be belled and mechanically expended to firmly bound the copper tube to the fins. All coils shall be installed on tracks for easy removal from the air handling unit.

3. Drainable water coils shall be designed to operate at 250 psig design working pressure and up to 300 degrees F and shall be tested with 325 psig compressed air under water. Circuiting shall provide free draining and venting when installed, counter flow of air and water with water velocities not to exceed seven feet per second and without exceeding the water pressure drops schedule. All coils must have same end connections regardless of the number of rows deep. Clearly label supply and return headers on outside of units such that direction of coil water flow is counter to direction of unit airflow.

4. Construct coils of configuration plate fins and seamless tubes. Fins shall have collars drawn, belled and firmly bonded to tubes by means of mechanical expansion of tubes. Do not use soldering or tinning in bonding process.

5. Construction coil casings of Galvanized G90-U Steel with formed end supports and top and bottom channels. If two or more coils are stacked in unit, install intermediate drain channels between coils to drain condensate to main drain pans without flooding lower coils or passing condensate through airstream.

6. Coil grommets shall be provided on all coils to completely seal the area between the coil connection and the unit casing.

G. Filters

1. Filters shall be nominal 2-inch standard size filters; MERV8 pleated media type. Filters shall be Farr, medium efficiency pleated type 30/30 with welded wire media support grid.

2. Provide one additional set of filter media for each air handling unit to be delivered to the Owner’s representative upon completion of the project.

H. Access Sections and Access Doors

1. Fully insulated, access sections shall be provided as indicated on the drawings. Sections provide a minimum of 18 inch accessible space with full-size access doors. Access for inspection and cleaning of the unit drain pan, coils, and fans

sections shall be provided.

2. Access doors shall be provided in all sections as indicated on the drawings. Access doors shall be double wall construction.

3. Panels shall be fully removable to allow for a proper way to thoroughly clean panels of microbial growth and to access internal parts.

I. Filter Box

1. Provide factory fabricated filter box section of the same construction and finish as unit casing. Filter sections shall be filter guides, and full height double wall, hinged, removable access door for filter removal. Provide filter blockoffs as required to prevent air bypass around filters. Angle filters shall be accessible from either side with hinged access doors.

2. Outside air dampers shall be supplied by ATC contractor and install by mechanical contractor in adjacent ductwork. Damper blades shall be parallel acting and shall rotate in nylon bearings providing smooth action and requiring no lubrication. Dampers shall be sectionalized to limit blade length, prevent warpage and assure a tight closure. Actuators shall be provided and installed by the ATC contractor.

3. Provide field installed differential pressure gauge, two static pressure tips, vent valves, and red pointer flag and air filter gauge accessory package to measure filter resistance. Accuracy shall be 2 percent of full scale 0 to 1.0 inch w.g. range. Gauges shall be 2003 magnahelic by Dwyer Instruments or approved equal.

J. Installation

1. Install make-up air units where shown, in accordance with equipment manufacturer’s written instructions, and with recognized industry practices, to ensure that units comply with requirements and serve intended purposed.

K. Air Handling System Efficiency

1. Because it is important to the Owner to minimize the operating cost of equipment where applicable, the unit manufacturer’s selected air handling unit shall not exceed the maximum cumulative break horsepower indicated on the plans.

L. Fan-Section Source quality Control: the following factory tests are required:

1. Sound Power Level Ratings: Comply with AMCA 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data. Test fans according to AMCA 300, Reverberant Room Method for Sound Testing of Fans. Fans shall bear AMCA-certified sound rating seal.

2. Factory test fan performance for flow rate, pressure, power, air density, rotation speed, and efficiency. Establish ratings according to AMCA 210, Laboratory Methods of Testing Fans for Rating.

2.2. AIR COOLED SCREW CHILLERS WITH ACOUSTIC DISCHARGE PLENUMS

A. Provide packaged air cooled "screw" chiller of the size, capacity, and electrical characteristics as shown on the contract drawings. Provide demand limiting feature and interlock with automatic temperature control system.

B. Chiller shall be Model YCAV as manufactured by York, Trane Model RTAC, Daikin, Carrier, or approved equal. Provide demand limiting feature and interlock with ATC system.

C. General

1. Operating test shall include operation with water flowing through the cooler. The unit structure shall be heavy-gauge, galvanized steel. All external parts shall be covered with a baked-on powdered paint to withstand 500 hours of salt-spray testing using 5 percent salt-spray solution per ASTM B117 without exhibiting any film breakdown beyond 1/8-inch on each side of a scribed line. (This shall be equivalent to an ASTM D 1654 rating of "6".) The unit shall be shipped with a full operating charge of R-134A and reordered refrigerant oil. All units shall contain multiple refrigerant circuits, each with two (2) compressors, for standby operation. All units shall be designed and constructed in accordance with the applicable sections of the following: ANSI/ASHRAE 15 Safety Code for Mechanical Refrigeration; American Society of Mechanical Engineers (ASME) Pressure Vessel Code; National Electrical Code/National Fire Protection Association NFPA 70; U.L. and C.U.L. listed. All units shall be produced at an ISO 9000 registered facility. All units shall be rated in accordance with ARI Standard 550 and shall be certified up to 300 tons in accordance with ARI Standard 590.

2. All schedule capacities are based on 30% propylene glycol.

3. Provide factory mounted painted metal louvered panels around compressors, tubes, condenser sections, etc, to prevent bird nesting and vandalism.

4. Full unit metal louvered panels shall be heavy gauge, painted to match chiller and to resist corrosion. Panels shall be removable for service.

5. Furnish chiller with low sound fans, discharge mufflers, and complete compressor enclosure attenuator housings.

6. Install and commission, as shown on the schedules and plans, one factory assembled, charged, and tested air-cooled screw compressor chiller as specified herein. Chiller shall be designed, selected, and constructed using a refrigerant with Flammability rating of "1", as defined by ANSI/ASHRAE STANDARD-34 Number Designation and Safety Classification of Refrigerants. Chiller shall include, but is not limited to: a complete system with screw compressors, direct expansion type evaporator, air-cooled condenser, refrigerant lubrication system, interconnecting wiring, safety and operating controls including capacity controller, control center, motor starting components, and special features as specified herein or required for safe, automatic operation.

7. Cabinet: External structural members shall be constructed of heavy gauge, galvanized steel coated with baked on powder paint which, when subject to ASTM B117, 1000 hour, 5 percent salt spray test, yields, minimum ASTM 1654 rating of "6".

8. Chiller shall be delivered to the job site completely assembled and charged with refrigerant and oil by the manufacturer.

D. Compressor and Refrigerant Circuits

1. There shall be a maximum of two compressors per refrigerant circuit. The compressor shall be of the accessible-hermetic rotary twin-screw type. The compressor shall be driven by electrical motor via a gear speed-increaser. The compressor housing shall be made of cast iron, precisely machined to provide minimal clearance of the rotors. The design working pressure shall be 250 PSIG (992 kPa) on the suction side and 450 PSIG (3.1mPa) on the discharge side (hydrostatic tests shall be done at 5 times design working pressure, i.e. 1250 PSIG (5.0 mPa) and 2250 PSIG (15.5 mPa) respectively). The compressor shall be mounted on isolators. The rotors shall be manufactured from hot-rolled steel and use asymmetric profiles. Accurate rotor positioning shall be maintained at all pressure ratios by four separate, cylindrical, roller bearings for radial loads and angular-contact ball bearings for axial loads. The compressor shall contain an internal discharge check-valve to prevent reverse-rotation at shut-down. The compressor shall also contain a 500 watt 115 volt/1 phase/60 Hz) temperature-actuated, immersion heater to prevent refrigerant condensation during shutdown.

2. Capacity Control

   a. Compressor slide valves shall provide fully modulating capacity control from 100 percent of full load down to 15 percent of chiller full load. The slide valve shall be actuated by oil pressure, controlled by external solenoid valves via the Control Center or approved equal. Additional capacity controls shall be provided as necessary to accomplish sequence of operation.

3. The unit shall contain a minimum of two (2) separate refrigerant circuits. Each shall be constructed of ACR copper tubing with brazed joints and shall include shut-off valve with charging connection, liquid sight glass with moisture indicator, direct acting maximum operating pressure thermal expansion valve, solenoid valve, and filter drier. The entire suction line and liquid line between the expansion valve and the cooler shall be insulated with 1-inch flexible closed cell insulation.

4. Accessible Hermetic Motor

   a. The compressor motor shall be refrigerant-gas-cooled, 60 Hz motors shall operate at 3,600 RPM. The motor starter shall have U.L. Class "H" insulation. The terminal boxes shall be rain-tight. The hermetic motor shall be high torque, (Wye-Delta) start. The motor shall be equipped with a minimum of three, internal, heat-sensing thermistors.

5. Oil Separation, Lubrication, and Cooling

   a. An external oil separator with no moving parts shall be provided to minimize oil carry-over for each circuit. Oil separation shall be achieved by the impingement and direction change of the refrigerant gas as its velocity decreases. The oil separators shall be utilized to provide gas/oil separation before the gas enters the air-cooled condenser. The oil separators shall be designed for a maximum working pressure of 450 PSIG (3.1mPa) and are UL/CSA-listed. The oil separator shall include a sight glass. The compressor shall also have integral oil reservoirs located at the rotor bearings to provide lubrication during start-up, coast-down and in the event of power failure. During operation, system-pressure differential shall provide proper oil flow without the need of an oil pump.

6. An external, replaceable-cartridge, 3-micron oil filter shall be provided, with manual isolation stop-valves for ease of servicing.

7. Oil cooling shall be provided by liquid injection to maintain proper oil temperatures for all conditions. A temperature-blending solenoid, controlled via the Millennium Control Center, or equal shall provide consistent oil temperature at all times to assure proper oil viscosity, independent of system conditions.

E. Economizer

1. An economizer shall be included in each circuit to enhance the overall system performance. The refrigerant-to-refrigerant, plate-type economizer shall be constructed of acid-resistant stainless steel. The heat exchanger shall be UL/CSA-listed and designed for 450 PSIG (3.1 mPa). The temperature limits shall be –320 degrees F (-195.6 degrees C) minimum to 365 degrees F (185 degrees C) maximum.

F. Cooler

1. The dual-circuit cooler shall be a direct-expansion type, with refrigerant in the tubes and chilled liquid in the baffled shell. The design working pressure of the cooler shell (liquid side) shall be 150 PSIG (1.0 mPa), and 200 PSIG (1.6 mPa) for the tube (refrigerant side). Refrigerant shall be removable. The cooler shall be equipped with a heater cable covered with 1-½-inch, flexible, closed-cell-foam insulation (K'0.25 maximum) and thermostatically controlled immersion heaters and strip heaters for freeze-up protection to –20 degrees F (-28.9 degrees C) ambient. The cooler shall be constructed and tested in accordance with the applicable sections for the ASME Pressure Vessel Code requirements Section VIII, Division (1). The water connections shall be fully accessible and grooved to accept Victaulic couplings, welded, or flanged.

2. Brazed plate stainless steel heat exchangers shall be UL Listed. Units shall have a water strainer that is factory furnished and installed with blowdown valve.

G. Condenser

1. Coils: The condenser coils shall be constructed of seamless copper tubes,

arranged in staggered rows, mechanically expanded into aluminum fins and include an integral subcooling section. The design working pressure of the condenser coil shall be 450 PSIG (3.1 mPa). Provide louvered panels to protect condensers. Provide condenser corrosion protection including flexible dip and baked epoxy coating.

2. Fans: The condenser fans shall be glass-reinforced polypropylene, high-efficiency, airfoil-type, providing vertical air discharge. The fans shall be directly driven by independent motors and positioned in extended orifices for low sound. The fan guards shall be constructed of heavy-gauge, rust-resistant, PVC-coated steel. Fan blades shall be dynamically and statically balanced for vibration-free operation.

3. Motors: The fan motors shall be Totally Enclosed Air-Over (TEAO), squirrel-cage type, and current-protected. They shall feature ball bearings that are double-sealed and permanently lubricated. Each motor shall have U. L. Class "F" insulation.

4. Fans shall be partitioned to avoid cross circulation.

H. Refrigerant Circuit

1. The unit shall contain a minimum of two independent refrigerant circuits and shall be constructed of copper tubing with brazed joints. The liquid line shall include a shutoff valve with a charging port; sight glass with moisture-indicator; direct-acting maximum-operating-pressure thermal expansion valve; solenoid valve with internal relief; and filter-drier. The entire suction line, and the liquid line between the expansion valve and the cooler, shall be insulated with flexible, closed cell-insulations.

I. Control Center

1. Each unit shall contain a Control Center or approved equal. Control center shall include BACnet protocol. All controls shall be contained within a rain tight/dust tight NEMA 3R (and equivalent to IP55 European standard) cabinet with hinged outer door having positive-acting latches. The center shall contain the "user friendly" and interactive inputs and outputs as follows: LCD display with light-emitting-diode back-lighting for outdoor viewing of data, and input buttons for DISPLAY (temperatures, pressures, etc.). ENTRY (enter/cancel inputs, advance day, change AM/PM), SET POINTS (change), CLOCK (set time and schedule), PRINT (calling up operating and shutdown data), PROGRAM (change inputs for special conditions such as brine chilling, and UNIT ON/OFF.

2. The Control Center or approved equal shall be capable of displaying the following in English or Metric: return and leaving liquid temperature; low leaving-liquid-temperature cutout setting; ambient temperatures (actual outdoor temperature, low and high ambient cutout); suction pressure cutout setting; percent full-load motor current for each phase and the average of all three phases, suction, discharge and oil differential pressures; liquid-pulldown rate-sensitivity adjustment (0.5 degrees F to 5 degrees F (6.3 to 2.8 degrees C) per minute in one-tenth increment); anti-recycle-timer status; slide-valve position (each

compressor); superheat status; discharge pressure and current limiting; phase-rotation safety; compressor-run status; no-cooling-load condition; day; date; time: out-of-range message; daily and holiday scheduling of start/stop times; automatic or manual lead/lag status; lead-compressor definition; number of compressor starts and running hours; evaporator heater, fan operation; liquid line solenoid valves; water pump; last fault-shutdown data; number of unloading steps; chiller pump control for freeze protection, compressor load-and-unload timer status.

3. The standard unit shall include run-signal contacts; automatic pumpdown on start-up and shutdown; alarm contacts; evaporator-pump control; automatic restart after power failure, remote start-stop, high suction and discharge pressure unloading. Three steps of demand load limiting, and remote chilled liquid re-set from an external building automatic system via 4 to 20 Ma or 0 to 10VDC with an interface board.

4. The operating program is stored in a non-volatile memory (EPROM) to eliminate chiller failure due to AC-power failure/battery discharge. Programmed setpoints are retained in lithium-battery-backed RTC memory for 5 years minimum.

5. Provisions shall be included for: a hard copy print-out from a printer (by others) via an RS-232 electrical output; remote water-temperature and current reset.

6. Pressure transducers shall be factory mounted to allow control to sense and display discharge pressure.

7. All controls, setpoints and BACNET attributes shall be fully integrated with ATC system.

8. The unit shall be protected in two ways: (1) by alarms that shut the unit down and require manual reset to restore unit operation and (2) by limit alarms that reduce unit operation in response to some out-of-limit condition. Shut down alarms shall activate an alarm signal.

9. Shutdown Alarms

    a. No evaporator water flow (auto restart)
    b. Sensor failures
    c. Low evaporator pressure
    d. Evaporator freeze protection
    e. High condenser pressure
    f. Outside ambient temperature (auto-restart)
    g. Motor protection system
    h. Phase voltage protection (Optional)
    i. Phase loss protection

10. Limit Alarms

    a. Condenser pressure stage down, unloads unit at high discharge pressures.
    b. Low ambient lockout, shuts off unit at low ambient temperatures.
    c. Low evaporator pressure hold, holds stage #1 until pressure rises.

d. Low evaporator pressure unload, shuts off one compressor.

11. Unit Enable Section

a. Enables unit operation from either local keypad, digital input, or BAS.

12. Unit Mode Selection

a. Selects standard cooling, or test operation mode.

13. Analog Inputs:

a. Reset of leaving water temperature, 4-20Ma.
b. Current Limit.

14. Digital Inputs

a. Unit off switch
b. Remote start/stop
c. Flow switch
d. Motor protection

15. Digital Outputs

a. Shutdown alarm; field wired, activates on an alarm condition, off when alarm is cleared.
b. Evaporator pump; field wired, starts pump when unit is set to start.
c. Chiller pump control for freeze protection. (Sends a signal to ATC system to energize pump flow for freeze protection.)

J. Building Automation System (BAS) Interface

1. Factory mounted DDC controller(s) shall support operation on a BACnet® network via one of the data link/physical layers listed below as specified by the successful Building Automation System (BAS) supplier.

2. BACnet MS/TP master (Clause 9)

3. BACnet IP, (Annex J)

4. BACnet ISO 8802-3, (Ethernet)

5. The information communicated between the BAS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notifications as specified in the unit sequence of operation and the unit points list.

6. All communication from the chiller unit control as specified in the points list shall be via standard BACnet objects. Proprietary BACnet objects shall not be allowed. BACnet communications shall conform to the BACnet protocol (ANSI/ASHRAE135-2001). A BACnet Protocol Implementation Conformance

Statement (PICS) shall be provided along with the unit submittal.

K. Power Panel

1. The power panels shall contain the compressor power terminals, compressor motor-starting contactors with three external over-load protection, three additional current transformer sensing on each compressor phase for current monitoring, for protection against under-voltage, over voltage, imbalanced voltage, single phasing, compressor stall and voltage spikes, and control power supply terminal strip for 115-1-60. The power panel shall contain a 15-amp, 115 volt convenience outlet with Ground Fault Protection. Separate 1154-60 receptacles shall be provided by Division 26.

2. The compressor and fan power wiring shall be routed through U.L. listed, liquid-tight, nonmetallic conduit suitable for outdoor use.

3. Single Point Connection Circuit Breaker: Provide a HACR rated molded case capacity circuit breaker (U.L. Approved). The circuit breaker shall be able to be used as disconnect through the door handle and shall be pre-wired from factory with terminal block connections. The external operator handle shall be lockable.

L. Control Transformer

1. A control transformer shall be factory installed to convert unit power voltage to 115-1-60. Factory mounting shall include primary and secondary wiring between the transformer and the control panel.

M. Tuned Discharge Mufflers

1. Muffler shall be included in each discharge line. It is acoustically tuned to attenuate the predominant frequencies of the gas pulsations for the particular compressor.

N. Sound Attenuation

1. Provide comprehensive sound enhancement package, including custom acoustic discharge plenum, low sound fans and an acoustical blanket shall be furnished on each unit. Fans shall be reduced RPM, 8 pole fan motors with steeper pitch fans.

O. Start-up and Warranty:

1. Provide the services of the chiller manufacturer’s factory trained service technician to start the chiller(s). Service shall also provide concurrent training to the Owner’s personnel.

2. Provide two (2) year parts and labor warranty with each unit. Provide extended compressor warranty for three (3) additional years.

P. Comprehensive Sound Enhancement Package:

1. Low sound fans and an acoustical blanket shall be furnished on each unit. Fans

shall be reduced RPM, 8 pole fan motors with steeper pitch fans.

2. Sound power levels so as not to exceed the following:

Sound Power Level db re 1 picowatt								
dBa	63Hz	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz
99	90	98	99	97	94	92	85	80

3. Compressor sound attenuation shall be of the perimeter design to allow ease of removal and access to compressor components.

4. Net chiller capacity shall be maintained as scheduled with the addition of the chiller sound enclosures.

Q. Custom Acoustic Discharge Plenum

1. Provide custom acoustic discharge plenum by Hushcore IS UnitaryPLUS "Silencer Bank" or approved equal.

2. Discharge plenum shall be 54" tall acoustical panel discharge plenum constructed from 4" thick acoustic panels (STC 40). Panels shall have a galvanized finish and (1) end panel shall include a 3'x2' tall service access door.

3. System includes vertical columns with baseplates. System also includes 22 guage/22 gauge construction HUSH DUCT rectangular low pressure drop silencers (shipped loose) and field installed as required for number of condenser fans. Provide 3"x4" galvanized angles for interior silencer supports (recessed silencers) as well as all hardware required for the installation. Provide anchor bolts as required for installation. Coordinate base structure for chiller with sound enclosure supports.

4. Estimated acoustic performance: 12 Dba. (Reduction).

R. Vibration Isolators

1. Provide level adjusting spring type, 1-inch deflection isolator with mounting brackets for mounting under the unit base. All exterior vibration isolators shall be stainless steel including hardware. As an alternate, vibration isolators may be provided as specified under Section 230548 at contractor's option.

S. Accessories and Options

1. Microprocessor controlled, Factory installed Across-the-Line type compressor motor starters as standard.

2. Power Supply Connection:

a. Single Point Connection Circuit Breaker: Provide a HACR rated molded

case capacity circuit breaker (U.L. Approved). The circuit breaker shall be able to be used as disconnect through the door handle and shall be pre-wired from factory with terminal block connections. The external operator handle shall be lockable.

b. Ground Fault Protection: Factory installed circuit breakers.

c. Phase loss protection with under/over voltage protection and with LED indication of the type of fault.

3. Pressure Transducers and Readout Capability

a. Discharge Pressure Transducers: Permits unit to sense and display discharge pressure.

b. Suction Pressure Transducers: Permits unit to sense and display suction pressure.

4. Control Power Transformer: Converts unit power voltage to 120-1-60 (500 VA capacity). Factory mounting includes primary- and secondary-wiring between the transformer and the control panel.

5. Flow Switch (Factory Mounted): Vapor proof NEMA 4X switch (150 psig), -20 degrees F to 250 degrees F. Thermal dispersion type. Provide additional contacts to allow monitoring on the ATC system. An additional mechanical flow switch shall also be installed in evaporator piping.

6. Building Automation System (EMS) Reset Interface: Chiller to accept 4 to 20Ma, 0 to 10 VDC, or discrete contact closure input to reset the leaving chilled liquid temperature.

7. Sound Reduction (Factory Mounted): Acoustic Compressor Blankets. Low speed condenser fans and sound attenuation enclosure.

8. Vibration Isolation (Field Mounted):

a. 1 inch deflection spring isolators: level adjusting, spring and cage type isolators for mounting under the unit base rails.

9. Wye strainers with stainless steel mesh size as required by chiller manufacturer. Furnish with blowdown valve, pipe extension, two Schraeder valves, fittings, and grooved couplings.

T. Source Quality Control

1. Verification of Performance: Rate chillers according to ARI 550 and up to 200 tons in accordance with ARI Standard 590.

2. Testing Requirements: Factory test for the following:

a. Sound-Power-Level Ratings: According to ARI 370.

2.3. AUTOMATIC GLYCOL MAKEUP SYSTEM

A. Furnish an automatic glycol feeder to provide consistent operating pressure in the closed loop system by feeding a controlled percentage of glycol solution. Glycol shall be made-up automatically from a pre-mixed solution tank. A low level switch shall prevent pump operation when solution level is too low.

B. The glycol feeder package to consist of a prewired control unit in a NEMA 1 steel enclosure and a pre-piped flow assembly including a pressure switch, pressure relief valve, 50 gallon polyethylene tank, low level switch, positive displacement pump, and pressure gauges. Automatic glycol feed system shall be Pulsafeeder Model GF-1, or approved equal.

C. Glycol solution tank shall be 50 gallons polyethylene tank with steel supports for mounting the transfer pump below the tank. Provide hinged polyethylene cover, pump suction connection, and drain valve.

D. Positive displacement flooded suction pump rated at capacity as scheduled on the contract drawings.

E. Provide PVC piping from the tank to the pump with PVC ball valve and steel strainer. Include at discharge a check valve, ball type shutoff valve and pressure relief valve piped back to the solution tank.

F. Provide a dolly suitable for transporting 55 gallon drums to the charging station. Dollies shall be suitable for storing a drum in the horizontal position so that the solution may be drained into a transfer pail. Include spring loaded draw valve.

G. Provide 5 gallon plastic pail.

H. Provide low level switch and dry contacts for monitoring on the ATC system.

2.4. INDUSTRIAL INHIBITED PROPYLENE GLYCOL

A. Provide a 30 percent by volume (as installed) industrial grade inhibited propylene glycol heat transfer fluid as manufactured by the Dow Chemical Company (Dowfrost HD), Houghton, Interstate Chemical (Intercool P-300) Glycochill Plus or approved equal. The 30 percent solution shall provide freeze protection to 12 degrees F and burst protection to –20 degrees F. The propylene glycol solution as supplied by the manufacturer shall contain corrosion inhibitors specially formulated for cool storage services to keep internal surfaces free from corrosion and fouling and shall include buffers, reserve alkalinity agents, antifoaming additives, and a fluorescent dye to aid in leak detection. The solution shall be easily re-inhibited using specially formulated inhibitor readily available from the field manufacturer. The manufacturer shall provide free propylene glycol yearly solution laboratory analysis. The analysis shall accurately report propylene glycol concentration, freeze point temperature, inhibitor level, alkalinity, particulate and recommended additions of glycol, inhibitor and buffers to ensure twenty-year minimum life. The fluid shall pass the ASTM D-1384 test with less than 0.5 mils penetration per year.

B. Automotive antifreeze or any solutions containing silicates shall not be acceptable.

C. Propylene glycol shall be supplied preduilted with deionized water and installed in the specified piping systems.

D. Provide a Misco Products calibrated hand held refractor meter.

E. Provide one spare 55 gallon drum of glycol.

F. Contractor shall chemically clean and flush the completed propylene glycol system. As a minimum, system shall be cleaned with a 1 percent to 2 percent solution of trisodium phosphate in water. Provide temporary bypasses at the ice storage modules for the initial pressure testing, cleaning and flushing operations. This prevents the transfer of contaminants to the clean tubing in the modules. The system shall be thoroughly flushed using clean water and circulated for a minimum of 72 hours at which time water samples shall be taken by the contractor who shall certify that the system is free of particulate, mil scale, weld scale, solder flux, rust, metal filings, oil, grease, chlorides, sulphates, silicates and other foreign matter that could degrade the propylene glycol. After the system is charged with the approved heat transfer fluid, air shall be eliminated from the system, and the heat transfer fluid shall be circulated for 72 hours through all components. The contractor shall test and adjust the concentration to achieve 30 percent by volume propylene glycol.

G. Entire system shall conform to EPRI Standard propylene glycol systems 15751.

H. Flushing period (72 hours) shall be closely monitored to prevent excess heat build-up due to pump heat.

2.5. GLYCOL FEEDER PRESSURE TANK

A. Provide and install glycol feeder pressure tanks of size, capacity and as indicated on contract drawings. Glycol feeder pressure tanks shall be Therm-X-TROL as manufactured by AMTROL Inc., Flexcon, Wessels, Taco or approved equal. Mount tank as detailed on the drawings.

B. Glycol feeder pressure tanks shall be specifically designed for use in glycol systems. Tanks shall be pre-charged to require pressure at the factory. The maximum working pressure shall be 150 psig. The maximum operating temperature shall be 200 degrees F. Expansion tanks shall contain removable FDA approved butyl bladder.

C. Before installation, Contractor shall adjust the tank air pre-charge pressures to equal glycol feed pump pressure.

D. The tank must be constructed in accordance with Section VIII of the A.S.M.E. boiler and pressure vessel code and stamped 150 psig working pressure.

E. Accessories: Pressure gauge and air charging fitting, tank drain, pre-charge as indicated on contract drawings and factory installed clip angles.

2.6. DUCTLESS SPLIT SYSTEM HEAT PUMP (INVERTER TYPE) (CEILING CASSETTE TYPE)

A. The heat pump air conditioning system shall be a Mitsubishi Electric, Sanyo, LG, Daikin,

Samsung, or approved equal split system. The system shall consist of a slim silhouette, compact ceiling recessed packaged evaporator section with matching Slim Line outdoor unit. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label. All wiring to be in accordance with the National Electrical Code (N.E.C.). The units shall be rated in accordance with ARI standard 240 and bear the ARI label. A full charge of R-410A for 100 feet of refrigerant tubing shall be provided in the condensing unit. A dry nitrogen holding charge shall be provided in the condensing unit. A dry nitrogen holding charge shall be provided in the evaporator. System SEER shall meet or exceed Federal Standards latest edition

B. The units shall have a manufacturer's warranty for a period of two (2) years from date of installation. The compressor shall have a warranty of six years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of Mitsubishi Electronics America, Inc. This warranty does not include labor. Manufacturer shall have ten years experience in the U.S. market. Capacity shall be as scheduled on the contract drawings.

C. The indoor unit shall be completely factory assembled and wired. The casing shall be galvanized sheet with grey heat insulation. This unit shall fit in the ceiling and have the capability of attaching a branch supply duct as well as a fresh air duct. The evaporator fan shall be an assembly with a high performance, fan direct driven by a single motor. The fans shall be statically and dynamically balanced and run on permanently lubricated bearings. The indoor unit shall have an adjustable air outlet system offering 4-way air flow, 3-way air flow, or 2-way air flow. The auto air swing vanes shall automatically swing up and down for uniform air distribution. Return air shall be filtered by a long-life filter to provide approximately, 2500 hours of use in a normal office environment before cleaning. The indoor unit shall be covered with a flat panel which protrudes only 1 inch below the ceiling to provide a neat and clean installation. The coils shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tubes joints shall be brazed with phoscopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan shall extend under the coil and piping. An integral drain pan pump capable of lifting condensate 12 inches shall be provided. An integral booster heater shall not be provided to supplement the unit during the heating mode. The unit variable speed compressor shall allow full heating capability and defrost without the need for a booster heater. The unit electrical power requirements shall be as scheduled on the contract drawings.

D. The control system shall consist of two (2) microprocessors interconnected by a single non-polar two wire cable as supplied. Wiring shall run from indoor unit to controller direct. NO SPLICES. When running longer lengths or more than one set of hardwired remote controller wires together, a double insulated, two wire cable equivalent to that provided e.g. Belden 9407 cable, is mandatory or use shielded two wire cable. One microprocessor shall be factory wired and located within the indoor unit. It shall have the capability of sensing return air temperature and indoor coil temperature; receive and process commands from the hardwired remote controller provide emergency operation; control the booster heater and control the outdoor unit. The microprocessor within the wall mounted hardwired remote controller shall provide automatic cooling and heating system changeover; display set point and room temperature; a 24 hour on/off timer so

that automatic operation can be set on the timer at one hour intervals from one to twenty-four hours; have self-diagnostic function display; check mode for memory of most recent problem; System shall control continued operation of the air sweep louvers; and provide on-off and system/mode function switching. The heating system shall be controlled so that only warm air is discharged whenever the fan speed exceeds the very low (VLO) speed. Normal operation of the hardwired remote controller provides individual system control in which one hardwired remote controller and one indoor unit are installed in the same room. The hardwired remote controller shall have the capability of controlling up to a maximum of 50 systems at a maximum developed control cable distance of 1650 feet. The control voltage between the hardwired remote controller and the indoor unit shall be 12 volts, D.C. The control voltage between the indoor unit and the outdoor unit shall be 12 volts D.C. Both 12 VDC shall be generated from the indoor unit microprocessor board. The system shall be capable of automatic restart when power is restored after power interruption. System shall include twenty function self-diagnostics including total hours of compressor run time.

E. The outdoor unit shall be completely factory assembled, piped, and wired. The casing shall be fabricated of galvanized steel, bonderized and finished with baked enamel. The unit shall be furnished with one (1) direct drive, propeller type fan arranged for horizontal discharge. The motors shall have inherent protection be of the permanently lubricated type, and resiliently mounted for quiet operation. Each fan shall be provided with a raised guard to prevent contact with moving parts. The variable speed compressor shall be of the high-performance, rotary type with crankcase heater, accumulator and internal thermal overloads. The variable speed compressor shall be mounted so as to avoid the transmission of vibration. The refrigeration system shall be equipped with pressure switch and have the capability to operate with a maximum height difference of 130 feet and overall refrigerant tubing length of 130 feet between indoor and outdoor sections without the need for line size changes, traps or additional oil. Refrigerant flow from the condenser to be controlled by means of a capillary tube. The condenser coil shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The coil shall be protected with an integral metal guard. The unit shall be controlled by the microprocessor located in the matching indoor unit. A built-in, low-ambient controller shall allow cooling to 23 degrees F outdoor temperature. The unit electrical power requirements shall be as scheduled on the contract drawings. The outdoor unit shall be placed on vibration isolators and mounted on a concrete pad.

F. High condensate water safety shutdown: Each indoor unit’s detection unit shall be interlocked to alarm and stop the outdoor unit if a high condensate water level is sensed.

2.7. DUCTLESS SPLIT SYSTEM HEAT PUMP (INVERTER TYPE) (WALL MOUNTED)

A. The heat pump air conditioning system shall be a Mitsubishi Electric Series split type Sanyo, LG, Daikin, Samsung, or approved equal. The system to consist of a slim silhouette, compact wall mounted packaged evaporator section with matching Slim Line air cooled outdoor unit. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label. All wiring to be in accordance with the National Electrical Code (N.E.C.). The units shall be rated in accordance with ARI Standard 240 and bear the ARI label. A full charge of R-410A for 25 feet of refrigerant tubing shall be provided in the condensing unit. A holding charge shall be provided in the evaporator. System SEER shall meet or exceed 1992 Federal Standards.

B. The units shall have a manufacturer's warranty for a period of one (1) year from date of installation. The compressor shall have a warranty of six (6) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of Mitsubishi Electronics America, Inc. This warranty does not include labor. Manufacturer shall have ten years experience in the U.S. market.

C. Capacity shall be as scheduled on the contract drawings.

D. The indoor unit shall be completely factory assembled and wired. The casing shall have a white finish. The evaporator fan shall be a high performance, forward curve line flow fan direct driven by a single motor. The fan shall be statically and dynamically balanced and run on permanently lubricated bearings. A manually adjustable change vane shall be provided. The vane shall have the ability to direct the air from horizontal to vertical. An adjustable guide vane shall be provided to manually change the air direction from lift to right. The evaporator coil shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phoscopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan with drain shall be provided under the coil. Split system heat pump manufacturer shall furnish condensate lift pumps for field installation within the indoor unit. Condensate pumps shall be complete with float switch sensor, alarm, reed switch, relay, contact, adapters, and detection block etc., for a completely operational system. Contractor shall mount, pipe, and wire condensate pump per split system heat pump manufacturer's recommendations. Condensate pump shall be model EE as manufactured by Sauermann or approved equal. The units' electrical power requirements shall be as scheduled on the contract drawings.

E. The outdoor unit shall be completely factory assembled, piped, and wired. The casing shall be fabricated of galvanized steel, bonderized and finished with baked enamel. The unit shall be furnished with a direct drive, propeller type fan arranged for horizontal discharge. The motor shall have inherent protection, be of the permanently lubricated type and resiliently mounted for quiet operation. The fan shall be provided with a raised guard to prevent contact with moving parts. The variable speed compressor shall be of the high performance rotary type with accumulator and internal thermal overloads. The variable speed compressor shall be mounted so as to avoid the transmission of vibration. The refrigeration system shall have the capability to operate with a maximum height difference of 25 feet and overall refrigerant tubing length of 49 feet between indoor and outdoor sections without the need for line size changes, traps, or additional oil. Refrigerant flow from the condenser to be controlled by means of a capillary tube. The condenser coil shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The coil shall be protected with an integral metal guard. The unit shall be controlled by the microprocessor located in the matching indoor unit. The unit electrical power requirements shall be as scheduled on the contract drawings. The outdoor heat pump unit shall be placed on vibration isolators and mounted on rooftop equipment rail or concrete pad as indicated. Inverter type compressor shall allow defrost without the need for auxiliary electric heat.

F. The control system shall consist of two (2) microprocessor section. One microprocessor section shall be factory wired and located within the indoor unit. It shall have the capability of sensing indoor coil temperature; receive and process commands from the

hardwired remote controller; control the booster heater; and control the outdoor unit. The microprocessor within the wall mounted remote monitor and hardwired remote controller shall display set point; provide two (2) manually selected modes of cooling, normal and economy operation at 2 degrees above set point; provide manual heating selection; with set back operation of 4 degrees above set point for cooling and 4 degrees below set point for heating; and manual or automatic fan speed control. Automatic fan speed control shall be based upon the temperature difference between set point and room temperature maintaining lowest speed possible. The heating system shall be controlled so that only warm air is discharged whenever the indoor fan operates above the very low (VLO) speed. Heating shall be switched back to the heat pump only when the difference drops back to less than 3.6 degrees. The control voltage between the indoor unit and the outdoor unit shall be 12 volts D.C. The hardwired remote controller shall be wireless, using infrared line of sight for system control and shall include automatic ON/OFF timer; liquid crystal display; "I FEEL" control mode which adjusts temperature by tapping the button that describes the present condition "Too Cool", "Too Warm", or "OK". The optimum temperature set this way is memorized for immediate recall whenever the system is used again. The system shall be capable of automatic restart when power is restored after power interruption.

G. High condensate water safety shutdown: Each indoor unit's detection unit shall be interlocked to alarm and stop the outdoor unit if a high condensate water level is sensed.

2.8. ELECTRIC RADIANT HEATERS

A. Electric Radiant Ceiling Panel

1. General: Provide electric radiant ceiling panels as indicated on the drawings. The electric ceiling heating panel shall be AZTEC, as manufactured by Berko, a Division of Marley Electric Heating, CP series as manufactured by Qmark or as approved equal. The construction and design shall permit it to be: recessed ceiling-mounted with the use of Recessed Mounting Kit, fit into standard or custom designed modules of a T-bar suspended ceiling, surface-mounted with the use of a Surface Mounting Kit, or exposed with the use of a surface mounting kit and duct strap attached to roof structure. In finished spaces with hard ceilings, install units recessed. Panels shall be UL listed. Panels shall include the custom features listed below.

2. Heating Assembly: The heating assembly shall be UL and CSA approved and shall consist of powdered graphite encapsulated in a plastic laminate with heavy duty copper buss bars running the entire length, backed by 1-inch, 1-pound density high temperature fiberglass insulation to insulate against heat loss to the ceiling and separated from the inside of the panel by a dielectric insulation to assure uniform heat transfer24hermosghout the entire radiating surface of the heater.

3. Thermal Cutout: A thermal cutout shall be built into all high density panels to automatically shut off the heater in the event of overheating and reactivate the heater when temperatures return to normal.

4. Wiring: For connection to the main power supply, the heater shall be completely prewired, with the lead wires housed in a 40-inch length of flexible metal conduit

and connector for J-Box mounting. Appropriate diagrams shall appear on the back of the panel. Provide modular connectors, pre-wired system for unit mounted end to end. Coordinate with Division 26.

5. Panel Assembly: The metal heating panel, containing the completely prewired heating assembly, shall be of 22 gauge formed galvanized steel front and 24 gauge formed galvanized steel back. Sides are overlapping front and back panels riveted together.

6. Finish: The front of the heating panel shall be multi-faceted25hermos25inee type surface finished with high temperature silicone paint.

7. Controls: All radiant heaters shall be thermostatically controlled. When more than one radiant heater is shown in a space, provide the minimum number of thermostats required to control the total quantity of heating panels in the space. Thermostats, control transformers and associated controls shall be provided by the Manufacturer. Coordinate requirements with Division 26 and ATC Subcontractor.

8. Features: Radiant heating panels shall be provided with the following features:

   a. Painted frame to match heater.
   b. Factory silicone scaled for shower rooms.
   c. Seal tight flexible conduit and connectors for shower rooms.

9. Thermostats shall be Q-Mark Model WRIE 30S Mercury Bulb, single pole single throw, 24 volt with 40 degrees F and 80 degrees F range. Provide and install stainless steel thermostat guards over all thermostats. Provide and install Q-Mark Model LTR2-277 dual level temp relays. Relays shall be enclosure mounted. Provide and install low voltage transformers as required.

2.9. HORIZONTAL ELECTRIC UNIT HEATERS

A. General: Provide horizontal electric unit heaters as indicated, of type and minimum capacity as scheduled, and as specified herein.

B. Furnish and install Emerson-Chromalox type MUH, Trane, Qmark, Markel, Marcor, Indeeco, or approved equal horizontal unit heaters with heating and air delivery capacities as shown on the heating schedule. The cabinet shall be made of 18 gauge die formed, furniture grade steel. Individual adjustable louvers with 30 degree downward stops shall be furnished to provide desire control of discharge air. All metal surfaces of the casing shall be phosphate coated to resist corrosion and finished in a decorative two toned neutral grey-bronze brown baked enamel. Mounting brackets designed for either ceiling or wall swivel mounting shall be furnished. Heater to be of the draw-through air flow design to eliminate element hot spots and extend design life.

C. For safety, the electric heating bank shall consist of Chromalox or equal metal sheath heating elements. The elements shall have a copper clad steel sheath for strength and corrosion resistance and aluminum fins for faster heat transfer. Automatic reset thermal over-heat protection, shall be of the linear capillary type wired for instantaneous de-energizing in case of thermal overload. Heating bank to have protective air inlet louvers.

D. All heaters drawing in excess of 48 amperes shall be provided with factory installed subdivided circuits of 48 amps or less.

E. Motors shall be of the totally enclosed continuous heavy-duty all-angle operation equipped with built-in thermal overload protection.

F. Fans shall be aluminum, directly connected to fan motor, designed specifically for unit heater application.

G. Low voltage control transformers shall be provided allowing safer more precise temperature control. Thermostat to be provided by mechanical contractor including relays, as necessary to accomplish specified sequence. Provide Chromalox Model UR-1E30 single stage, low voltage; 24 volt mercury switch thermostats with each unit heater.

H. Individual optional field installable control kits shall be provided with all models. All controls shall have pig tails and spade terminals for ease of wiring to centrally located terminal board. All heaters of 63 amperes or less shall be provided with power disconnect switches.

I. Furnish and install the following accessories for operation:

1. Wall/ceiling mounting bracket.

2. Low voltage thermostats with stainless steel wire guard.

J. All heaters shall be U.L. listed and meet the requirement of the National Electrical Code.

K. All units shall have built-in contactors and control circuit transformers to provide single source power connection. Built-in fuse blocks and factory supplied fuses shall be installed on all models. A wiring diagram and grounding LUG shall be included in each control compartment.

2.10. WALL MOUNTED FINNED TUBE RADIATION

A. Furnish and install sloped top, wall mounted finned tube radiation of the capacity, size, and arrangement as indicated on the Contract Drawings. All ratings shall be IBR approved. Units shall be installed in a neat and workmanship manner in accordance with specifications and manufacturer recommendations. Finned tube radiation shall be Model S as manufactured by Trane, Vulcan, Slant-Fin, Dunham Bush, Rittling, or approved equal.

B. Element types, as indicated on plans, shall have integral fin collars which space the fins and provide fin-to-tube surface firmly bonded by mechanical expansion of the tube to ensure durability, eliminate noise from loose fins and assure performance at cataloged ratings. Elements shall be positively positioned front-to-back, with provisions for silent horizontal expansion and contraction.

1. Enclosures shall be as scheduled on the plans, constructed of 14-gauge (1.9mm) thickness steel and shall mount into a continuous roll-formed captive channel mounting strip which permits hinge-type mounting and access at the top and invisible fastening onto rigidized, 14-gauge (1.9mm thickness) steel enclosure

brackets at the bottom. Enclosure brackets shall be spaced at not more than four-foot (1.2m) intervals.

2. Front panels shall be individually removable to facilitate cleaning, servicing or replacement. All accessories shall fasten to the enclosure assembly in a manner which prevents contact with the back wall during installation.

3. Cabinet air outlets of stamped sheet metal or the manufacturer shall supply a bar type extruded aluminum grille to provide strong linear styling.

C. Pipe enclosure shall be as scheduled on the plans, constructed of solid (14-gauge 1.9mm thickness) steel and shall mount into a continuous roll-formed captive channel mounting strip which permits hinge-type mounting and access at the top and fastening at the bottom with visible fasteners by others. Front panels shall be solid metal top and bottom, one piece wrap around and be individually removable to facilitate servicing or replacement.

D. All enclosures, mounting strips and accessories shall be cleaned, phosphatized and painted with one coat of prime, baked enamel finish in color as selected by Architect.

1. End panels, inside and outside corners and enclosure extensions shall be diformed and shall lock to enclosure assembly without visible fasteners.

2. Dampers (hydronic units only) shall reduce heating capacity up to 70 percent when closed and shall be factory mounted on the element. The control dial shall be jam-proof and have a mechanism which prevents damage to the dial or damper.

3. Access panels shall be installed where valves, balancing cocks or traps are indicated on the plans.

4. Back panels, still extensions, mullion channel, stamped sheet metal, front air inlet grilles, tamper proof screw assemblies and pilaster covers shall be provided. To prevent dirt streaking, contractor shall either apply dirt guard gasket to mounting strip or caulk along top of mounting strip.

2.11. BARE ELEMENT FINNED TUBE RADIATION

A. Furnish and install bare element finned tube radiation of the capacity, size, and arrangement as indicated on the contract drawings. All ratings shall be IBR approved. Units shall be installed in a neat and workmanlike manner in accordance with specifications and manufacturer recommendations. Finned tube radiation shall as manufactured by Trane, Vulcan, Slant-Fin, Dunham Bush, or approved equal. Finned tube radiation shall be installed within enclosures provided under the Architectural Division of these specifications.

B. Element types, as indicated on plans, shall have integral fin collars which space the fins and provide fin-to-tube surface firmly bonded by mechanical expansion of the tube to ensure durability, eliminate noise from loose fins and assure performance at cataloged ratings. Elements shall be positively positioned front-to-back, with provisions for silent horizontal expansion and contraction.

1. Enclosure brackets and element hangers shall be installed not farther than 4' apart. Brackets shall be die-formed form 3/16" thick stock, 1 ½-inch wide, and shall be lanced to support and position lower flange of enclosure. Enclosures shall be firmly attached to brackets by set screws, operating from under the enclosure. Devices which do not provide positive fastening of enclosures are not acceptable. Brackets shall be inserted in pre-punched slots in mounting channel to insure correct alignment and shall be fastened securely to wall at bottom.

2. Sliding saddles shall support heating elements and provide positive positioning of element in enclosure to insure maximum heating efficiency while preventing any possibility of fin inspringement on brackets or enclosure joints during expansion or contraction. Element supports shall be a double saddle design fabricated from 16-gage zinc-coated steel. Saddle shall slide freely on saddle support arm bolted to support bracket. Support arm shall allow 1 ½-inch height adjustment for pitch. The element support saddle shall allow 1 5/8-inch lateral movement for expansion and contraction of heating element.

2.12. FANS

A. General

1. Provide fans as indicated on the drawings. All fans shall have been tested and their performance rated in accordance with Air Movement and Control Association, Inc., Bulletin 210-85 Test Code and shall be licensed to bear the AMCA Seal. All fans shall carry the AMCA Certified Rating Seal for air and sound. Sound power levels shall be submitted for approval. Fan curves shall be submitted with all fan shop drawings.

2. Fan manufacturer shall submit under what duct configuration (unducted, partially ducted, or ducted) the manufacturer certified the performance of a particular fan or group of fans.

3. When indicated on Contract Drawings provide inverter duty rated motors for all variable speed fans.

4. Any fan utilized to exhaust paint rooms, finishing rooms, and similar spaces shall be sparkproof and shall include a phenolic coating on all components exposed to the airstream.

5. For fans utilized in corrosive environments provide fans with polyester or epoxy coating on all surfaces exposed to air stream.

B. In-Line Centrifugal Fans

1. Belt Drive

   a. Furnish and install in-line centrifugal belt drive fans of the size, capacity and electrical characteristics as shown on contract drawings.
   b. Duct mounted fans shall be of the centrifugal belt driven in-line type. The fan housing shall be of the square design constructed of heavy gauge galvanized steel and shall include square duct mounting collars.

c. Fan construction shall include two removable access panels located perpendicular to the motor mounting panel. The access panels must be of sufficient size to permit easy access to all interior components. All in-line fans shall be factory insulated. The housing interior shall be insulated with 1-inch acoustical insulation.

d. The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.

e. Motors shall be heavy duty ball bearing type, carefully matched to the fan load and furnished at the specified voltage, phase and enclosure. Motors and drives shall be mounted out of the airstream. Motors shall be readily accessible for maintenance. Motors shall be high efficiency type.

f. Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed.

g. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.

h. Motor pulleys shall be adjustable for final system balancing.

i. All fans shall bear the AMCA Certified Ratings Seal for both sound and air performance.

j. Each fan shall bear a permanently affixed manufacture’'s nameplate containing the model number and individual serial number for future identification.

k. Explosion proof fans shall be provided with explosion proof motor and non-sparking explosion proof wheel construction.

l. Fans shall be Model BSQ as manufactured by Greenheck Fan Corporation, ACME Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

C. Sidewall Propeller Fans

1. Belt drive

a. Furnish and install belt driven propeller fans of size, capacity and electrical characteristics as shown on contract drawings.

b. All sidewall fans shall be belt driven axial type.

c. Propellers shall be constructed with die formed galvanized steel blades riveted to a steel hub. Propellers shall be statically and dynamically balanced.

d. Motors shall be of heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure. Two speed motors shall be furnished where indicated.

e. Ground and polished steel fan shafts shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. Propellers shall be attached to fan shafts with a standard square key and set screws or tapered bushings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speeds. Drives shall

be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor sheaves shall be adjustable for final system balancing.

f. Drive frame assemblies shall be formed galvanized steel construction. Fan panels shall have prepunched mounting holes, formed flanges with welded corners and a deep formed inlet venturi.

g. The axial exhaust or supply fans shall bear the AMCA Certified Ratings Seals for both air and sound performance.

h. All steel parts shall be protected with thermally fused polyester urethane. Fan shafts shall be coated with a zinc phosphate corrosion resistant coating.

i. Fans shall be provided with OSHA Safety Guard. Supply fans shall be of the reverse flow configuration. Provide wall mount collars, and 2-inch aluminum birdscreen with each fan as indicated on contract drawings. Motor operated dampers shall be provided by ATC subcontractor and installed by mechanical contractor.

j. Fans shall be Model SBE for exhaust and SBS for supply as manufactured by Greenheck, ACME Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

D. Power Roof Ventilators

1. Belt Drive

a. Furnish and install belt driven power roof ventilators of the size, capacity, and electrical characteristics a shown on contract drawings.

b. Roof fans shall be centrifugal belt driven type.

c. The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.

d. The fan housing shall be constructed of heavy gauge aluminum with a rigid internal support structure. The fan shroud shall have a rolled bead for added strength.

e. Motors shall be heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure. Motor and drives shall be mounted on vibration isolators, out of the airstream. Fresh air for motor cooling shall be drawn into the motor compartment from an area free of discharge contaminants. Motors shall be readily accessible for maintenance. Motors shall be two (2) speed type where indicted on drawings.

f. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators.

g. Precision ground and polished fan shaft shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulley shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.

Motor pulleys shall be adjustable for final system balancing.

h. A disconnect switch shall be factory installed and wired from the fan motor to a junction box installed within the motor compartment. A fan conduit chase shall be provided through the curb cap to the motor compartment for ease of installation.

i. All fans shall bear the AMCA Certified Ratings Seal for sound and air performance.

j. Each fan shall bear a permanently affixed manufacture''s nameplate containing the model number and individual serial number for future identification.

k. Provide 12-inch high, fully insulated, aluminum roof curbs with each ventilator. Fan and roof curb shall be provided by the same manufacturer.

l. Provide 2-inch aluminum birdscreen with each fan.

m. Motor operated dampers shall be provided by ATC subcontractor and installed by mechanical contractor.

n. Fans shall be Model GB as manufactured by Greenheck Fan Corporation, ACME Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

E. Kitchen Hood Exhaust Fans (Belt Drive) (Upblast)

1. Provide and install belt drive upblast centrifugal roof exhauster of the size, performance, and electrical characteristics as indicated on contract drawings. The upblast exhaust fan shall be installed on a ventilated roofcurb.

2. Roof exhaust fans shall be upblast centrifugal belt driven type. The fan wheel shall be centrifugal backward inclined, Teflon coated constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced. The fan housing shall be constructed of heavy gauge aluminum with a rigid internal support structure. Windbands shall have a rolled bead for added strength and shall be joined to curbcaps with a welded seam.

3. Motors shall be heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure. Motors and drives shall be mounted on vibration isolators, out of the airstream. Fresh air for motor cooling shall be drawn into the motor compartment from an area free of discharge contaminants. Motors shall be readily accessible for maintenance. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators. Where scheduled to be variable speed provide inverter rated motors. Coordinate required VFD size provided in Division 23 Section “Packaged Kitchen Hood Ventilation Control System”.

4. Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.

5. Motor pulleys shall be adjustable for final system balancing. A disconnect switch shall be factory installed and wired from the fan motor to a junction box installed within the motor compartment. A conduit chase shall be provided through the curb cap to the motor compartment for ease of electrical wiring. All fans shall bear the AMCA Certified Ratings Seal for sound and air performance.

6. The upblast exhaust fans shall be provided with baffled grease container, and shall be listed per U.L. 762. Fan discharge shall terminate a minimum of 40-inch above roof. Fan and installation shall comply with N.F.P.A.-96.

7. Provide fan with a minimum 36 inch wind band to elevate exhaust discharge.

8. Kitchen hood exhaust fans shall be Model CUBE as manufactured by Greenheck, Acme Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

F. Utility Fans (Belt Drive)

1. Furnish and install belt driven, utility fans of the size, capacity and electrical characteristics as shown on contract drawings.

   a. Fans shall be of the belt driven utility fan type in AMCA Arrangement 10 with a single width, single inlet housing in CW or CCW rotation as specified. Fan arrangement shall be carefully coordinated with requirements as shown on contract drawings.
   b. The housing shall be constructed of heavy gauge steel with lock formed seams permitting no air leakage. The housing shall be field rotatable to any of the eight standard discharge positions. Housing and bearing supports shall be constructed of welded steel members to prevent vibration and rigidly support the shaft and bearings. For supply, return, or exhaust air fans, the housing shall be externally insulated with 1 ½ - inch rigid duct insulation.
   c. The fan wheel shall be of the forward curved or backward inclined type, constructed of heavy gauge steel with uniform stamped steel blades.
   d. Wheels shall be statically and dynamically balanced. The wheel cone and fan inlet cone shall be carefully matched for maximum performance and operating efficiency.
   e. Motors shall be permanently lubricated, heavy duty, ball bearing type carefully matched to the fan load and furnished at the specified voltage, phase and enclosure. The fan shaft shall be ground and polished solid steel mounted in heavy duty, permanently sealed, pillow block ball bearings. Bearings shall be selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. The motor pulley shall be adjustable for final system balancing. Motors shall be inverted duty rated where variable speed drives are utilized.
   f. Fan performance shall be based on tests conducted in accordance with AMCA Standard 210 test code for air moving devices. Fans shall be licensed to bear the AMCA Certified Ratings Seal for air performance.

g. All utility fans shall be provided with OSHA belt guards, flanged outlets, scroll access doors, and drain fittings in scroll. All fan components shall be painted with a rust preventative primer prior to assembly and the entire fan shall have a finish coat of corrosion resistant machinery grade enamel.

h. Provide 2-inch aluminum mesh screen on discharge of each utility set. Motor operated dampers to be provided by ATC subcontractor and installed by mechanical contractors.

i. Utility fans shall be Model SFB where forward curved and SWB where backward inclined as manufactured by Greenheck, ACME Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

G. Fume Hood Exhaust Fans (Vertical In-Line with Integral Discharge Nozzle)

1. Laboratory Fume Hood Exhaust Fans (Vertical In-Line Laboratory Fume Hood Fan With Integral Discharge Nozzle)

a. General

i. Base fan performance at standard conditions (density 0.075 Lb/ft3).

ii. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.

iii. Each fan shall be belt driven.

iv. Fans to be equipped with 316 stainless steel lifting lugs for corrosion resistance.

v. Fasteners exposed to corrosive exhaust shall be stainless steel.

vi. Fan assembly shall be designed for a minimum of 125 MPH wind loading, without the use of guy wires.

vii. Fume hood exhaust fans shall be Greenheck Fan Corp Model Vektor – H, High plume laboratory exhaust system or approved equal.

viii. Motor operated damper shall be provided by ATC subcontractor and installed by mechanical contractor.

b. Corrosion Resistant Coating

i. All fan and system components (fan, nozzle, wind band, plenum) shall be corrosion resistant coated with LabCoatTM, a two part electrostatically applied and baked, sustainable, corrosion resistant coating system; or Heresite P-413C. Color to be selected by the Owner.

c. Fan Housing And Outlet

i. Fan housing to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.

ii. Fan housing shall be welded steel with corrosion resistant coating. No uncoated metal fan parts shall be acceptable.

iii. A high velocity conical discharge nozzle shall be supplied by the fan manufacturer and be designed to efficiently handle an outlet velocity of up to 6000 FPM.

iv. Provide housing drain for removal of rain and condensation.

v. A bolted and gasketed access door shall be supplied in the fan housing allowing for impeller inspection or removal of impeller,

shaft and bearings without removal of the fan housing.

vi. Color selection by Architect.

d. Fan Impeller

i. Fan impeller shall be centrifugal, backward inclined, with non-stall characteristics. The impeller shall be electronically balanced both statically and dynamically per AMCA Standard 204.

ii. Fan impeller shall be manufactured of aluminum (AMCA type B spark resistant), fully welded be provided with for corrosion resistant coating.

e. Support Curb

i. Exhaust system manufacturer shall supply a structural support curb for the fan, of specified height, as shown on the drawings.

ii. Curb shall be fabricated of a minimum of 14 gauge corrosion resistant coated steel and structurally reinforced.

iii. Curbs shall be insulated.

iv. The standard curb/plenum/blower assembly shall withstand wind loads of up to 125 mph without additional structural support.

v. Coordinate roof curbs, penetrations, and supports with roofing type. Refer to Architectural Drawings.

f. Fan Motors and Drive

i. Motors shall be premium efficiency, standard NEMA frame, 1800 or 3600 RPM, TEFC with a 1.15 service factor. Motor maintenance shall be accomplished without fan impeller removal or requiring maintenance personnel to access the contaminated exhaust components.

ii. Drive belts and sheaves shall be sized for 200% of the motor horsepower, and shall be readily and easily accessible for service, if required. Drive shall consist of a minimum of two belts under all circumstances.

iii. Shaft to be polished and ground steel.

iv. Fan shaft bearings shall be Air Handling Quality, ball or roller pillow block type and be sized for an L-10 life of no less than 100,000 hours. Bearings shall be fixed to the fan shaft using concentric mounting locking collars, which reduce vibration, increase service life, and improve serviceability.

v. All shaft bearings shall have extended lube lines with zerk fittings.

vi. Fan motors shall be factory-wired to a factory-mounted heavy duty NEMA 3R disconnect switch. Wiring shall be enclosed in non-metallic liquid-tight conduit. All electrical connections shall be factory tested before shipment.

H. Upblast Centrifugal Roof Exhauster (Belt Drive, Non Grease Applications–- Dishwasher Machine or Chemical Room)

1. Provide and install belt drive upblast centrifugal roof exhauster of the size, performance, and electrical characteristics as indicated on contract drawings. The upblast exhaust fan shall be installed on a insulated roofcurb.

2. Roof exhaust fans shall be upblast centrifugal belt driven type. The fan wheel

shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced. The fan housing shall be constructed of heavy gauge aluminum with a rigid internal support structure. Windbands shall have a rolled bead for added strength and shall be joined to curbcaps with a welded seam.

3. Motors shall be heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure. Motors and drives shall be mounted on vibration isolators, out of the airstream. Fresh air for motor cooling shall be drawn into the motor compartment from an area free of discharge contaminants. Motors shall be readily accessible for maintenance. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators. Motors shall be two (2) speed type or explosion proof where indicated on contract drawings.

4. Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.

5. Motor pulleys shall be adjustable for final system balancing. A disconnect switch shall be factory installed and wired from the fan motor to a junction box installed within the motor compartment. A conduit chase shall be provided through the curb cap to the motor compartment for ease of electrical wiring. All fans shall bear the AMCA Certified Ratings Seal for sound and air performance.

6. The upblast exhaust fans shall be provided with 2-inch aluminum birdscreen 12-inches high, fully insulated, aluminum roof curb. Fan and roof curb shall be provided by the same manufacturer.

7. Motor operated dampers shall be provided by ATC subcontractor and installed by mechanical contractor. Where indicated, provide tilting curb to allow damper access from roof.

8. Exhaust fans shall be Model CUBE as manufactured by Greenheck, Acme Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

9. Chemical Storage Room Fan and accessories shall be coated with Hi-Pro polyester coating suitable for corrosive environment.

I. Variable Speed Ceiling Paddle Fans

1. The facility shall be equipped with variable speed ceiling paddle fans, mounting hardware and variable speed fan controls as manufactured by Big Ass Fan Co., Greenheck, Marco Air, Technologies, Sky Blade Fan Company, Entrematic, or approved equal.

2. Complete Unit: The fan shall be designed to move the maximum amount of free air contained within a given space with the least amount of electrical power. Free air is defined as that air within a given space at a constant static pressure.

3. Airfoils: Each fan shall have low speed airfoils of precision extruded aluminum alloy, weighing no more than 1.52 pounds per foot of length. Each airfoil shall be of the high performance blade design. The foils shall be connected to the hub section of the fan by means of locking bolts. Locking bolts are to be SAE grade 8 only, 5/1”" diameter with 150,000 psi tensile strength. Additionally, the airfoils shall be interlocked with a safety strap 14 A36 steel with clear zinc chromate finish to prevent an individual airfoil from becoming accidentally disconnected from the hub.

4. Motor: The fan motor shall be Reliance, 1750 RPM, Inverter rated with Class F Insulation, 40 degrees Celsius ambient-continuous.

5. Gear Reducer: The gear reducer shall be Inline Helical Gear Reducer or equivalent hardened to 58-62 Rockwell C. The gear reducer shall be precision finished for low noise and long service life with double lip seals to keep oil in and contaminants out, and be lubricated for life. The gear reducer shall have a standard backlash of less than 20 arc minutes and be equipped with a 17-4 stainless steel shaft of 1.2”" diameter conditioned to 1150.

6. Motor Frame: The fan motor frame and mount shall be constructed of ”" powder coated steel. The mount shall be designed to allow safety cables to be easily and securely attached.

7. Hub: The fan hub assembly shall be constructed of a precision cast of prime 713 aluminum zinc magnesium ally. The hub shall incorporate six (6) safety clips made of ¼ steel that will restrain the hub/airfoil assembly in case of shaft failure.

8. Mount: The fan mount shall be designed for quick and secure mounting of the fan from a structur’'s support beams. The mounting system of the fan shall allow easy removal and relocation. The fan mount shall be lightweight and constructed of ¼“" power coated steel.

9. Safety Wire Rope: The safety wire rope shall consist of a 7 x 19 stranded galvanized steel of ¼ inch diameter with 4 dropped forged wire rope slips to secure the motor frame to the lower portion of the extension tube and the upper portion of the extension tube to the building framework. The safety wire rope shall have a breaking strength of not less than 7,000 pounds.

10. Fan Controller: Each fan controller will be UL listed as Industrial Control Panels and built pursuant to construction guidelines set forth by Underwriters Laboratories Article 508A, and the National Electrical Code. Each fan controller shall include a factory programmed Variable Frequency Drive (VFD) to provide a soft-start for the fan as well as infinite speed control capability for the fan(s). The VFD shall be sized per the moto’'s full load amp rating. One (1) controller shall be provided for each fan.

11. Fan Controller Program: Controllers and VFD shall be factory programmed to

minimize starting and braking torques.

12. Fire Control Panel Integration: Include a pilot relay for fire control system integration, such relay shall be wired normally open or normally closed in the field.

2.13. DRYER DUCT BOOSTER FAN (RESIDENTIAL TYPE DRYER)

A. Furnish and install in-line dryer duct booster fan of the size, capacity, and electrical characteristics as shown on the contract drawings. Dryer duct booster fan shall be Tjernlund or approved equal.

B. Duct mounted dryer duct booster fans shall be the direct drive type. The fan housing shall be constructed of 22 gauge G90 galvanized steel. The access for wiring shall be eternal. The unit shall be plug-in type. The motor shall be PSC, permanently lubricated ball bearing type and located outside the dryer exhaust air stream. The material handling impeller shall be reverse inclined, particulate handling impeller type, and be constructed of 18 gauge G90 galvanized steel.

C. Provide rubber isolated mounting bracket.

D. Dryer duct booster fan shall be Listed to ANSI/UL 507.

E. The dryer duct booster fan shall be controlled by an electronic Pressure Response Control (PRC). The control shall continuously monitor the pressure in the dryer duct. When the dryer is activated, dryer exhaust pressurizes the inside of the dryer duct, activating the dryer duct booster fan. When the dryer duct booster fan and dryer operating together, they establish a resulting pressure that is monitored by the PRC. When the dryer shuts off, this pressure decreases and the PRC shuts off the dryer duct booster fan.

F. Unit shall be hardwired and a disconnect installed to comply with NEC.

G. Unit shall be provided with a 5-year warranty.

2.14. LABORATORY PASS-THROUGH BENCH TOP LABORATORY FUME HOODS.

A. Scope and Classification

1. This specification covers the requirements for the purchase of bench-mounted panel-lined pass through laboratory fume hoods for remote exhaust blower systems. It is written to cover the by-pass design configuration, vapor-proof electrical configurations and with end viewing window.

2. Bench-mounted laboratory fume hoods in 4, 5, and 6-feet widths and internal depth of 23.9 inches are covered by this specification. Refer to the contract drawings for the hood sizes.

3. This specification sets the intent for quality, performance and appearance.

B. Requirements:

1. Laboratory hoods shall be double wall construction with epoxy-coated, cold rolled steel exterior and 3/1”" sheet molded composite board internal liner and baffle. The hoods shall have two single sashes of 3/1”" thick tempered safety glass with counterbalance weights. Viewing height shall be 37.5 inches. Sash opening height shall be 28 inches. Hoods shall be provided with an air foil across the bottom of each sash area with 5 rows of perforations to maintain airflow should the operator inadvertently block the airflow. Access for maintenance shall be from the front and exterior. All hood-mounted service fixtures, where provided, shall be pre-plumbed except for the inlet tubing. All electrical services shall be pre-wired to a single point internal junction box at the top right of the hood. Hood shall be one-piece construction. Hoods shall be pass through a 3”" opening without disassembly.

C. Quality Assurance:

1. The hood manufacturer shall maintain a testing facility at its place of business for the testing of bench-mounted laboratory hoods in accordance with ASHRAE Standard 110-2016. Both hoods and installation shall be in conformance to good construction practice and approved by the owner/user. Only fume hood manufacturers who have had fume hoods as a principal product for ten years will be considered. The hood manufacture’'s manufacturing and test facilities and its quality control procedures shall be available for owner/user inspection.

D. References:

1. The laboratory hoods shall conform to the following regulations and standards:

   a. SEFA - #1 (Laboratory Fume Hoods)
   b. NFPA - #45 (Fire Protection for Laboratories Using Chemicals 2011)
   c. ASTM E84-09C–- Surface Burning Characteristics of Building Materials
   d. ASHRAE-110-2016 (Method of Testing Performance of Laboratory Fume Hoods)
   e. ANSI–- Std. Z 9.5 (Laboratory Ventilation)
   f. UL Standard 3101 (Electrical Wiring)
   g. UL-61010-1 (Hood Construction)
   h. CAN/CSA Standard C22.2 No. 61010.1

E. Submittals:

1. Laboratory hood specification sheets and product manuals shall be submitted by the hood manufacturer upon request. The hood supplier shall submit shop drawings.

2. Sample pieces of the hood exterior wall material, interior liner and baffle material, work surface material, and color selection chips shall be made available and shall be submitted from the hood manufacturer.

F. Delivery and Storage:

1. Laboratory hoods and work surfaces shall be delivered adequately protected from damage during shipment.

G. Warranty

1. Manufacture''s warranty against defects in material or workmanship on its fume hoods shall be 2 years from date of installation or 3 years from date of purchase, whichever is sooner, and includes replacement of parts (except lamps) and labor.

H. Acceptable Manufacturer:

1. Labconco Corporation, 8811 Prospect Avenue, Kansas City, Missouri 64132, Protector Pass-Through Laboratory Hoods or approved equal.

I. Materials:

1. Hood exterior construction shall be 20 gauge (or heavier) cold rolled sheet steel or galvanized steel supports. All exterior painted surfaces shall be baked on, dry powder epoxy applied electro-statically. Base metal material shall be properly prepared for epoxy coating. Color selection by the Architect.

2. Hood interior liner and baffles shall be sheet molded homogenous polyester panels. Baffles include chemical-resistant polyester brackets for support. Minimum thickness shall be 3/1”". Flame spread shall be less than or equal to 25 per ASTM E84.

3. Corner posts shall be 16 gauge cold-rolled steel with epoxy-coated finish.

4. Exhaust connection shall be epoxy-coated 316 stainless steel.

5. Hood sashes shall be 3/1”" thick tempered safety glass surrounded by an epoxy-coated aluminum and PVC frame.

6. The sash tracks shall be epoxy-coated steel.

7. Sash foils shall be 18-gauge epoxy-coated cold-rolled steel and have 5 rows of perforations.

J. Specific Fabrication Requirements:

1. Overall exterior dimensional information shall be as indicated on the contract drawings.

2. The Pass-Through benchtop mounted laboratory hood with by-pass design shall minimize face velocity fluctuations as either sash is raised or lowered. With the sash positioned six inches above the air foil, the average inflow velocity shall be not less than twice the selected full open face velocity nor greater than three times that amount.

3. Exhaust air volume requirements and static pressure losses shall be as described in the schedule on the contract drawings.

4. The exhaust connection shall be one round connection measuring 12.81 inches ID, with a powder-coated stainless steel finish.

5. Right-hand corner post shall have ADA-compliant light and blower switches and one electrical receptacle box and cutout for face velocity alarm. The three other corner posts shall be factory prepared to accept two electrical duplex.

6. The perforated air foils shall be located directly across the bottom of the sash openings to allow the air to bypass underneath and through the foil and sweep across the work surface to prevent any back flow of fumes escaping from the front of the hood. The foils shall be at least ”" wide and extend back under the sashes to prevent closure of the lower by-pass opening when the sashes are in the fully closed position. The air foils shall have a large aerodynamic radius to sweep the air into the hood with minimal turbulence and shall be perforated to pull inflow air from beneath so that clean air continually flows over the foils creating a constant protective barrier from contaminants. Airflow shall continue even if blocked by the presence of the operator.

7. The front and side exterior of the hood shall feature baked on powder epoxy paint applied electro-statically.

8. The interior liner and baffle shall be cut to fit in terms of size and securely held in place with supports. Baffle shall be removable for cleaning.

9. The hoods shall have two single vertical-rising sash counterbalanced by independent sash weights suspended by two vinyl-coated stainless steel cables that pass through ball bearing pulleys. Each sash shall operate smoothly without tilting when raised or lowered from either end and remain at rest in any open position. All sashes shall be framed with extruded epoxy-coated aluminum and PVC.

10. The fume hood shall include a sash alarm. Only one sash shall be open at a time. If the second sash is raised, an audible alarm will sound until one sash is closed.

11. Fume hood models with viewing window shall be provided with a 1”" x 2”" viewing window on the appropriate side of the hood for additional observation. Window shall be clear tempered safety glass.

12. The vapor-proof hood shall be provided with one vapor proof incandescent light fixture. Hoods shall be provided with a light switch, blower switch, and all internal wiring to a single point internal junction box.

13. The vapor-proof hoods shall accommodate up to eight 115 volt, three-wire polarized and grounded electrical duplex receptacles as required.

14. Work surfaces shall be available with ”" x ”" oval cupsink(s) featuring 1-1/”" drain connection as well as other sink cutout requirements upon request. A work surface with a ”" leading edge radius shall be required. Furnish hood service fixtures including gas, cold water, and hot water. Furnish with color coded labels, valves, and provide water sensors with vacuum breakers and valves.

15. Face velocity alarms to monitor hood performance shall be provided and shall be factory installed.

2.15. FUME HOOD AIR FLOW MONITORS

A. In addition to fume hood manufacturer, provide air flow monitor. Furnish and install magnahelic pressure gauges to monitor hood static pressure for all fume hoods. Static pressure taps shall be installed 2-6 duct diameter downstream of hood in a straight run of duct.

B. Differential pressure gauges for measuring hood static pressure shall be the diaphragm, activated dial type 4 - ¾-inches O.D. with white dial, black figures and graduations and pointer zero adjustment. Gauges shall be Dwyer Instruments, Inc. Magnahelic, Catalog No. 2302 with zero center, 1.0 inch water column range in .05 divisions.

C. Provide each unit with aluminum surface mounting bracket, screws ¼ -inch aluminum tubing, stainless steel static pressure tips, plastic vent valve, integral compression fittings on both tips and valves.

D. Provide Green/Red overlay factory furnished on all fume hood magnahelic gauges. With high port open to atmosphere and low port connected to static pressure tip. Green should be left of center and Red on right of center.

E. Actual dial shall be remotely located adjacent to each fume hood with sufficient ¼-inch aluminum tubing.

F. Provide all gauges with integral adjustable signal flag with external reset screw.

2.16. HOT WATER CONDENSING BOILERS

A. Section includes packaged, factory-fabricated and -assembled, gas-fired, fire-tube condensing boilers, trim, and accessories for generating hot water.

B. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

C. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.

D. Include diagrams for power, signal, and control wiring.

E. Source quality-control reports.

F. Field quality-control reports.

G. Warranty: Special warranty specified in this Section.

H. Other Informational Submittals:

1. ASME Stamp Certification and Report: Submit“"A”"“"S”" or“"P”" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.

I. Operation and Maintenance Data: For boilers to include in emergency, operation, and

maintenance manuals.

J. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

K. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code including ASME CSD-1, amendments, and addenda, latest edition.

L. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to“"Gas and Oil Fired Boilers–- Minimum Efficiency Requirements”"

M. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N,“"Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers”"

N. UL Compliance: Test boilers for compliance with UL 795,“"Commercial-Industrial Gas Heating Equipment”" Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

O. The boiler and installation shall comply with all requirements of the local boiler inspector.

P. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Install concrete, reinforcement, and formwork requirements are specified with concrete.

Q. Special Warranty: Manufacture’'s standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Fire-Tube Condensing Boilers:

a. Leakage and Materials: 10 years from date of Substantial Completion.
b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Nonprorated for five years from date of Substantial Completion.

R. Manufacturers: Subject to compliance with contract documents, provide products by one of the following:

1. Cleaver Brooks

2. AERCO International

3. Raypack

4. Lochinvar

5. Viessmann

6. Weil McLain

7. Patterson Kelley

S. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.

T. Heat Exchanger: Nonferrous, corrosion-resistant combustion chamber. Type 316 L Stainless steel tubes and tube sheets.

U. Pressure Vessel: Carbon steel with welded heads and tube connections.

V. Burner: Natural gas, forced draft with electronic flame safeguard control and flame detector with UV scanner. Interlock flame failure with ATC system.

W. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.

1. Motors: Comply with requirements specified in Division 23, Section“"Common Work Results for HVAC”"

a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

X. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

Y. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

Z. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.

2. Control Compartment Enclosures: NEMA 250, Type 1A.

3. Finish: Baked-enamel or Powder-coated protective finish.

4. Insulation: Minimum 2-inch- (50-mm-) thick, mineral-fiber insulation surrounding the heat exchanger.

5. Combustion-Air Connections: Inlet and vent duct collars.

6. Mounting base to secure boiler.

a. Characteristics and Capacities:
i. Heating Medium: Hot water.
ii. Design Water Pressure Rating: 160 psig (1100 kPa)
iii. Safety Relief Valve Setting: As indicated on the Contract Drawings.
iv. Refer to contract drawings for additional capacity information.

AA. Include devices sized to comply with ANSI B31.9,“"Building Services Piping”"

BB. Aquastat Controllers: Operating, firing rate, and high limit.

CC. Safety Relief Valve: ASME rated.

DD. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.

EE. Boiler Air Vent: Automatic.

FF. Drain Valve: Minimum NPS¾4 (DN 20) hose-end gate valve.

GG. Flow Switch: Water flow switch to prevent burner operation during low water flow condition.

HH. Fully testable and manual re-set low water cut-off with manifold fitting. Provide low water cut-off with dry contacts for interfacing with ATC system.

II. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size or larger than nozzle. Valves larger than NPS 2 (DN 50) shall have rising stem. All valves shall be OS&Y type.

JJ. Supply and return piping connections and accessories up to first OS&Y valves shall be welded, flanged, or screwed.

KK. Refer to Division 23, Section“"Instrumentation and Controls of HVAC and Plumbing Systems”"

LL. Boiler operating controls shall include the following devices and features:

1. Control transformer.

2. Set-Point Adjust: Set points shall be adjustable.

    a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
    b. Hot water re-set of supply water temperature based on outside air temperature.

MM. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Cutoff: Manual reset stops burner if operating conditions rise above maximum boiler design temperature.

2. Low-Water Cutoff Switch: Hydro level 550 Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual-reset type.

3. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.

4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

5. Primary gas safety controls: Labeled and listed by nationally recognized testing agency. Manual re-set type that requires intervention by operator or service technician ro re-set.

NN. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1. Hardwired Points:

a. Monitoring: On/off status, common trouble alarm low water level alarm.
b. Control: On/off operation, hot water supply temperature set-point adjustment.
c. Flame failure and low water condition alarms.

2. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

OO. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

PP. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.

2. Wiring shall be numbered and color-coded to match wiring diagram.

3. Install factory wiring outside of an enclosure in a metal raceway.

4. Field power interface shall be to nonfused disconnect switch and circuit breaker.

5. Provide each motor with overcurrent protection.

6. For three (3) phase units, furnish phase loss protection.

QQ. Kit: Complete system, ASTM A 959, Type 29-4C stainless steel, double wall pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.

RR. Combustion-Air Intake: Complete system, PVC intake, pipe or stainless steel, vent terminal with screen, inlet air coupling, and sealant.

SS. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

TT. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

UU. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

2.17. BASE MOUNTED PUMPS–- END SUCTION

A. Furnish and install base mounted centrifugal end suction pumps to circulate hydronic water to the various items of equipment throughout the building, associated with the HVAC system. Pumps shall have sizes and capacities as indicated on the drawings.

B. All pumps shall be suitable for the service and temperatures designated and shall conform to the following requirements. Each pump shall have a factory installed seal flushing line running from the seal area to the pump suction to insure removal of trapped air from the seal area, removal of sediment, and cooling of the seal to extend seal life. Provide and install Cuno five (5) micron filters in seal flushing lines. Provide two (2) sets of cartridges for each side–- stream filter.

C. Pumps shall be cast iron bronze fitted and shall be suitable for up to 175 psi working pressure and up to 250 degrees F water temperature. Pumps shall have center-line discharge for positive venting and flanged bodies. Pumps shall incorporate a grease lubrication system and be so designed that the bearing assembly can be removed in one piece. A water slinger shall be provided between the mechanical seal and bearing areas. Pump shafts shall be stainless steel with a cupro-nickel sleeve, and be coupled to the motor shaft by a noiseless, non-metallic coupler with guard. Impellers shall be one piece cast bronze, dynamically balanced. Motors shall be 1750 rpm. For variable speed pumps, motors shall be inverter duty rated.

D. Pumps shall be designed so that they shall not overload at low heads and shall not develop excessive pressure under throttled flow conditions or overload motor anywhere on the operating curve. Operating performance curves shall be submitted for approval. Provide gauge tappings on each pump flange. Furnish dust caps at all oil fill tubes. Pump motors shall be non-overloading throughout the range of the curves.

E. When pumps are operated in parallel, pumps must be selected so as not to “run-out” to the end of the pump curve. Submit pump curves for parallel pump operation and single pump operation.

F. Units shall be provided with motors of not less than the horsepower indicated, suitable for the service and available electrical characteristics. Units shall be controlled as hereinafter specified. After installation and prior to operation, each pump shall be aligned. Motors shall be as specified hereinbefore.

G. Casing: Cast iron, with suction and discharge gage ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.

H. Impeller: Bronze, fully enclosed, keyed to shaft.

I. Baseplate: Cast iron or fabricated steel with integral drain rim.

J. Pumps shall be primed and painted in baked enamel, rust resistant paint.

K. Electrical characteristics shall be as scheduled on the contract drawings. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA-70.

L. Pumps shall be FE series as manufactured by Taco, 2000 Series by Allis Chalmers, Aurora, Bell & Gossett, PACO, Armstrong, Patterson, or as approved equal.

2.18. IN-LINE CIRCULATING PUMPS

A. Furnish and install in-line circulating pumps as shown on the contract drawings. Pump and motor shall be equipped with sleeve bearings for quiet operation. Pumps shall be suitable for up to 175 psi working pressure and up to 300 degrees F water temperature as per ASA B16.1. Pump rating curves shall be the result of testing and rating in accordance with the procedures of the Hydraulic Institute.

B. Pump motors shall be non-overloading throughout the range of the curves. Pumps shall have center-line discharge for positive venting, flanged bodies, and same size suction and discharge. Pumps shall incorporate a disc type lubrication system and be so designed that the bearing assembly can be removed in one piece. One bearing assembly shall be suitable for all sizes of the inline pumps furnished. Sump oil temperature may not exceed 180 degrees F when circulating 250 degrees F water with a 90 degree F ambient. Vent and drain openings at least 3 square inches in area and a water slinger shall be provided between the mechanical seal and bearing area. This water slinger shall be integral with shaft sleeve. All in-line circulating pumps shall be provided with all bronze construction when used in open system and shall be bronze fitted for closed system.

C. Provide gauge tappings on each pump flange.

D. Pump body shall be cast iron and pump shafts shall be alloy steel with cupro-nickel sleeve covering all wetted parts, and be coupled to the motor shaft by a noiseless non-metallic coupler. Impellers shall be one piece cast bronze, dynamically balanced. Pumps shall have a two piece mechanical seal assembly easily replaceable without the use of special tools. Motors shall be resilient mounted, 1750 RPM, and require no external overload protection when used with single phase current.

E. Electrical characteristics shall be as scheduled on the contract drawings. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA-70.

F. In line pumps shall be Red Baron Series 110 in-line circulators or 1600 Series, as manufactured by Taco, Bell & Gossett, Thrush, Armstrong, Patterson, or as approved equal.

2.19. IN-LINE CLOSE COUPLED CIRCULATING PUMP

A. Furnish and install in-line closed coupled circulating pumps as shown on the contract drawings. Pump and motor shall be equipped with permanently lubricated bearings for quiet operation. Pumps shall be suitable for up to 150 psi working pressure and up to 225 degrees F water temperature as per ASA B16.1. Pump rating curves shall be the result of testing and rating in accordance with the procedures of the Hydraulic Institute.

B. The pumps shall be of the horizontal, permanently lubricated type, specifically designed and guaranteed for quiet operation.

C. Provide gauge tappings on each pump flange.

D. The pumps shall have a steel shaft supported by permanently lubricated, sealed precision ball bearings. The pumps are to be equipped with a water-tight seal to prevent leakage. Mechanical seal faces to be carbon on silicon carbide. The motor shall be non-overloading at any point on the pump performance curve.

E. The motor shall be of the drip-proof, sealed precision ball-bearing, quiet-operating construction. The permanent split-capacitor motor shall be equipped with thermal overload protection.

F. Pumps to be suitable for 0 degrees to 225 degrees F (107 degrees C) operating temperature at 150 psig (10 bar) working pressure.

G. Pumps shall be provided with all bronze construction when used in open systems and shall be bronze fitted for closed systems.

H. Electrical characteristics shall be as scheduled on the contract drawings. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA-70.

I. In line pumps shall be close coupled in-line circulators Model PL as manufactured by Bell & Gossett, Thrush, Armstrong, Taco, Patterson, or as approved equal.

2.20. VERTICAL IN-LINE PUMPS

A. Furnish and install vertical centrifugal in-line single stage pump(s), with capacities and characteristics as shown on the plans. Pumps shall be Taco Model VI, Bell and gossett, Thrush, Patterson, Armstrong or approved equal.

B. Pump volute or casing shall be constructed of class 35 cast iron. The pump shall be fitted with replaceable bronze wear rings, drilled and tapped for gauge ports at both the suction and discharge flanges and for drain port at the bottom of the casing. The pump shall be capable of being serviced without disturbing system piping. Pumps shall be bronze fitted for use in closed systems and all bronze construction in open systems.

C. The impeller shall be bronze and hydraulically balanced by either back vanes or back wear ring and balancing holes. The impeller shall be dynamically balanced and shall be fitted to the shaft with a key.

D. The pump shall be close coupled to a NEMA standard JM regreasble high efficiency motor. The pump shall incorporate a dry shaft design to prevent the circulating fluid

from contacting the shaft. The shaft shall be covered with a replaceable bronze shaft sleeve. Motors shall be 1750 rpm. Pumps shall be designed so that they shall not overload at low heads and shall not develop excessive pressure under throttled flow conditions or overload motor anywhere on the pump curve.

E. When pumps are operated in parallel, pumps must be selected so as not to "run-out" to the end of the pump curve. Submit pump curves for parallel pump operation and single pump operation.

F. The pump shall have a factory installed seal flushing line running from the seal area to the pump suction to insure removal of trapped air from the seal area, removal of sediment and cooling of the seal to extend seal life. Provide and install Cuno 5 micron filters in seal flushing line.

G. The pump seal shall be EPT Ceramic rated to 250 degrees F. Pumps shall be finished in a baked enamel finish designed to resist rusting. Pumps shall be suitable for up to 175 psi working pressure and up to 250 degrees F water temperature. For pool applications the pump seal shall be Viton-carbon/Ceramic seal with extended flush line and cuno filter rated to 250 degrees F. Pumps shall be finished in a baked enamel finish designed to resist rusting. Pumps shall be suitable for up to 175 psi working pressure and up to 250 degrees F water temperature.

H. Electrical characteristics shall be as scheduled on the contract drawings. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA-70.

2.21. VARIABLE SPEED DRIVES

A. Provide variable speed drive controllers for Rooftop Air Handling Units, Air Handling Units, Carbon monoxide Makeup Air Units, Relief Air Fans, Welding Makeup Air Units, Pumps, and as indicated on contract drawings. Drive shall be subject to the requirements of this section.

B. ERV variable speed drives shall be factory furnished by ERV unit manufacturer.

C. Kitchen make-up air unit and kitchen exhaust fan variable speed drives shall be factory furnished with the packaged kitchen hood ventilation control system. Under this Division install VFDs where indicated on the Contract Drawings. VFDs are subject to the following requirements.

D. The adjustable frequency controller (AFC) shall convert three phase 60 Hertz utility power to adjustable voltage and frequency, three phase, AC power for stepless motor control from 5 percent to 110 percent of base speed.

E. The single zone VAV air handling units shall be factory furnished with variable frequency drives for the supply and exhaust air fan.

F. The AFC shall be a voltage source type with a PWM output utilizing power transistor semi-conductors.

G. The AFC together with all options and modifications shall mount within a standard

NEMA 1, NEMA-3R or NEMA-4X enclosure for exterior/dusty area installation suitable for continuous operation at ambient temperature of 0 to 40 degrees C. with relative humidity to 95 percent non-condensing. All high voltage components within enclosure shall be isolated with steel covers. The complete unit shall be UL approved and UL labeled.

H. Circuits shall provide DV/DT and DI/DT protection for semi-conductors. AFC shall be capable of starting into a rotating load without delay. Protective circuits shall cause instantaneous trip (IET) should any of the following faults occur:

1. Motor overload.
2. Shortcircuit.
3. Motor overtemperature fault.
4. Reverse phase.
5. 110 percent of controller maximum sine wave current rating is exceeded.
6. Output phase to phase and phase to ground short circuit condition.
7. High input line voltage.
8. Low input line voltage.
9. Loss of input phase.
10. External fault. This protective circuit shall permit, by means of the terminal strip, wiring of remote NC safety contacts such as high static, firestat, etc., to shut down the drive.

I. The following adjustments shall be available in the controller and retained in non-volatile memory:

1. Maximum frequency (15 to 400 Hz) factory set at 60 Hz.
2. Minimum frequency (3 to 60 Hz) factory set at 6 Hz.
3. Acceleration (.1 to 360 seconds) factory set at 20 seconds.
4. Deceleration (.1 to 360 seconds) factory set at 20 seconds.
5. Volts/Hertz ratio factory set for 460V at 60 Hz.
6. Voltage offset or boost factory set at 100 percent torque.
7. Current limit (50 percent to 110 percent sine wave current rating) factory set at 100 percent current.

J. The AFC shall have the following basic features:

1. Door-mounted operators controls consisting of a membrane command center which allows manual stop/start and speed control, local/remote indication and manual/or automatic speed control selection. In addition, the command center shall serve as a means to configure controller parameters such as min speed, max speed, acceleration and deceleration times, Volts/Hz ratio, torque boost etc. Potentiometers shall not be allowed for these settings.

2. Main input disconnect to provide a positive disconnect between the controller and all phases of the incoming A-C line. This disconnect shall be mounted inside the controller enclosure and have through-the-door interlocking toggle with provisions for padlocking.

3. Electronic motor overload relay.

4. Automatic restart after power outage, drive fault or external fault, with drive in automatic mode. The circuit shall allow the user to select up to (10) restart attempts as well as the dwell time between attempts. The reset time between fault occurrences shall also be selectable. All settings shall be via the membrane command center.

5. Door-mounted LED display for digital indication of:

    a. Frequency output
    b. Voltage output
    c. Current output
    d. First fault indication
    e. Fan or Pump Speed (RPM)

6. Relay contacts for remote indication of drive fault and motor finning.

7. Three critical frequency avoidance bands, field programmable via the membrane command center. Each critical frequency avoidance band shall have a bandwidth adjustable via keypad entry of up to 10 Hz.

8. Three programmable preset speeds which shall force the AFC to a preset speed upon a user contract closure.

9. Isolated process follower to enable VFC to follow a 4-20 MA signal.

10. The AFC shall have the capability to ride through power dips up to 500 msec without a controller trip depending on load and operating condition.

11. Line reactor to minimize line surges, line notching, and voltage distortions. Line reactor shall be installed upstream of the drive.

K. Manual bypass-to-line with magnetic contactors to transfer motor from the variable frequency controller to full speed operation on utility supplied input power while the motor is at any speed. Two motor contactors, electrically interlocked shall be utilized, one contactor between the controller output and the motor and the other between the bypass power line and the motor, providing across-the-line starting.

L. Motor protection per National Electrical Code shall be provided in both the“"controlle”" mode and the“"bypas”" mode by a motor overload relay. The 115 volt A-C relay control logic, allowing common start/stop commands in the“"controlle”" mode and the“"bypas”" mode shall also be included within the enclosure.

M. The bypass shall include a door interlocked, main power input circuit breaker providing positive shutdown of all power to both the bypass circuitry and the VFC. The bypass circuit shall also include a second input disconnect to the VFC. This disconnect shall provide the ability to safely troubleshoot and test the controller, both energized and de-energized, while operating the bypass mode. Terminal connectors for over pressurization switches shall be provided, to protect the duct work in the bypass mode.

N. The VFC and all components shall be supplied within a single NEMA 1 enclosure, and shall be U.L. Listed as a single unit. Furnish all components necessary to provide a minimum lead length between motor and drive of 400 ft. The VFC shall not generate damaging transistor pulses greater than the limits set by NEMA MG-1 at 400 Ft lead length.

O. The VFC manufacturer shall maintain and staff nationwide service centers. These service engineers shall be employed by the manufacturer and provide start-up service including physical inspection of drive and connecting wiring and final adjustments to meet specified performance requirements.

P. The VFC shall carry a full parts and labor warranty for two years from date of substantial completion.

Q. The variable speed drive shall be ABB, or approved equal of Accutrol, Cutler Hammer, Graham, York, Baldor, AC Tech, Trane, Emerson, Danfos, Yaskawa, Toshiba, or as approved equal.

R. The variable speed drive manufacturer shall coordinate with the ATC contractor and provide all necessary devices whether optional or not to perform complete and automatic operation as described in the sequence of operation. All safeties, including freezestats, duct smoke detectors, and high static pressure sensors shall be enabled when variable speed drives are in manual or bypass.

S. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VF''s nonvolatile memory.

1. Network Communications Ports: Ethernet and RS-422/485.

2. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet; protocols accessible via the communications ports.

T. Variable speed drives shall be carefully selected for the duty required. Variable speed drives shall be specifically designed for the specified equipment to be controlled. Pump drives shall be selected for pumps and fan drives shall be selected for fans.

2.22. COMBINATION COALESCING AIR AND DIRT SEPARATOR

A. Furnish and install as shown on the drawings a Spirotherm steel, Taco Series 4900, Caleffi , Armstrong, Wessels, or approved equal air elimination and dirt separator. All fittings shall be fabricated steel, rated for 150 psig design pressure and selected for less than 1 foot of water pressure drop and velocity not to exceed 4 feet per second through the unit at specified GPM. All units shall include an integral copper bundle of Spirotubes or approved equal, to act as the turbulence suppressive coalescing medium which must completely fill the fittin''s internal area. Units are to remove free and entrained air during system start up and continue to eliminate dissolved air and dirt through continual circulation and the coalescing action of the Spirotubes. Each fitting is to have a separate air and venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral float actuated brass air vent. There shall be no restriction in the connection from the venting chamber to the vent. The fittings are to include a valve side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Units shall include a bottom connection for use as a blow down connection for periodic cleaning. Unit shall have the bottom of the vessel extended for dirt separation with the system connection nozzles equal distant from the top and bottom of the vessel. Air separator shall be primed and finished in rust resistant paint. Units shall be Spirovent dirt models of the size required to meet pressure drop and velocity criteria.

B. A blowdown connection and valve shall be provided to facilitate routine cleaning of the strainer and the separator. Unit shall include a removable lower head to facilitate removal of the tube assembly for cleaning.

C. A manufacture''s data report for pressure vessels, for U-1 as required by the provisions of ASME Boiler and Pressure Vessel code, shall be furnished for each air separator upon request. Manufacturer to furnish data sheet specifying air collection efficiency and pressure drop at rated flow.

D. Conventional tangential or centrifugal non-coalesing air separators shall not be acceptable.

2.23. EXPANSION TANKS

A. Furnish and install as shown on the drawings, pre-pressurized captive air bladder type expansion tank pre-charged with air. Tank shall be suitable for a maximum working pressure of 125 psi and constructed and certified to ASME Section VII. It shall have a replaceable elastomeric bladder suitable for a maximum operating temperature of 240 degrees F (115 degrees C). Expansion tanks shall be primed and finished in rust resistant paint. It shall have an integral steel base ring for vertical mounting and saddle for horizontal mounting. Expansion tank shall be as manufactured by Taco, Bell & Gossett, Wessels, Amtrol, Armstrong or as approved equal.

2.24. HORIZONTAL HOT WATER UNIT HEATERS

A. Provide and install horizontal hot water unit heaters of the size, capacity and electrical characteristics as indicated on the contract drawings. Horizontal unit heaters shall be Trane Model S, Dunham Bush, Modine, or approved equal.

B. Casing shall be two-piece with "picture frame" front formed into wrap around sides, top and bottom. Furnish each unit with louvered fin diffuser for versatility in lateral

diffusion. Casing shall be 18 gauge back panel with deep-drain fan orifice for extreme rigidity. Steel supply and return pipe top connectors bolted to back. Casings phosphatized to prevent corrosion and finished with a green baked enamel finish.

C. Fan shall be high efficiency Model A with aluminum blades, factory balanced and sturdy for standard applications.

D. Coils shall be hot water, single tube single serpentine design. Fins shall be aluminum sigma-flow, mechanically bonded to seamless copper tubing. All coils one-row deep in air flow direction. Coils shall be tested at 300 psig air under water. Coils shall be suitable for operation at 200 psig or 325 degrees F.

E. Motors shall be totally enclosed, class "B" insulated shaded pole and permanent split capacitor. All motors shall have built-in overload protection. Sleeve bearing motors can be oiled. Ball bearing motors are permanently lubricated. Units shall be U.L. listed.

2.25. VERTICAL HOT WATER UNIT HEATERS

A. Provide and install vertical hot water unit heaters of the size, capacity and electrical characteristics as indicated on the contract drawings. Vertical unit heaters shall be Trane Model P, Dunham Bush, Modine, Rittling, or approved equal.

B. Casing shall be formed by two (2) square steel plates. Bottom plate forms orifice for easy air delivery. Air ports shall be stamped in top plate for easy removal for low final air temperature.

C. Fan shall be high efficiency Model A with aluminum blade, factory balanced and sturdy for standard applications. Furnish each unit with discharge diffuser.

D. Coils shall be hot water, rectangular 3 or 4 sided, one pass, multiple circuit, with sigma flow fins mechanically bonded to tubes. Coils shall be seamless copper tubing. Coils shall be tested at 300 psig air under water. Coils shall be suitable for operation at 200 psig or 325 degrees F.

E. Motors shall be totally enclosed, class "B" insulated shaded pole and permanent split capacitor. All motors shall have built-in overload protection. Sleeve bearing motors can be oiled. Ball bearing motors are permanently lubricated. Units shall be U.L. listed.

2.26. FAN COIL UNITS (FLOOR MOUNTED, FOUR PIPE UNIT)

A. Provide and install fan coil units of the type, capacity, and electrical characteristics as shown and scheduled on the plans. The units shall be installed in a neat and workmanship like manner in strict accordance with specifications. Floor mounted fan coil units shall be exposed type as manufactured by York. Fan coil units fully equal to the specified manufacturer and manufactured by Carrier, McQuay, Rittling, or Trane, and Johnson Controls are acceptable provided they meet connection limitations. All fan coil units shall be U.L. and CSA approved. All floor mounted units shall be rated in accordance with ARI Industry Standard 440.

B. Basic Unit: The basic unit shall be fabricated of 18 gauge galvanized steel. Interior surfaces of coil section of Floor mounted models shall be lined with 2 inch coated glass

fiber insulation meeting NFPA-90A requirements. The fan and motor assembly shall be easily removable for serviceability.

C. Cabinet: Exposed Floor and Lowboy models shall have 18 gauge steel panels acoustically and thermally insulated with ½ inch coated glass fiber insulation meeting NFPA-90A requirements. Exposed panels shall be bonderized and finished with a baked primer. Baked enamel finish, of color selected by Architect shall be provided. Floor mounted models shall have an easily removable front panel for complete serviceability. Stamped aluminum supply grilles and die formed recessed access doors for control and piping compartments shall be provided in the top panel. Each unit shall have a return air grille stamped into the front panel. Furnish each unit with insulated valve and pipe enclosure end piece for concealment of all pipes and valves. Units shall be sloped top type.

D. Coils: All cooling coils shall be ARI rated. Coils shall have 2 inch OD copper tubes with aluminum fins, mechanically bonded to the tubes. All coils shall be fitted with manual air vents. Coils shall be factory leak tested at 300 psig and suitable for working pressures to 250 psig at 200 degrees F. Coil connections shall be 5/8 inch OD male sweat fittings.

E. Motors: Motors shall be 3-speed, resilient mounted with UL listed thermal overload protection. Motor bearings shall be of the sleeve type or ball bearing type. Standard motors are permanent split capacitor (PSC). Motors shall be premium efficiency type.

F. Fan Switch: All units shall be provided with a OFF-HI-MED-LO fan speed switch unit mounted on Floor models. Fan switches shall be utilized for balancing to design CFM.

G. Temperature Sensor: Remote temperature sensors shall be furnished and installed under Section 230900, Instrumentation & Controls of HVAC and Plumbing Systems.

H. Junction Box: Exposed floor shall have the fan speed switch and optional controls wired to the control box.

I. Fans: Fans shall be of the centrifugal, forward-curved type. Fan wheels shall be statically and dynamically balanced. Fan wheels shall be painted or galvanized, and housings shall be galvanized steel.

J. Drain Pan: Floor models shall have a combination drain pan and fan deck assembly, fabricated of 18 gauge galvanized steel. Pans shall be insulated with closed cell, polyurethane, sprayed-on foam. Floor models shall be provided with an auxiliary drain pan of molded plastic with a¾4 inch MPT drain connection. Steel sleeved auxiliary drain pans shall be provided to permit piping through the auxiliary drain pan.

K. Filters: Floor models shall have 1 inch throwaway filters of woven glass fiber furnished as standard equipment.

L. Fresh Air Dampers: 0-25 percent nominal outside air dampers with motorized control shall be provided on Floor models with rear inlet openings. Dampers shall be furnished with electric/electronic actuators by ATC subcontractor. All motor operated dampers shall be furnished by ATC subcontractor and installed by mechanical contractor.

M. All cooling and heating coils shall be sized and selected to operate with 30 percent propylene glycol.

N. Freezestats shall be installed downstream of coils on all fan coil units that have outdoor air provisions. Freezestats shall de-energize units upon sensing a temperature below set-point and fully open hot water control valve to coil (see ATC Sequence of Operation).

O. The ATC controls contractor shall furnish the terminal control unit controller for installation on each fan coil unit by the unit manufacturer. These devices shall be delivered to the unit manufacture''s factory in sufficient time for the manufacturer to meet their schedule obligations. The relay for fan shall be provided by the unit manufacturer who shall also provide the interconnect wiring between the relays and the DDC control unit. The unit manufacturer shall also provide a 24 VAC power source at each terminal unit. The cost of factory mounting, wiring, enclosure to meet local code and any factory testing and programming of the terminal control unit shall be included by the terminal box manufacturer.

P. The ATC control valves shall be furnished by the ATC contractor for factory installation by the fan coil unit manufacturer. The ATC control valves, piping, valves and fittings shall be arranged to fit within the standard fan coil unit enclosure.

Q. All units shall be sound tested using a qualified reverberant room per ARI Standard 350-82.

R. Junction Box: Units shall have the fan speed switch and optional controls wired to the control box. Furnish all units with factory installed/wired fused disconnect, motor starter, and relay package.

2.27. FAN COIL UNITS (CEILING MOUNTED WITH DUCTED SUPPLY/RETURN)

A. Provide and install fan coil units of the type, capacity, and electrical characteristics as shown and scheduled on the plans. The units shall be installed in a neat and workmanship like manner in strict accordance with specifications. Concealed fan coil units shall be as manufactured by York. Fan coil units fully equal to the specified manufacturer and those manufactured by McQuay, AAF, Trane, Johnson Controls, and Rittling are acceptable provided they meet connection limitations. All fan coil units shall be U.L. and CSA approved. All units shall be rated in accordance with ARI Industry Standard 440. Conform to ANSI/NFPA 70 code for internal wiring of factory wired equipment.

B. Basic Unit: The basic unit shall be fabricated of 18 gauge galvanized steel. Interior surfaces of coil section shall be lined with 2 inch coated glass fiber insulation meeting NFPA-90A requirements. The fan and motor assembly shall be easily removable for serviceability.

C. Cabinet: All models shall have 18 gauge steel panels acoustically and thermally insulated with ½ inch foil-faced insulation meeting NFPA-90A and U.L.94-5v requirements. The exposed side of insulation shall be high density erosion proof material suitable for use in air streams up to 4500 FPM. Exposed panels shall be bonderized and finished with a baked primer. Baked enamel finish, of color selected by Architect shall be provided. The cabinet shall include a telescoping frame with a finished bottom panel visible from

the room. The telescoping frame and removable hinged access panel shall offer exact alignment of the panel to the ceiling and complete access to all internal components. The bottom panel shall be finished in a baked enamel finish in color as selected by the Architect. The supply and return air connections shall be on the front/rear of each unit with a one inch duct collar.

D. Coils: All cooling coils shall be ARI rated. Coils shall have 2 inch OD copper tubes with aluminum fins, mechanically bonded to the tubes. All coils shall be fitted with manual air vents. Coils shall be factory leak tested at 300 psig and suitable for working pressures to 250 psig at 200 degrees F. Coil connections shall be 5/8 inch OD male sweat fittings.

E. Motors: Motors shall be 3-speed, resilient mounted with UL listed thermal overload protection. Motor bearings shall be of the sleeve type or ball bearing type. Standard motors are permanent split capacitor (PSC). Motors shall be premium efficiency type. Motors shall be resiliently mounted and factory run-tested. Motors shall be provided with a keyed plug type connector for power leads that allows easy motor removal without removing power wires from terminals to facilitate unit cleaning and service.

F. Fan Switch: All units shall be provided with a 4 position (OFF-HI-MED-LO) fan speed switch unit factory wired and electrically tested on ceiling models. Remote or unit mounted fan speed switches shall be controlled by three 24 unit relays wiring using a factory-wired transformer.

G. Junction Box: Units shall have the fan speed switch and optional controls wired to the control box.

H. Fans: Fans shall be of the centrifugal, forward-curved, double width, double inlet, corrosion resistant type. Fan wheels shall be direct driven and statically and dynamically balanced. Fan wheels shall be painted or galvanized, and housings shall be galvanized steel.

I. Drain Pan: Units shall have a combination drain pan and fan deck assembly, fabricated of 18 gauge galvanized steel, ABS plastic, or 304 stainless steel. Pans shall be insulated with closed cell, polyurethane, sprayed-on foam. Ceiling models shall be provided with an auxiliary drain pan of galvanized steel with a¾4 inch MPT drain connection. Steel sleeved auxiliary drain pans shall be provided to permit piping through the auxiliary drain pan. Provide a positively sloped, easily removable non-corrosive drain pan under cooling coils according to ASHRAE 62-89R. Drain pans shall be easily removable without disconnecting piping, wiring or unit removal.

J. Filters: All units shall have 1 inch throwaway filters of woven glass fiber furnished as standard equipment.

K. The ATC controls contractor shall furnish the terminal control unit controller for installation on each fan coil unit by the unit manufacturer. These devices shall be delivered to the unit manufacture''s factory in sufficient time for the manufacturer to meet their schedule obligations. The relay for fan shall be provided by the unit manufacturer who shall also provide the interlock wiring between the relays and the DDC control unit. The unit manufacturer shall also provide a 24 VAC power source at each terminal unit. The cost of factory mounting, wiring, enclosure to meet local code and any

factory testing and programming of the terminal control unit shall be included by the fan coil unit manufacturer.

L. All fan coil units shall be sound tested using a qualified reverberant room per ARI Standard 350-82.

M. Junction Box: Units shall have the fan speed switch and optional controls wired to the control box. Furnish all units with factory installed/wired fused disconnect, motor starter, and relay package.

2.28. DUCTLESS FAN COIL UNITS (100% RECIRCULATING, ECM FANS, 2-WAY CONTROL VALVES 4-PIPE)

A. General:

1. The supplied product shall be a Airedale, Carrier Airstream, Multiaqua, or approved equal, four (4) pipe chilled/hot water ceiling cassette unit.

B. Cases:

1. The unit casing shall be manufactured from lightweight galvanized sheet steel with integral fan mounting rails for added strength. Fire resistant foam insulation (to UL94 VO) shall be fitted internally to provide both thermal and acoustic insulation.

C. Coils:

1. Chilled water units utilize large surface area coils positioned to optimize heat transfer and airflow. Each coil shall be manufactured from refrigeration quality copper tubes with mechanically bonded aluminum fins and shall be circuited from headers to ensure low water pressure drops.

D. Condensate Pump:

1. A condensate pump and check valve shall be fitted to carry water out of the unit and stop water from flowing back into the condensate tray. The pump is shall be fixed to a mounting bracket which can be withdrawn from the side of the chassis and shall incorporate an inspection hole to allow a visual check of the pump during operation. A float switch shall be fitted to stop the cooling action should the pump become blocked or fail.

E. Air Vanes:

1. Air outlet vanes shall designed to prevent condensation from forming. Vanes shall be manually adjustable on the 2 x 2 model units but driven by an electric motor on all other model units. Where fitted, the motorized air vanes can be set to auto sweep or can be stopped in a fixed position. Polystyrene blanking pieces are supplied with Cassette packing so that up to two fascia discharge slots can be blanked off.

F. Fans & Fan Motor:

1. All units shall utilize ECM fans (or 3 speed if ECM is not available) that are statically and dynamically balanced for quiet operation. Fan impellers are made from either aluminum or fire-retardant plastic (UL94 VO) for light weight and corrosion resistant operation. Fans shall be driven by ECM motor allowing good heat dissipation and an increased motor efficiency. Fans shall come complete with thermal overload protection and sealed-for-life lubricated bearings.

G. Step Up Transformer:

1. The unit shall be fitted with an appropriate 115 volt to 277 volt step up transformer.

H. Filter:

1. MERV 10, 2" thick radial pleated disposable cotton and synthetic blend filters. Minimum Efficiency Reporting Value of MERV 10 per ASHRAE standard 52.2.

I. Electro-Mechanical Controls:

1. The unit shall include an electro-mechanical controller that includes the recessing relays and safety switch for proper operation. The ATC contractor shall field install unit controllers and control valves to fully control and monitor the units operation per the sequence of operations.

J. Options–- Factory Installed:

1. Alarm Interlock Relay: The unit shall include a relay for unit failure notification. Normally open contact available for field connection.

2. Start / Stop Terminals: The unit shall include terminals for remote start/stop of the unit. The unit is enabled when contact between the terminals is closed.

3. Hot Water Coil: A hot water heating coil shall be factory fitted in addition to the chilled water coil to provide heating. The coil shall be manufactured from refrigeration quality copper tubes with mechanically bonded aluminum fins.

4. Disconnect Switch: The unit shall be fitted with a power disconnect switch located on the control panel, sized for the full load amperage of the unit to enable the unit to be disconnected from the power supply prior to any maintenance.

K. Junction Box: Units shall have the fan speed switch and optional controls wired to the control box. Furnish all units with factory installed/wired fused disconnect, motor starter, and relay package.

2.29. DUCTED BELT DRIVE FAN COIL/BLOWER COIL UNITS (BELT DRIVE, FOUR (4) PIPE, DUCTED SUPPLY/RETURN AIR)

A. Provide and install fan coil/blower coil units of the type, capacity, and electrical characteristics as shown and scheduled on the plans. The units shall be installed in a neat and workmanship like manner in strict accordance with specifications. Fan coil units shall be as manufactured by Daikin (Destiny Series). Fan coil/blower coil units fully

equal to the specified manufacturer and those manufactured by JCI/York, BCH, Price (Genesis Series), and Trane are acceptable provided they meet connection limitations. All fan coil/blower coil units shall be U.L. and CSA approved. All units shall be rated in accordance with ARI Industry Standard 440. Conform to ANSI/NFPA 70 code for internal wiring of factory wired equipment.

B. Basic Unit: The basic unit shall be fabricated of 18 gauge galvanized steel. Interior surfaces of coil section shall be lined with 2 inch coated glass fiber insulation meeting NFPA-90A requirements. The fan and motor assembly shall be easily removable for serviceability.

C. Cabinet: All models shall be double wall and thermally insulated with 1-inch thick insulation meeting NFPA-90A and U.L.94-5v requirements. The cabinet shall include a solid removable hinged access panel with handles. The supply air connection shall be on the front or top of each unit with a one inch duct collar. The return air connections shall be on the rear or side of each unit with a one inch duct collar. Refer to floor plans for duct arrangement.

D. Cooling and Heating Sections:

1. Access to coils from drive side or opposite connection side of unit for service and cleaning shall be provided. Coil headers and return bends shall be fully enclosed within unit casing. Coil connections shall be factory sealed with grommet on exterior and gasket sleeve between outer wall and inner liner where each pipe extends through the unit casing to minimize air and condensate leakage.

2. Cooling Coils:

   a. Cooling performance shall be as specified on the unit schedule.
   b. Water coil fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Seamless copper tubes shall be mechanically expanded into the fins to provide a continuous primary-to-secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins. Coil casing shall be constructed of galvanized steel.
   c. Water coils shall be provided with headers of seamless copper tubing with intruded tube holes to permit expansion and contraction without creating undue stress or strain. Coil connections shall be copper sweat connections with connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain connections shall be furnished on the coil connection, external to the cabinet. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point.
   d. Drainpan shall be constructed from stainless steel, pitched and sloped in direction of airflow to drain connection to allow for condensate drainage. Drainpan shall be positioned above 1” thick insulated double wall panel. Condensate drain connections shall be provided on both sides of drain pan. Secondary drain connection shall be provided.
   e. Coil casing shall be constructed of Galvanized steel.

3. Water Heating Coil:

   a. Heating performance shall be as specified on the unit schedule.
   b. Hot water coil fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Seamless copper tubes shall be mechanically expanded into the fins to provide a continuous primary-to-secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.
   c. Water coils shall be provided with headers of seamless copper tubing with intruded tube holes to permit expansion and contraction without creating undue stress or strain. Coil connections shall be copper sweat connections with connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain connections shall be furnished on the coil connection, external to the cabinet. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point.

E. Supply Fan:

1. The supply fan shall be a DWDI forward-curved type. Fan assemblies including fan, motor and sheaves shall be dynamically balanced by the manufacturer on all three planes at all bearing supports. Manufacturer must ensure maximum fan RPM is below the first critical speed.

2. Fan and motor assembly shall be mounted on vibration type isolators inside cabinetry.

3. Units shall be certified in accordance with the central station air handling units certification program that is based on ARI Standard 430.

F. Bearings and Drives:

1. Basic load rating computed in accordance with AFBMA–- ANSI Standards, L-50 life at 200,000 hours heavy duty pillow block type, self-aligning, grease-lubricated ball bearings.

2. Shafts shall be solid, hot rolled steel, ground and polished, keyed to shaft, and protectively coated with lubricating oil. Hollow shafts are not acceptable.

3. V-Belt drives shall be cast iron or steel sheaves, dynamically balanced, bored to fit shafts and keyed. Variable and adjustable pitch sheaves selected so required RPM is obtained with sheaves set at mid-position and rated based on motor horsepower. Contractor to furnish fixed sheaves at final RPM as determined by balancing contractor.

G. Electrical:

1. Motor shall be a high efficiency open drip-proof type and must meet EPAct minimum motor efficiency standards (applicable only to 1HP motors and larger). Electrical characteristics shall be as shown on the schedule.

2. A junction box shall be furnished and mounted by fan manufacturer for field power connection to motor.

H. Junction Box: Furnish all units with factory installed/wired fused disconnect, motor starter, and relay package.

I. Fans: Fans shall be of the centrifugal, forward-curved, double width, double inlet, corrosion resistant type. Fan wheels shall be belt driven and statically and dynamically balanced. Fan wheels shall be painted or galvanized, and housings shall be galvanized steel. Provide adjustable sheaves for fan. Furnish spare set of belts.

J. Drain Pan: Units shall have a drain pan fabricated of 304 stainless steel. Pans shall be insulated with closed cell, polyurethane, sprayed-on foam. Ceiling models shall be provided with an auxiliary drain pan of galvanized steel with a 1-inch MPT drain connection. Steel sleeved auxiliary drain pans shall be provided to permit piping through the auxiliary drain pan. Provide a positively sloped, easily removable non-corrosive drain pan under cooling coils according to ASHRAE 62-89R. Drain pans shall be easily removable without disconnecting piping, wiring or unit removal.

K. Filters: All units shall have 2 inch deep flat pleated filters with a minimum of MERV-8 rating. Furnish spare set of filters.

L. The ATC controls contractor shall furnish the terminal control unit controller for installation on each fan coil/blower coil unit by the unit manufacturer. These devices shall be delivered to the unit manufacture''s factory in sufficient time for the manufacturer to meet their schedule obligations. The relay for fan shall be provided by the unit manufacturer who shall also provide the interlock wiring between the relays and the DDC control unit. The unit manufacturer shall also provide a 24 VAC power source at each terminal unit. The cost of factory mounting, wiring, enclosure to meet local code and any factory testing and programming of the terminal control unit shall be included by the fan coil unit manufacturer.

M. All fan coil/blower coil units shall be sound tested using a qualified reverberant room per ARI Standard 350-82.

2.30. KITCHEN MAKE-UP AIR UNITS (KMAU-1, 2 & 3)

A. Provide and install outdoor rooftop central station air handling units as shown and scheduled on the plans. The units shall be installed in a neat and workmanship like manner in strict accordance with the specifications. Rooftop air handling units shall be as manufactured by JCI/York, Trane, McQuay, Carrier, Mammoth, Aaon, Addison, Venmar or approved equal.

B. General

1. Rooftop unit manufacture''s standard materials and components as indicated by published product information, designed and constructed as recommended by the manufacturer and as required for a complete air handling unit installation as specified herein. The air handling unit shall be specifically designed for curb mounting in an outdoor application. Weatherized indoor air handling units are not acceptable.

2. Rooftop unit shall meet or exceed the scheduled cooling and heating capacity, selected and rated in accordance with ARI 410. All necessary components for meeting scheduled performance shall be factory assembled per ARI 430 and shipped as one (1) piece where possible.

3. Rooftop units shall be provided with all necessary tags and decals to aid in the service and/or indicate caution areas. Electrical wiring diagrams shall be attached to the control panel access door. Lifting lugs will be supplied to facilitate rigging of the rooftop unit.

4. Manufacturers: The design shown on the drawing is based upon products of the manufacturer scheduled (York). Alternate equipment manufacturers will be acceptable if equipment meets the scheduled performance and complies with these specifications. If equipment manufactured by manufacturer other, than that scheduled is utilized, then the Mechanical Contractor shall be responsible for coordinating with all other Contractors and all affected Subcontractors to insure proper provisions for installation of the furnished unit. This coordination shall include, but not limited to, the following:

    a. Structural supports for units.
    b. Piping size and connection/header locations.
    c. Electrical power requirements and wire/conduit and over current protection sizes.
    d. The Mechanical Contractor shall be responsible for all costs incurred by the other contractor, Subcontractors, and Consultants to modify the building provisions to accept the furnished units.

5. The units shall be furnished complete with double wall insulated casings, centrifugal fans, coils as scheduled, insulated drain plans, motor, drives, belt guards, filter boxes, outside air damper section, roof curbs, discharge plenums and accessories as required. Coils shall not exceed a face velocity of 525 feet per minute.

6. All units shall be horizontal draw through medium pressure units. Construct casing section located upstream of supply fan for operation at a minimum 4 inches w.g. negative static pressure and downstream section for operation at a minimum of 6 inches water gauge positive static pressure.

7. All units shall be factory primed and finished in colors as selected by Architect.

8. Fan discharge arrangements shall be coordinated with ductwork layout to minimize“"system-effec”" per AMCA Publication 201-90.

9. All glycol temperature coil capacities shall be based on 30 percent propylene glycol.

10. Unit shall be factory wired as a single point connection. Each connection shall contain a disconnect in accordance with the National Electric Code. Furnish units with phase loss protection.

11. Provide a GFCI receptacle with each unit. Receptacle shall be wired separate

from unit wiring as indicted in Division 26.

12. Furnish and install variable frequency drive motor bearing protective rings as indicated in Division 23, Section “Common Work Results for HVAC”.

C. Construction

1. Rooftop unit shall be supplied with a full length, continuous bass rail channel.

    a. The base rail channel shall be formed of 12 gauge minimum galvanized steel.
    b. The base rail channel shall support all major components.
    c. The unit base shall be supplied with a recessed curb mounting location.
        i. The recessed curb-mounting surface shall provide a continuous surface for field application of curb gasketing to create a weather-tight seal between the curb and unit.
        ii. Units without a recessed mounting location for the roof curb shall not be acceptable.

2. Rooftop unit shall be supplied with a frame construction consisting of integral galvanized steel vertical and horizontal structural members.

    a. The frame shall be constructed to permit complete removal of the wall and roof panels without affecting the structural integrity of the unit.

3. Rooftop unit shall be supplied with double walled panels for walls, roof, and floor constructed of G90 mill galvanized sheet steel.

    a. All panels shall be formed and reinforced to provide a rigid assembly.
    b. The exterior casing shall be constructed of 18 gauge minimum galvanized steel.
        i. Exterior casing screws shall be zinc chromate coated.
    c. The interior lining of the walls and roof panels shall be a solid lining of 20 gauge minimum galvanized steel.
    d. The interior lining of the floor panels shall be a solid lining of 18 gauge minimum galvanized steel.
    e. All walls, roof, and floor panels in the rooftop unit shall be supplied with 2-inches (two inches) of insulation.
        i. Insulation shall be a full 2-inches (non-compressed) throughout the entire unit.
        ii. Insulation shall be of 1.5 pound per cubic foot in density with a thermal conductivity R of 8.33 BTU/hr-Ft5 - degree F.
        iii. Units with less than 2-inch of insulation in any part of the walls, floor, or roof shall not be acceptable.
        iv. Insulation shall meet the flame and smoke generation requirements of NFPA 90A.
    f. All wall and roof panels shall be completely removable for unit access and removal of components.
        i. Panel removal shall not affect the structural unit frame.
    g. All panels shall be completely gasketed with a copolymer rubber sealant ribbon.

h. All panel fasteners shall be secured through standing seams to prevent fastener penetrations that are exposed to the airstream.
i. Roof and sidewall seams shall be continuously caulked and covered with formed 20 gauge galvanized seam caps.

4. Rooftop unit shall be supplied with a sloped roof to promote drainage of precipitation and prevent standing water.

a. The roof shall have a minimum pitch of 3-inches per foot.
b. The roof shall overhang the side panels by a minimum of 2 inches to prevent precipitation drainage from streaming down the unit side panels. (Roof shall not overhang doors.)
c. Units supplied with flat roofs shall not be acceptable.

D. Fans

1. Units shall be provided with double width double inlet, centrifugal type wheels. Fans shall be standard or Class II (as required by total static pressure) forward curved wheels, air foil type, or backward inclined as scheduled. Every fan shall be rated in accordance with AMCA standards and the fan section shall be certified in accordance with ARI Standard 430. Fans shall be selected to operate well below the first critical speed and each shaft shall be factory coated after assembly with an anti-corrosion coating. After the pre-balanced fan is installed in the rooftop unit the entire fan section shall be run to assume smooth and trouble free operation.

2. Fan bearings shall be self-aligning, pillow block or flanged-type regreasable ball bearings and shall be supplied for an average life (L50) or 200,000 hours. All bearings shall be factory-lubricated and equipped with standard hydraulic grease fitting and extended lube lines. Provide dust caps on all hydraulic grease fittings.

3. Mount fans on isolation bases. Internally mount motors on same isolation bases and internally isolate fans and motors with spring isolators. Install flexible canvas ducts between fan and casings to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A. The fan and fan motor shall be isolated on a full width isolator support channel using rubber in shear 2-inch springs.

4. Fan section shall have full height, double wall, hinge removable access doors for inspection and maintenance of internal components.

5. Weight fan and motor assembly at rooftop unit manufacture''s factory for isolator selection. Statically and dynamically balance fan section assemblies. Fan section isolators. Allow isolators to free float when performing fan balance. Measure vibration at each fan shaft bearing in horizontal, vertical and axial directions. Balance at design RP''s as schedule on drawings.

6. Fans with variable frequency drives shall be balanced for inverter duty operation. Variable frequency drive to be furnished with the packaged kitchen hood ventilation system. Refer to Division 23, Section “Packaged Kitchen Hood Ventilation Control Systems”.

E. Motors and Drives

1. Fan motors shall be internally mounted. Rooftop units shall be provided with additional cooling capacity to compensate for motor heat added to airstream. Total cooling capacity, as schedule, shall be increased by 2500 btuh per motor horsepower for units with internally mounted motors.

2. Units shall be provided with the motor efficiencies as specified in Division 23 Section, Common Work Results for HVAC.

3. Motors shall be open NEMA Design B, rigid base, open drip proof, with Class B insulation. Where scheduled, variable speed units shall have inverter duty motors.

4. Fan drives shall be selected for a 1.5 service factor and anti-static belts shall be furnished. One additional set of belts shall be provided for each air handling unit and delivered to the Owne''s representative at the completion of the project.

5. Fan sections shall be equipped with double width double inlet, centrifugal type wheels.

6. Drives shall be variable pitch and suitable for adjustment within plus or minus 15 percent of specified RPM but not to exceed the maximum RPM of the unit.

7. Motors shall be premium efficiency inverter duty type. Refer to Division 23 Section, “Common Work Results for HVAC”. Coordinate required VFD size provided in Division 23 Specification Section, Packaged Kitchen Hood Ventilation Control System.

F. Coils

1. Chilled Water Coil, Hot Water Pre-Heat, and Hot Water Coils: hydronic coils shall be UL listed; factory tested and rated in accordance with ARI 410. Coils shall be copper with ½ -inch OD seamless tube, 0.022-inch tube thickness and 0.006-inch thick fins or 5/8-inch OD seamless tube, 0.020-inch tube thickness and 0.0075-inch thick fins. Coils shall be tested with 315 psig air pressure under water and maximum working pressure of 250 psig and temperature of 300 degrees F. Fins shall be permanently expanded aluminum, with a maximum of 12 fins per inch. Coil face velocity shall not exceed 500 feet minute.

2. Coil casing shall be constructed of heavy gauge galvanized metal with aluminum die-formed corrugated fins and guide channels to create turbulent wiping behind the tubes. The fins shall have drawn collars, be belled and mechanically expanded to firmly bound the cooper tubes to the fins. All coils shall be installed on tracks for easy removal from the air handling unit.

3. Drainable water coils shall be designed to operate at 250 psig design working pressure and up to 300 degrees F and shall be tested with 325 psig compressed air under water. Circuiting shall provide free draining and venting when installed, counter flow of air and water with water velocities not to exceed seven feet per second and without exceeding the water pressure drops scheduled. All

coils must have same end connections regardless of the number of rows deep. Clearly label supply and return headers on outside of units such that direction of coil water flow is counter to direction of unit airflow.

4. Construct coils of configuration plate fins and seamless tubes. Fins shall have collars drawn, belled and firmly bonded to tubes by means of mechanical expansion of tubes. Do not use soldering or tinning in bonding process.

5. Construction coil casings of Galvanized G90-U Steel with formed end supports and top and bottom channels. If two or more coils are stacked in unit, install intermediate drain channels between coils to drain condensate to main drain pans without flooding lower coils or passing condensate through airstream.

6. Coil grommets shall be provided on all coils to completely seal the area between the coil connection and the unit casing.

7. Wrap Around Heat Pipe: De-humidifier heat pipe shall pre-cool the outdoor air and reheat the air leaving the cooling coil in a wrap around configuration. Both heat exchangers shall be inside and integral to the equipment cabinet. Tubes shall be ½ -inch OD seamless copper tube, 12 fins per inch and 0.006-inch thick fins. Fins shall be permanently expanded aluminum. Wrap around heat pipe shall be UL listed. Heat transfer fluid shall be classified as Safety Group A1 in BDR/ASHRAE Std. 15-1989R.

G. Filters

1. Rooftop unit shall be supplied with a filter segment as an integral part of the unit.

2. Filters shall be nominal 2-inch standard size filters; 45 percent efficient pleated media type. Filters shall be Farr medium efficiency pleated, type with welded wire media support grid.

3. Provide one additional set of filter media for each rooftop unit to be delivered to the Owne''s representative upon completion of the project.

4. Provide factory installed differential pressure gauge, two static pressure tips, vent valves, and red pointer flag, and air filter gauge accessory package to measure filter resistance. Accuracy shall be + - 2 percent of full scale–- to 1.0 inch w.g. range. Gauges shall be 2003 magnahelic by Dwyer Instruments or approved equal.

H. Access Sections and Access Doors

1. Fully insulated, access, sections shall be provided as indicated on the drawings. Sections provide a minimum of 18-inch space with fully-size access door. Access for inspection and cleaning of the unit drain pan, coils, fans sections, filter, wrap around heat pipes, pre-heat coils, chilled water coils, and inlet sections shall be provided.

2. Access doors shall be provided in all sections as indicated on the drawings. Access doors shall be of double wall construction.

3. Panels shall be fully removable to allow for a proper way to thoroughly clean panels of microbial growth and to access internal parts.

4. Doors shall be of double wall construction with a solid liner.

5. Doors shall have a minimum thickness of 2-inches.

6. Doors shall be attached to the unit by a continuous, full length piano type stainless steel hinge. All doors and access sections shall be labeled and identified on the exterior of the unit.

7. Latches shall be positive action, creating an airtight seal between the door and the unit.

8. In lieu of the standard latch, doors for units larger than 6 feet shall be available with a single point, multi-latch system including handles on the interior and exterior of the door.

    a. Latch system shall include a 3 point deadbolt latch with flat rods and tapered take-up side bolts, stainless steel outside handle designed for 90 degrees rotation, and zinc plated inside handle.

9. Door panels shall be completely gasketed with a closed-cell neoprene gasket.

10. Provide access section down stream of dual temperature coil and upstream of heat pipe re-heat coil to allow installation of coil sensor and freezestats.

I. Rooftop unit shall be provided with a pipe chase to enclose field piping and valves.

1. Pipe chase shall be sized to accommodate all chilled water and hot water pipes and shall be no less than 5 feet deep.

2. Pipe chase shall be of double wall construction and have 2 access doors.

J. Damper Section

1. Rooftop unit shall be supplied with a damper segment to provide a means of providing fresh air to the rooftop unit.

    a. The outside air segment shall consist of multi-leaf, parallel acting ultra low leak blades.
    b. The outside air dampers shall be sized for 100 percent of unit airflow.
    c. A weatherproof louver and bird screen assembly shall protect the outside air dampers from the elements.
        i. The outside air dampers shall be furnished with the rooftop units. Dampers in the damper segment shall be ultra low leakage dampers with a leakage rate not to exceed 3.0 CFM/Ft5 @ 1-inch w.g. Dampers blades shall be airfoil type with extended vinyl edge seals and stainless steel jamb seamless. Dampers blades shall be parallel acting. Actuators shall be provided and installed by the ATC Contractor.

K. Rooftop units shall be supplied with a demount segment to allow for a unit split for shipping or installation purposes.

L. Rooftop unit shall be supplied, with the manufacturer's standard curb, shipped loose for field installation prior to unit placement.

1. Roof curb shall be a prefabricated galvanized steel-mounting curb.

2. Roof curb shall be a perimeter type with a complete perimeter support of the air handling unit.

3. The curb shall be a minimum of 18 inches high.

4. Gasketing shall be provided for field mounting between the unit base and the roof curb.

5. The curb shall include a 2-inch x 4-inch wood nailer.

6. The roof curb shall be insulated with 2-inch thick 3 pcf insulation.

7. The roof curb shall be sloped to accommodate installation on a sloped surface where required.

M. Finishes

1. Rooftop unit shall be painted prior to shipment.

a. The exterior of the unit shall be completely cleaned prior to application of finished coats.
b. A prime coat of two component epoxy wash shall be applied to the unit.
c. A finish coat of machine acrylic polyurethane shall be applied to a minimum thickness of 2.5 mills. Color selection by Architect.
d. The finished unit shall exceed 500 hour salt spray solution (5 percent) without any sign of red rust when tested in accordance with ASTM B-117.

N. Installation

1. Install rooftop units where shown, in accordance with equipment manufacturer's written instructions, and with recognized industry practices, to ensure that units comply with requirements and serve intended purposed.

2.31. EXTERIOR EQUIPMENT/DUCT SUPPORT

A. Exterior Equipment Supports shall be Pate Model ES suitable for roof construction. Equipment supports shall be constructed of 18 gauge galvanized steel, unitized construction with integral base plate, continuous welded corner seams, pressure treated wood nailer counterflasing and lag screws. Units shall be internally reinforced. Minimum height shall be 12-inches above the finished roof or as shown on the detail(s) on the drawing(s).

2.32. EXTERIOR PIPE ROLLER SUPPORTS

A. Furnish and install pipe roller supports for all exterior piping as indicated on contract drawings. Pipe roller supports shall be constructed of heavy gauge galvanized steel, continuous welded corner seams, 2 x 4 treated wood nailer, heavy gauge galvanized steel counterflashing with galvanized steel channel track attached.

B. Roller assembly shall consist of galvanized steel channel track, galvanized steel fittings, washers, nuts, and painted cast iron roller. Installation shall permit both vertical and horizontal adjustment. Units shall be Pate Model RAC, RTS, or approved equal.

2.33. ROOF CURBS (DUCT PENETRATIONS)

A. Furnish and install roof curbs at all penetrations of roof by ductwork and where indicated on contract drawings. Roof curbs shall be Model PC as manufactured by Pate, Greenheck, or approved equal.

B. Roof curbs shall be constructed of heavy gauge galvanized steel, unitized, full material corners, all seams welded, 1 ½ -inch thick rigid fiberglass insulation, pressure treated wood nailer strip. Curbs shall be minimum 12-inch height unless otherwise noted and have inner diameter equal to indicated duct diameter.

2.34. SINGLE ZONE VAV ROOFTOP AIR HANDLING UNITS (SZVAV-1, 2, 3, 4, 5 & 6)

A. Provide and install single zone VAV Roof Top Unit(s) as shown on contract drawings. RTU's shall be Venmar, Aaon, Valent, Daikin, Addison, JCI/York, or approved equal.

1. Roof Top Unit(s) shall be as manufactured by Aaon or approved equal provided all specifications are met. Aaon Model RN equipment is used as the basis of design. Units shall be listed per UL 1812 and bear the UL label. Performance to be as scheduled on plans. Return discharge and outside air intake shall not be located on the same side on rooftop units.

2. Unit shall be of internal frame type construction of galvanized steel. All frame and panel shall be G90 galvanized steel. Where top panels are joined there shall be a standing seam to insure positive weather protection. All metal-to-metal surfaces shall be sealed, requiring no caulking at job site. Unit base to be designed for roof mounting.

3. Unit casing to be insulated with minimum thermal resistance R-value of 13. Foam insulation shall have minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D-1929 for minimum flash ignition temperature of 610 degrees Fahrenheit. Insulation in accordance with NFPA 90A and tested to meet UL 181 erosion requirements and secured to unit with water proof adhesive and permanent mechanical fasteners.

4. All components shall be easily accessible through removable hinged doors for both return fan, supply fan, filter, coil components, energy wheel, and damper compartments.

5. All piping within the unit enclosure shall be insulated with insulation type,

thickness and jacketing as specified in Division 23 Section, HVAC Insulation.

6. Furnish and install motor bearing protective rings at all variable frequency drive motors. Refer to Division 23 Section, Common Work Results for HVAC.

B. Fans

1. Fans shall be direct drive unhoused, backward curved plenum fans. All blower wheels shall be statically and dynamically balanced. Ground and polished steel fan shafts shall be mounted in permanently sealed ball bearing pillow blocks. Bearings shall be selected for a minimum life in excess of 200,000 hours at maximum cataloged operating speeds. Blowers shall enable independent balancing of exhaust and supply airflow with adjustable sheaves for motors 10 horse power and below. Fans shall be located in draw-through position in referenced to the energy recovery wheel. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be inverter duty premium efficiency. Furnish units with extended lube lines with grease plugs.

2. All internal electrical components shall be pre-wired for single point power connection. All electrical components shall be UL listed, approved or classified where applicable and wired in compliance with the National Electrical Code. The control center shall include a weatherproof disconnect switch, motor starters, variable frequency drives, control circuit fusing, control transformer for 24 VAC circuit and motor starters. Motor starters shall consist of a contactor and Class 20 adjustable overload protection and shall be provided for all motors in the unit.

3. Roof Top Unit housings shall be factory primed and painted in color as selected by Architect.

4. Return air stream shall be filtered prior to cooling coil. Furnish and install 30 percent pleated filters (Farr 30/30 or approved equal), filter racks and access panels. Provide one (1) set of additional filter media to Owner for each unit.

5. Unit shall include 1 inch aluminum mesh pre-filters upstream of outside air opening.

6. Unit shall include 2 inch thick, pleated panel outside air and return air filters with an ASHRAE efficiency of 30% and MERV rating of 8, upstream of the wheels.

7. Furnish relief air outlet and outside air inlet with hoods provided with bird screens and sound lining.

8. Unit shall be provided with 120 volt convenience receptacle. Wiring shall be provided under Division 26.

C. Coils

1. Chilled water and hot water coils shall be furnished to meet the performance requirements set forth in the schedule. All coils shall have performance certified in accordance with ARI Standard 410. Coils shall be arranged in the unit for horizontal air flow and selected for a maximum face velocity as scheduled.

Install coils such that headers and return bends are enclosed by unit casings.

2. Coil casing shall be constructed of heavy gauge galvanized metal with aluminum die-formed corrugated fins and guide channels to create turbulent wiping behind the tubes. The fins shall have drawn collars, be belled and mechanically expanded to firmly bound the cooper tubes to the fins. All coils shall be installed on tracks for easy removal from the rooftop air handling unit.

3. Drainable water coils shall be designed to operate at 250 psig design working pressure and up to 300 degrees F and shall be tested with 325 psig compressed air under water. Circuiting shall provide free draining and venting when installed, counter flow of air and water with water velocities not to exceed seven feet per second and without exceeding the water pressure drops scheduled. All coils must have same end connections regardless of the number of rows deep. Clearly label supply and return headers on outside of units such that direction of coil water flow is counter to direction of unit airflow.

4. Construct coils of configuration plate fins and seamless tubes. Fins shall have collars drawn, belled and firmly bonded to tubes by means of mechanical expansion of tubes. Do not use soldering or tinning in bonding process.

5. Construction coil casings of Galvanized G90-U Steel with formed end supports and top and bottom channels. If two or more coils are stacked in unit, install intermediate drain channels between coils to drain condensate to main drain pans without flooding lower coils or passing condensate through airstream.

6. Coil grommets shall be provided on all coils to completely seal the area between the coil connection and the unit casing.

7. Control valves shall be furnished by ATC subcontractor and installed by the mechanical contractor.

8. Unit shall dehumidify using a chilled water and hot water coil control valves and an electronic controller. A factory-wired, field installed, supply air temperature sensor and a field-installed space humidity sensor shall be provided to control the amount of reheat. The supply air temperature set point shall be adjusted on the electronic controller within the controls compartment.

9. Furnish each unit with an insulated, stainless steel IAQ drain pan under the coil extending past the coil to ensure condensate retention.

D. Outside Air/Economizer

1. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 15 CFM of leakage per sq. ft. of damper area when subjected to 2 inches w.g. air pressure differential across the damper. Damper assembly shall be controlled by spring return sensible temperature activated fully modulating actuator. Unit shall include outside air opening bird screen, sound lined outside air hood with rain

lip.

2. Economizer shall be furnished with return air CO2 override.

3. During economizer mode the energy recovery wheel shall be bypassed.

E. Energy Recovery Section:

1. Unit shall contain a factory mounted and tested energy recovery wheel(s). The energy recovery wheel(s) shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.

2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.

3. Wheels shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop-to-efficiency ratios. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.

4. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

5. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.

6. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.

7. Energy recovery wheel cassette shall carry a 5 year non-prorated warranty.

8. Hinged service access door shall allow access to the wheel(s).

9. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer

and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.

10. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contacts for field indication of wheel rotation. Interlock energy recovery wheel rotation detector sensor with ATC system.

F. Extra Materials:

1. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

   a. Filters: Furnish one set of each type of filter.
   b. Belts: Furnish one set of belts for each belt drive including energy recovery wheel in rooftop unit.

G. Roof Curb, Plenum Base, and Service Platform

1. An insulated, pre-fabricated roof curb shall be provided and shipped knocked down. The roof curb will be made of 16-gauge galvanized steel with 4" flanges, minimum 14" high with a factory installed 2" x 3" wood nailer strip. Curbs shall be fully insulated with 1 ½ inch thick rigid insulation with duct adapters.

2. Electrical shall enter unit concealed within roof curb. All piping within the unit enclosure shall be insulated with insulation type, thickness, and jacketing as specified in Division 23 Section, HVAC Insulation.

3. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least ½ inch in height around the opening. Unit shall be provided with insulated plenum base for side ductwork connections.

4. Service Platform:

   a. Furnish and install service platform to match unit size and plenum curb. Service platform shall be as manufactured by Curb Technologies or approved equal. Service platform shall be shipped fully welded for bolting onto the curb. Material shall be steel, primed, and painted gray. Hand rails shall be 1-1/4” schedule 40 galvanized steel pipe and shall be fully removable. Furnish with ladders and safety chains.

H. Demand Control Ventilation Components:

1. RTU shall be equipped with demand control ventilation capabilities that enable the varying of outdoor air and return air volumes based on building occupancy. A sensor shall be located in the exhaust air stream and in the space to monitor average CO2 levels of the occupied spaces. A variable frequency drive shall

receive a 0-10 volt signal from the CO2 senosr and control the outdoor air volume to maintain a maximum of 1,000 ppm of CO2 in the occupied space. Supply air and return air fans shall be controlled simultaneously to maintain desired building pressure. Variable frequency drive shall be pre-programmed at the factory and shall assure that minimum outdoor air and return air volumes are always maintained. The sensor and variable frequency drive shall be factory mounted and wired.

2. Furnish each rooftop air handling unit with the following:

a. Supply air fan variable frequency drive.
b. Return air fan variable frequency drive.

I. Controls

1. All controls shall be provided and filed installed by the automatic temperature control contractor.

J. Electrical

1. Unit shall be provided with standard power block for connecting power to the unit.

2. Unit shall be provided with factory installed and factory wired, fused disconnect switch.

3. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 10% out of balance on the voltage, the voltage is more than 10% under design voltage, or on phase reversal.

4. Unit shall be provided with manual reset low temperature limit controls which shut off the unit when the discharge temperature reaches a field adjustable setpoint.

K. Rooftop unit shall be provided with a pipe chase to enclose field piping and valves.

1. Pipe chase shall be sized to accommodate all chilled water and hot water pipes and no less than 5 feet deep.

2. Pipe chase shall be of double wall construction and have 2 access doors.

2.35. SINGLE ZONE VAV ROOFTOP HEATING AND VENTILATING UNITS WITH ENERGY RECOVERY WHEEL, HOT WATER HEATING COIL, VARIABLE SPEED SUPPLY FAN, AND VARIABLE SPEED RETURN FANS (H&V-9)

A. Provide and install single zone VAV Roof Top Heating and Ventilating Unit(s) as shown on contract drawings. RTU's shall be Venmar, Aaon, Valent, Daikin, Addison, JCI/York, or approved equal.

1. Roof Top Unit(s) shall be as manufactured by Venmar or approved equal provided all specifications are met. Venmar equipment is used as the basis of

design. Units shall be listed per UL 1812 and bear the UL label. Performance to be as scheduled on plans. Return discharge and outside air intake shall not be located on the same side on rooftop units.

2. Unit shall be of internal frame type construction of galvanized steel. All frame and panel shall be G90 galvanized steel. Where top panels are joined there shall be a standing seam to insure positive weather protection. All metal-to-metal surfaces shall be sealed, requiring no caulking at job site. Unit base to be designed for roof mounting.

3. Unit casing to be insulated with minimum thermal resistance R-value of 13. Foam insulation shall have minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D-1929 for minimum flash ignition temperature of 610 degrees Fahrenheit. Insulation in accordance with NFPA 90A and tested to meet UL 181 erosion requirements and secured to unit with water proof adhesive and permanent mechanical fasteners.

4. All components shall be easily accessible through removable hinged doors for both return fan, supply fan, filter, coil components, energy wheel, and damper compartments.

5. All piping within the unit enclosure shall be insulated with insulation type, thickness and jacketing as specified in Division 23 Section, HVAC Insulation.

6. Furnish and install motor bearing protective rings at all variable frequency drive motors. Refer to Division 23 Section, Common Work Results for HVAC.

B. Fans

1. Fans shall be direct drive unhoused, backward curved plenum fans. All blower wheels shall be statically and dynamically balanced. Ground and polished steel fan shafts shall be mounted in permanently sealed ball bearing pillow blocks. Bearings shall be selected for a minimum life in excess of 200,000 hours at maximum cataloged operating speeds. Blowers shall enable independent balancing of exhaust and supply airflow with adjustable sheaves for motors 10 horse power and below. Fans shall be located in draw-through position in referenced to the energy recovery wheel. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be inverter duty premium efficiency. Furnish units with extended lube lines with grease plugs.

2. All internal electrical components shall be pre-wired for single point power connection. All electrical components shall be UL listed, approved or classified where applicable and wired in compliance with the National Electrical Code. The control center shall include a weatherproof disconnect switch, motor starters, variable frequency drives, control circuit fusing, control transformer for 24 VAC circuit and motor starters. Motor starters shall consist of a contactor and Class 20 adjustable overload protection and shall be provided for all motors in the unit.

3. Roof Top Unit housings shall be factory primed and painted in color as selected by Architect.

4. Return air stream shall be filtered prior to cooling coil. Furnish and install 30 percent pleated filters (Farr 30/30 or approved equal), filter racks and access panels. Provide one (1) set of additional filter media to Owner for each unit.

5. Unit shall include 1 inch aluminum mesh pre-filters upstream of outside air opening.

6. Unit shall include 2 inch thick, pleated panel outside air and return air filters with an ASHRAE efficiency of 30% and MERV rating of 8, upstream of the wheels.

7. Furnish relief air outlet and outside air inlet with hoods provided with bird screens and sound lining.

8. Unit shall be provided with 120 volt convenience receptacle. Wiring shall be provided under Division 26.

C. Coils

1. Hot water coils shall be furnished to meet the performance requirements set forth in the schedule. All coils shall have performance certified in accordance with ARI Standard 410. Coils shall be arranged in the unit for horizontal air flow and selected for a maximum face velocity as scheduled. Install coils such that headers and return bends are enclosed by unit casings.

2. Coil casing shall be constructed of heavy gauge galvanized metal with aluminum die-formed corrugated fins and guide channels to create turbulent wiping behind the tubes. The fins shall have drawn collars, be belled and mechanically expanded to firmly bound the cooper tubes to the fins. All coils shall be installed on tracks for easy removal from the rooftop air handling unit.

3. Drainable water coils shall be designed to operate at 250 psig design working pressure and up to 300 degrees F and shall be tested with 325 psig compressed air under water. Circuiting shall provide free draining and venting when installed, counter flow of air and water with water velocities not to exceed seven feet per second and without exceeding the water pressure drops scheduled. All coils must have same end connections regardless of the number of rows deep. Clearly label supply and return headers on outside of units such that direction of coil water flow is counter to direction of unit airflow.

4. Construct coils of configuration plate fins and seamless tubes. Fins shall have collars drawn, belled and firmly bonded to tubes by means of mechanical expansion of tubes. Do not use soldering or tinning in bonding process.

5. Construction coil casings of Galvanized G90-U Steel with formed end supports and top and bottom channels. If two or more coils are stacked in unit, install intermediate drain channels between coils to drain condensate to main drain pans without flooding lower coils or passing condensate through airstream.

6. Coil grommets shall be provided on all coils to completely seal the area between the coil connection and the unit casing.

7. Control valves shall be furnished by ATC subcontractor and installed by the mechanical contractor.

D. Outside Air/Economizer

1. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 15 CFM of leakage per sq. ft. of damper area when subjected to 2 inches w.g. air pressure differential across the damper. Damper assembly shall be controlled by spring return sensible temperature activated fully modulating actuator. Unit shall include outside air opening bird screen, sound lined outside air hood with rain lip.

2. Economizer shall be furnished with return air CO2 override.

3. During economizer mode the energy recovery wheel shall be bypassed.

E. Energy Recovery Section:

1. Unit shall contain a factory mounted and tested energy recovery wheel(s). The energy recovery wheel(s) shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.

2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.

3. Wheels shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop-to-efficiency ratios. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.

4. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

5. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.

6. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the

cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.

7. Energy recovery wheel cassette shall carry a 5 year non-prorated warranty.

8. Hinged service access door shall allow access to the wheel(s).

9. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.

10. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contacts for field indication of wheel rotation. Interlock energy recovery wheel rotation detector sensor with ATC system.

F. Extra Materials:

1. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

   a. Filters: Furnish one set of each type of filter.
   b. Belts: Furnish one set of belts for each belt drive including energy recovery wheel in rooftop unit.

G. Roof Curb, Plenum Base, and Service Platform

1. An insulated, pre-fabricated roof curb shall be provided and shipped knocked down. The roof curb will be made of 16-gauge galvanized steel with 4" flanges, minimum 14" high with a factory installed 2" x 3" wood nailer strip. Curbs shall be fully insulated with 1 ½ inch thick rigid insulation with duct adapters.

2. Electrical shall enter unit concealed within roof curb. All piping within the unit enclosure shall be insulated with insulation type, thickness, and jacketing as specified in Division 23 Section, HVAC Insulation.

3. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least ½ inch in height around the opening. Unit shall be provided with insulated plenum base for side ductwork connections.

4. Service Platform:

a. Furnish and install service platform to match unit size and plenum curb. Service platform shall be as manufactured by Curb Technologies or approved equal. Service platform shall be shipped fully welded for bolting onto the curb. Material shall be steel, primed, and painted gray. Hand rails shall be 1-1/4" schedule 40 galvanized steel pipe and shall be fully removable. Furnish with ladders and safety chains.

H. Demand Control Ventilation Components:

1. RTU shall be equipped with demand control ventilation capabilities that enable the varying of outdoor air and return air volumes based on building occupancy. A sensor shall be located in the exhaust air stream and in the space to monitor average CO2 levels of the occupied spaces. A variable frequency drive shall receive a 0-10 volt signal from the CO2 senosr and control the outdoor air volume to maintain a maximum of 1,000 ppm of CO2 in the occupied space. Supply air and return air fans shall be controlled simultaneously to maintain desired building pressure. Variable frequency drive shall be pre-programmed at the factory and shall assure that minimum outdoor air and return air volumes are always maintained. The sensor and variable frequency drive shall be factory mounted and wired.

2. Furnish each rooftop air handling unit with the following:

a. Supply air fan variable frequency drive.
b. Return air fan variable frequency drive.

I. Controls

1. All controls shall be provided and field installed by the automatic temperature control contractor.

J. Electrical

1. Unit shall be provided with standard power block for connecting power to the unit.

2. Unit shall be provided with factory installed and factory wired, fused disconnect switch.

3. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 10% out of balance on the voltage, the voltage is more than 10% under design voltage, or on phase reversal.

4. Unit shall be provided with manual reset low temperature limit controls which shut off the unit when the discharge temperature reaches a field adjustable setpoint.

K. Rooftop unit shall be provided with a pipe chase to enclose field piping and valves.

1. Pipe chase shall be sized to accommodate all chilled water and hot water pipes and shall be no less than 5 feet deep.

2. Pipe chase shall be of double wall construction and have 2 access doors.

2.36. SINGLE ZONE VAV ROOFTOP AIR HANDLING UNITS WITH ECONOMIZER (RTU-1 & 2)

A. Provide and install single zone VAV Roof Top Unit(s) as shown on contract drawings. RTU's shall be Venmar, Aaon, Valent, Daikin, Addison, JCI/York, or approved equal.

1. Roof Top Unit(s) shall be as manufactured by Venmar or approved equal provided all specifications are met. Venmar equipment is used as the basis of design. Units shall be listed per UL 1812 and bear the UL label. Performance to be as scheduled on plans. Return discharge and outside air intake shall not be located on the same side on rooftop units.

2. Unit shall be of internal frame type construction of galvanized steel. All frame and panel shall be G90 galvanized steel. Where top panels are joined there shall be a standing seam to insure positive weather protection. All metal-to-metal surfaces shall be sealed, requiring no caulking at job site. Unit base to be designed for roof mounting.

3. Unit casing to be insulated with minimum thermal resistance R-value of 13. Foam insulation shall have minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D-1929 for minimum flash ignition temperature of 610 degrees Fahrenheit. Insulation in accordance with NFPA 90A and tested to meet UL 181 erosion requirements and secured to unit with water proof adhesive and permanent mechanical fasteners.

4. All components shall be easily accessible through removable hinged doors for both return fan, supply fan, filter, coil components, energy wheel, and damper compartments.

5. All piping within the unit enclosure shall be insulated with insulation type, thickness and jacketing as specified in Division 23 Section, HVAC Insulation.

6. Furnish and install motor bearing protective rings at all variable frequency drive motors. Refer to Division 23 Section, Common Work Results for HVAC.

B. Fans

1. Fans shall be direct drive unhoused, backward curved plenum fans. All blower wheels shall be statically and dynamically balanced. Ground and polished steel fan shafts shall be mounted in permanently sealed ball bearing pillow blocks. Bearings shall be selected for a minimum life in excess of 200,000 hours at maximum cataloged operating speeds. Blowers shall enable independent balancing of exhaust and supply airflow with adjustable sheaves for motors 10 horse power and below. Fans shall be located in draw-through position in referenced to the energy recovery wheel. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be inverter duty premium efficiency. Furnish units with extended lube lines with grease plugs.

2. All internal electrical components shall be pre-wired for single point power

connection. All electrical components shall be UL listed, approved or classified where applicable and wired in compliance with the National Electrical Code. The control center shall include a weatherproof disconnect switch, motor starters, variable frequency drives, control circuit fusing, control transformer for 24 VAC circuit and motor starters. Motor starters shall consist of a contactor and Class 20 adjustable overload protection and shall be provided for all motors in the unit.

3. Roof Top Unit housings shall be factory primed and painted in color as selected by Architect.

4. Return air stream shall be filtered prior to cooling coil. Furnish and install 30 percent pleated filters (Farr 30/30 or approved equal), filter racks and access panels. Provide one (1) set of additional filter media to Owner for each unit.

5. Unit shall include 1 inch aluminum mesh pre-filters upstream of outside air opening.

6. Unit shall include 2 inch thick, pleated panel outside air and return air filters with an ASHRAE MERV rating of 13.

7. Furnish outside air inlet with hoods provided with bird screens and sound lining.

8. Unit shall be provided with 120 volt convenience receptacle. Wiring shall be provided under Division 26.

C. Coils

1. Chilled water and hot water coils shall be furnished to meet the performance requirements set forth in the schedule. All coils shall have performance certified in accordance with ARI Standard 410. Coils shall be arranged in the unit for horizontal air flow and selected for a maximum face velocity as scheduled. Install coils such that headers and return bends are enclosed by unit casings.

2. Coil casing shall be constructed of heavy gauge galvanized metal with aluminum die-formed corrugated fins and guide channels to create turbulent wiping behind the tubes. The fins shall have drawn collars, be belled and mechanically expanded to firmly bound the cooper tubes to the fins. All coils shall be installed on tracks for easy removal from the rooftop air handling unit.

3. Drainable water coils shall be designed to operate at 250 psig design working pressure and up to 300 degrees F and shall be tested with 325 psig compressed air under water. Circuiting shall provide free draining and venting when installed, counter flow of air and water with water velocities not to exceed seven feet per second and without exceeding the water pressure drops scheduled. All coils must have same end connections regardless of the number of rows deep. Clearly label supply and return headers on outside of units such that direction of coil water flow is counter to direction of unit airflow.

4. Construct coils of configuration plate fins and seamless tubes. Fins shall have collars drawn, belled and firmly bonded to tubes by means of mechanical expansion of tubes. Do not use soldering or tinning in bonding process.

5. Construction coil casings of Galvanized G90-U Steel with formed end supports and top and bottom channels. If two or more coils are stacked in unit, install intermediate drain channels between coils to drain condensate to main drain pans without flooding lower coils or passing condensate through airstream.

6. Coil grommets shall be provided on all coils to completely seal the area between the coil connection and the unit casing.

7. Control valves shall be furnished by ATC subcontractor and installed by the mechanical contractor.

8. Furnish each unit with an insulated, stainless steel IAQ drain pan under the coil extending past the coil to ensure condensate retention.

D. Economizer

1. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 15 CFM of leakage per sq. ft. of damper area when subjected to 2 inches w.g. air pressure differential across the damper. Damper assembly shall be controlled by spring return sensible temperature activated fully modulating actuator. Unit shall include outside air opening bird screen, sound lined outside air hood with rain lip.

2. Minimum outside air shall be provided to the spaces by a separate ERV unit.

E. Extra Materials:

1. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

   a. Filters: Furnish one set of each type of filter.
   b. Belts: Furnish one set of belts for each belt drive.

F. Roof Curb

1. An insulated, pre-fabricated roof curb shall be provided and shipped knocked down. The roof curb will be made of 16-gauge galvanized steel with 4" flanges, minimum 14" high with a factory installed 2" x 3" wood nailer strip. Curbs shall be fully insulated with 1 ½ inch thick rigid insulation with duct adapters.

2. Electrical and piping shall enter unit concealed within roof curb. All piping within the unit enclosure shall be insulated with insulation type, thickness, and jacketing as specified in Division 23 Section, HVAC Insulation.

3. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least ½ inch in height around the opening. Unit shall be provided with insulated plenum base for

side ductwork connections.

G. Demand Control Ventilation Components:

1. Furnish each rooftop air handling unit with the following:

a. Supply air fan variable frequency drive.
b. Outside air economizer damper.
c. Return air damper.

H. Controls:

1. All controls shall be provided and field installed by the ATC subcontractor.

I. Electrical

1. Unit shall be provided with standard power block for connecting power to the unit.

2. Unit shall be provided with factory installed and factory wired, fused disconnect switch.

3. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 10% out of balance on the voltage, the voltage is more than 10% under design voltage, or on phase reversal.

J. Rooftop unit shall be provided with a pipe chase to enclose field piping and valves.

1. Pipe chase shall be sized to accommodate all chilled water and hot water pipes and shall be no less than 5 feet deep.

2. Pipe chase shall be of double wall construction and have 2 access doors.

2.37. WATER TREATMENT SERVICES

A. Complete chemical water treatment service shall be provided by an organization regularly engaged in water treatment, ARC, Inc., RCCO Corp., Aquatel Ind., Inc., Mogul Corp., Oilin, Inc., HVAC Services, Inc., Feedwater Treatment Systems, Inc., Eco-Lab, Kurita, or approved equal. The service shall provide all equipment, chemicals and labor necessary to prevent corrosion, inhibit scale build-up and minimize organic growth for a period of 2 years starting from building acceptance. Service visits for the purpose of adding chemicals to feeding equipment, regulating bleed-off, inspecting and adjusting water treatment equipment, and obtaining samples of laboratory analysis shall be performed at monthly intervals for closed systems and every two weeks for open systems during the entire guarantee period. Chemicals shall not be injurious to water side equipment and construction materials. Records of all injurious to water side equipment and construction materials. Records of all service visits, chemical additions, laboratory tests, etc., shall be maintained and shall be provided to owner after each visit during guarantee period. Instruct mechanical contractor in field on piping and wiring of chemical feeding equipment.

B. Systems to be protected shall include chilled water system and hot water heating system. Services shall include flushing and cleaning of piping systems specified under Division 23 Section, "HVAC Piping, Fittings, and Valves" section, furnishing and installing all chemical treatment equipment and accessories to perform the water treatment specified below. Maintain complete records of the treatment program for each system.

C. Contractor shall perform an analysis of the building water supply as a basis of the chemical treatment. Contractor shall provide the Owner with written instructions for chemical feeding bleed-off, blowdown control and testing procedures, provide all required chemicals, filters and testing during the guarantee period, and provide all required test kits.

D. Contractor shall maintain the following conditions in each system:

SYSTEMS	Chiller Water System	Hot Water System
ph	8.0 to 10.5	7.0 to 10.0
Inhibitor for Scale & Corrosion Cycles	---	---
Cycles*	---	---
Organic Growth	---	---
Buffered Nitrate	550 ppm	1000 ppm to 180 degrees F 2000 ppm to 180 degrees F
Chromate (Low)		
Molybdate	30 to 50 ppm	100 to 150 ppm
Sulfite	---	---
Sodium Nitrite	500 to 1000 PPM	1000 to 1500 PPM
Corrosion Inhibitor	50 to 100 PPM (as Molybdate) or 1000 to 1500 PPm sodium Nitrite	100 to 150 (as Molybdate)
*Actual cycles of concentration to be determined from analysis of make-up water.		
Use Inhibited antifreeze supplied by Manufacturer		

E. Chemical Feeding Equipment: Provide chemical feeding equipment, as specified below, to introduce chemicals into each system only when the system is operating.

1. Closed Recirculating Systems

a. Five (5) gallon steel by-pass feeder installed across circulating pump suction and discharge lines, with tank and piping insulated using the same thickness and type of insulation as provided for the piping system. Provide filter. Unit shall contain quick opening cap and shall be suitable for working pressure of 175 psig. Tank shall be primed and finished in baked enamel paint.

2. Replace bypass feeder filter monthly during the entire 2-year warranty period.

F. Boilers shall be boiled out with an alkaline type boiling out compound to remove grease, oil, mill scale and other foreign matter. The compound should be used at the rate of 1-1/2 pounds per 20 boiler horsepower. After boiling out period, the boilers should be completely drained, flushed, refilled with fresh water and vented. All water treatment chemicals shall comply with Delaware Water Resources laws and regulations.

G. Closed Recirculating Systems shall be filled and sufficient detergent and dispersant added to remove all dirt, oil, and grease. System shall be circulated for at least 48 hours after which a drain valve at the lowest point shall be opened and allowed to bleed while the system continues to circulate. The automatic make-up valve shall be checked to be sure it is operating. Bleeding shall continue until water runs clear and all detergent is removed. A sample of water shall be tested and if PH exceeds the PH of the make-up water, flushing shall be resumed. After chemical cleaning is satisfactorily complete, open the inlet and outlet valves to each coil and close the bypass valves. Also, clean all strainers.

H. Where glycol is specified or used, additional corrosion inhibitors should not be added without consulting the glycol manufacturer. The boilers shall be fired, maintaining a slow, rolling boil and preventing steam pressure from building during the process, while the surface of the water is continuously skimmed to remove impurities, the boiler manufacturer's recommended procedure shall be followed.

I. Before adding cleaned chemicals to the closed system, all coils should be isolated by closing the inlet and outlet valves by opening the bypass valves. Also clean all strainers.

2.38. ENERGY RECOVERY VENTILATORS (INDOOR TYPE) (ERV-3, 6 & 9)

A. Provide and install ERV's (Energy Recovery Ventilators) as shown on contract drawings. ERV's shall be Model EnergyPack as manufactured by Venmar, Aaon, Innovent, McQuay-Vision, Venmar, Petra, or approved equal.

1. Energy Recovery Ventilator shall be as manufactured by Venmar or approved equal provided all specifications are met. Venmar Model EnergyPack equipment is used as the basis of design. Units shall be listed per UL 1812 and bear the UL label. Energy transfer ratings shall be in accordance with ASHRAE Standard 84 and ARI 1060. Wheels shall be ARI 1060 certified. Performance to be as scheduled on plans. Exhaust discharge and outside air intake shall not be located

on the same side.

2. Unit shall be of internal frame type construction of galvanized steel. All frame and panel shall be G90 galvanized steel. Where top panels are joined there shall be a standing seam to insure positive weather protection. All metal-to-metal surfaces shall be sealed, requiring no caulking at job site. Unit base to be designed for interior mounting.

3. Unit casing to be insulated with minimum 2 in - 3 lb. fiber-glass with Foil-Scrim-Kraft facing. Insulation in accordance with NFPA 90A and tested to meet UL 181 erosion requirements and secured to unit with water proof adhesive and permanent mechanical fasteners.

4. Wheel shall be of the enthalpy type for both sensible and latent heat recovery and be designed to insure laminar flow. Efficiency ratings shall be based on tests conducted in accordance with ASHRAE 84 and laminar flow. Efficiency ratings shall be based on tests conducted in accordance with ASHRAE 84 and ARI 1060 standards. Desiccant shall be silica gel for maximum a latent energy transfer. Wheel shall be constructed of light weight polymer or aluminum media to minimize shaft and bearing loads. Polymer or aluminum media shall be mounted in a stainless steel rotor for corrosion resistance. Wheel design shall consist of removable segments for ease of service and/or cleaning. Segments shall be removable without the use of tools. Silica gel desiccant shall be permanently bonded to wheel media to retain latent heat capability after cleaning. Energy recovery device shall transfer moisture entirely in the vapor phase.

5. All components shall be easily accessible through removable hinged doors for both exhaust fan, supply fan, filter and damper compartments. Energy recovery wheels (smaller than 54 in.) shall be mounted in a slide-out track for ease of inspection, removal and cleaning.

6. Energy recovery device shall be provided with a rotation sensor for the enthalpy wheel. The rotation sensor shall be an inductive proximity motion detector. The rotation sensor shall be interlocked with ATC system to provide rotation status of enthalpy wheel.

B. Energy Recovery Ventilators

1. Centrifugal blowers shall be backward inclined and housed in a scroll to maximize fan efficiency. Fans shall be AMCA certified for air performance. All blower wheels shall be statically and dynamically balanced. Ground and polished steel fan shafts shall be mounted in permanently sealed ball bearing pillow blocks. Bearings shall be selected for a minimum (L10) life in excess of 100,000 hours at maximum cataloged operating speeds. Blowers shall enable independent balancing of exhaust and supply airflow with adjustable sheaves for motors 10 horse power and below. Fans shall be located in draw-through position in referenced to the energy recovery wheel.

2. Motors shall be energy efficient, inverter duty complying with EPACT standards, for variable speed ODP and TE enclosures. Motors shall be permanently lubricated, heavy duty type, matched to the fan load and furnished at the

specified voltage, phase and enclosure. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be fully machined cast. Energy wheel motors shall have integral overload protection.

3. All internal electrical components shall be pre-wired for single point power connection. All electrical components shall be UL listed, approved or classified where applicable and wired in compliance with the National Electrical Code. The control center shall include a weatherproof fused disconnect switch, variable speed drives, control circuit fusing, control transformer for 24 VAC circuit and motor starters.

4. Chilled water and hot water coils shall be factory tested and rated in accordance with ARI 410. Coils shall have copper tubes with permanently expanded aluminum fins, 12 fins per inch or less.

5. Dehumidifier heat pipe shall precool the air leaving the wheel and reheat the air leaving the cooling coil in a wrap-around configuration. Both heat exchangers shall be inside and integral to the equipment cabinet. Coils shall have copper tubes with permanently expanded aluminum fins, 12 fins per inch or less. Heat transfer fluid shall be classified as Safety Group A1 in BDR/ASHRAE Std. 15-1989R.

6. Energy recovery ventilators housings shall be factory primed and painted in color as selected by Architect.

7. Both the supply and exhaust air streams shall be filtered to protect the enthalpy wheel. Furnish and install MERV 13 pleated filters, filter racks and access panels. Provide one (1) set of additional filter media to Owner for each unit.

8. Exhaust and outside air intakes shall be provided with birdscreens and shall be sound lined.

9. Furnish and install ERV wheel rotation sensor.

10. Refer to Division 23 Section, “Common Work Results for HVAC” for VFD motor bearing protective rings.

C. Demand Control Ventilation Components:

1. Energy recovery ventilator fans shall be controlled by a variable frequency drive, as manufactured by Yaskawa or approved equal. Outdoor air and exhaust air fans shall be controlled simultaneously to maintain desired building pressure. Variable frequency drive shall be pre-programmed at the factory and shall assure that minimum outdoor air and exhaust air volumes are always maintained. The variable frequency drive shall be factory mounted in the unit cabinet and wired.

2. Energy recovery ventilator shall be equipped with demand control ventilation capabilities that enable the varying of outdoor air and exhaust air volumes based on building occupancy. A sensor shall be located in the exhaust air stream to monitor average CO2 levels of the occupied spaces. A variable frequency drive shall receive a 0-10 volt signal from the CO2 sensor and control the outdoor air

volume to maintain a maximum of 1,000 ppm of CO2 in the occupied space. Outdoor air and exhaust air fans shall be controlled simultaneously to maintain desired building pressure. Variable frequency drive shall be pre-programmed at the factory and shall assure that minimum outdoor air and exhaust air volumes are always maintained. The sensor and variable frequency drive shall be factory mounted and wired. Additional space CO2 sensors shall be required (refer to plans for quantity and location) and interlocked with ERV and demand controlled ventilation.

3. Furnish each energy recovery ventilator with the following:

   a. Supply air fan variable frequency drive.
   b. Exhaust air fan variable frequency drive.
   c. Protective circuits.
   d. All motor operated dampers and actuators.
   e. Outside air flow monitoring stations.
   f. All other unit and space sensors/control, control wiring shall be furnished under Division 23 Section “Instrumentation and Controls for HVAC and Plumbing Systems”.

4. The CO2 sensors shall modulate air flow rates from minimum to maximum based on CO2 measurement and reset schedule. Coordinate with ATC Subcontractor.

D. Extra Materials:

1. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

2. Filters: Furnish one set of each type of filter.

3. Fan Belts: Furnish one set of link type belts for each belt drive fan in energy recovery ventilator.

4. Wheel Belts: Furnish one set of belts for each belt driven energy wheel.

E. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.

1. Network Communications Ports: Ethernet and RS-422/485.

2. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet; protocols accessible via the communications ports.

2.39. ENERGY RECOVERY VENTILATORS (ROOFTOP TYPE) (ERV-1, 2, 4, 5, 7 & 8)

A. Provide and install ERV's (Energy Recovery Ventilators) as shown on contract drawings. ERV's shall be as manufactured by Venmar, Aaon, Daikin, Addison, JCI/York, or approved equal.

1. Energy Recovery Ventilator shall be Model Energy Pack as manufactured by Venmar or approved equal provided all specifications are met. Venmar equipment is used as the basis of design. Units shall be listed per UL 1812 and bear the UL label. Energy transfer ratings shall be in accordance with ASHRAE Standard 84 and ARI 1060. Wheels shall be ARI 1060 certified. Performance to be as scheduled on plans. Exhaust discharge and outside air intake shall not be located on the same side of the rooftop units.

B. Factory Testing and Quality Control

1. Standard Factory Tests: Units shall be factory run tested to ensure proper functioning of components. Fans shall be factory run tested to ensure structural integrity and proper rpm and shall be statically and dynamically balanced for continuous operation at the maximum rated fan speed and motor horsepower in accordance with AMCA 204. All electrical circuits shall be tested to ensure correct operation before shipment of unit. Units shall pass quality control and be thoroughly cleaned prior to shipment.

C. Unit Construction Description

1. General: Provide factory fabricated Air Handling Units with capacity as indicated on the schedule. The units consist of factory assembled components as shown on drawings, including but not limited to fan and motor assemblies, energy recovery device(s), all necessary dampers, hoods (outdoor units only), plenums, filters, drain pans, wiring, controls and other accessories as outlined in the schedule, enclosed in a single or multiple piece casing as shown on the mechanical drawings. Units shall be stand alone controlled, except where noted, with all control devices provided and wired for single-point power connection by the Manufacturer unless otherwise outlined in the schedule. Units shall have overall dimensions as indicated and fit into the space available with adequate clearance for service as determined by the Engineer. Tags and decals to aid in service or indicate caution areas shall be provided. Electrical wiring diagrams and Installation, Operation and Maintenance Instructions Manual shall be attached to the control panel access doors within each unit. Units shall be UL or ETL listed. Units shall be shipped in one piece or shall be split for shipment to accommodate freight as required, as shown on mechanical drawings.

2. Unit Base and Floor: Unit perimeter base shall be completely welded and constructed from (6” [152 mm]) structural tubing and shall accommodate curb or concrete pad installation as shown on drawings. Unit base floor shall be constructed from four-break formed steel panels, made from 14 gauge hot rolled steel (HRS). Floor panels shall be welded to each other, creating I-beams at each floor panel junction. Floor panel junctions shall be located at 14” increments (maximum) or less, in order to provide floor rigidity and support as required for internal components. Unit floor panels shall be welded to perimeter base frame steel tubing. Unit floor shall be insulated from underneath with 3”, R20 polyurethane closed cell spray foam and protected with 24 gauge galvanized steel liners. Unit floor construction shall include two-stage thermal break, using gasket between base floor framing and liners underneath and floor membrane on top. Unit base and floor shall be factory covered with top coat industrial grade membrane to ensure air- and water-tightness as well as walk-on grip. Floor

membrane shall be high performance, sprayed, plural-component pure polyurea elastomer, based on amine-terminated polyether resins, amine chain extenders and prepolymers. Floor membrane shall be flexible, tough, resilient monolithic membrane with good water and chemical resistance and shall resist to temperatures up to 250°F. Floor membrane materials shall be free of solvents and VOC's, shall be suitable for use in compartments handling conditioned air and shall comply with the requirements for the Standard for Heating and Cooling Equipment, ANSI/UL 1995, third edition, dated 02/18/2005, Section 5.10 and Section 18. Single wall floor construction with glued and pined insulation and no subfloor is not acceptable; non-insulated floor construction is not acceptable. Entire base frame is to be painted with a phenolic coating for long term corrosion resistance. Base frame shall be attached to the unit casing frame at the factory. When rigging, base frame deflection shall be less than 1/360 of the unit length. All major components shall be supported by the base without sagging or pulsating.

3. Rigging Provision – Single Piece Units: The unit base frame shall include lifting lugs located at the corner of the unit (and along the sides as required by design) and sized to allow rigging and handling of the units. Rigging shall be performed using all lifting lugs at all times and in strict accordance with the instructions provided within the Installation, Operation and Maintenance Instructions Manual. Lifting lugs may be removed after rigging; however, bolts shall be set back in place after lug removal.

4. Rigging Provision – Multiple Piece Units: Units shipped in multiple sections shall be engineered for field assembly. The unit section base frame shall include lifting lugs located at the corner of the unit (and along the sides as required by design) and sized to allow rigging and handling of the units. Rigging shall be performed using all lifting lugs at all times and in strict accordance with the instructions provided within the Installation, Operation and Maintenance Instructions Manual. Peripheral lifting lugs may be removed after rigging; however, bolts shall be set back in place after lug removal. Lifting lugs located along a section side corresponding to a unit section split shall be removed without bolts being set back in place afterwards. Units shall be provided with all necessary gaskets, caulking, hardware and instruction for assembly on site by Installing Contractor. Compression points shall be provided at the base frame, along the sides at 18" increments and at the top for aligning and joining section splits.

5. Unit Casing: Unit wall and roof rigid frame shall consist of 16 gauge pre-painted galvanized formed steel corner posts and 16 gauge G90 galvanized formed steel (1" x 2") intermediate frame posts, providing stable construction allowing for removal of any panel without affecting unit structural integrity. Exterior casing panels shall be attached to the gasketed (1" x 2") steel frame with corrosion resistant fasteners. Air Handling Unit casing shall be of the no-through-metal design. Casing shall incorporate insulating thermal breaks as required so that, when fully assembled, there is no path of continuous unbroken metal to metal conduction from inner to outer surfaces. Provide necessary support to limit casing deflection to L/200 of the narrowest panel dimension. If panels cannot meet this deflection, additional internal reinforcing is required. Units shall be

designed for outdoor or indoor installation as indicated on the schedule. Indoor units weatherized for outdoor use are not acceptable. Outdoor units shall have a double sloped roof with 3% minimum roof pitch to prevent water accumulation, rain gutters above all access doors and roof joint seams of the T-shape construction, with minimum height of 1", metal strip sealed and encapsulated. Outdoor units shall be designed to resist snow, ice and wind loads, and if provided with weather hood(s), equipped with birdscreen and rain gutters. Indoor units shall have a flat roof. Hoods shall be shipped loose for field assembly. Internal partition on dual air tunnel units shall be insulated and constructed in the same manner and thickness as the unit cabinet outer liners. All panel seams shall be caulked and sealed for an air-tight unit. AHU exterior casing envelope shall be suitable to attain a maximum air leakage rate equal to 1.0% of design CFM when unit is operating at design static pressure.

Unit outside surfaces shall be made of pre-painted steel unless otherwise specified. All galvanized steel surfaces requiring paint shall be made of satincoat finished galvanized steel of the specified gauge(s). All galvanized steel surfaces without any paint shall be made of galvanized steel of the specified gauge(s).

a. Options:

i. Corrosion resistant exterior paint finish complete with one coat of air dried epoxy paint, which shall withstand 1,000 hours of salt spray as per ASTM B-117.
ii. Color selection shall be by the Architect.

6. Double Wall Construction: Units shall entirely be made of double wall construction. Single wall construction with coated insulation is not acceptable. Exposed insulation edges in the airstream are not acceptable. Unit panels shall be made of 18 gauge galvanized steel outer liners and 24 gauge galvanized steel inner liners.

7. Insulation: Unit wall and roof panels shall be insulated with 3" thick, R12.5, 1.5 lb./cu. ft. non-compressed fiberglass insulation. Unit internal partition (dual air tunnel units) shall be insulated with 2" thick, R8.3, 1.5 lb./cu. ft. non-compressed fiberglass insulation. Insulation shall meet the erosion requirements of UL 181 facing the airstream and fire hazard classification of 25/50 (per ASTM-84 and UL 723 and CAN/ULC S102-M88). All insulation edges shall be encapsulated within the panels. All perforated sections shall have insulation with black acrylic coating.

8. Access Doors: Full size access door(s) allowing for periodic maintenance and inspections shall be provided for all serviceable components as shown on the plans. Removable panels are not acceptable. Doors shall be solid double wall insulated construction. Insulation shall be the same as unit panels. Both the inner and outer liners shall be made of the same material as unit cabinet outer liner construction. The door hinge assembly shall be die cast zinc with stainless steel pivot mechanism, completely adjustable. Hinges shall allow doors to open at 180° with no shear effect on the hinge side of the perimeter gasket. The door frame shall be extruded aluminum with a built-in thermal break barrier and full perimeter gasket. The door gasketting shall employ a double seal comprising of

an adhesive neoprene compressible foam gasket on the outer door panel and an "automotive style" neoprene bulb gasket fixed onto the inner door frame for out-swing doors, "rippled" foam for in-swing doors. There shall be a minimum of two heavy duty cast, UV rated, nylon handles per door. Door handles shall be operable from both inside and outside of the unit. On all access doors where moving parts could cause injury, an ETL, UL 1995 and OSHA approved tool operated safety latch shall be provided.

Note: If Manufacturer cannot provide thermal break door design it must be noted as an exception on the bid.

a. Options:

i. Doors shall open against pressure.
ii. Access doors all sections shall be equipped with hold-open device.
iii. Access doors all sections shall be equipped with handle inter-linkage system to be able to open each door by operating only one handle.

9. Condensate/Drain Pans: IAQ style drain pans shall be provided as shown on the drawings. Drain pans shall be fabricated from 18 gauge stainless steel, except under coils, where drain pans shall be fabricated from 14 gauge stainless steel. All drain connections shall be piped and trapped for proper drainage. Drain pans shall be sloped at a minimum of 1.5% with a threaded drain pipe connection ending through the side of structural base frame. Drain pipe shall be schedule 40, 1¼" nominal, MPT stainless steel pipe. All drain pan corners shall be welded.

10. Enthalpy Wheel Heat Exchanger:

a. Quality Assurance

i. The wheel shall bear the AHRI 1060 Certified label. Wheels tested in independent laboratories, whether according to AHRI Standard 1060 or not, are not acceptable unless actually certified by AHRI. Wheel Manufacturer membership in AHRI is not an acceptable substitute for AHRI Certified™ performance.
ii. The energy recovery wheel shall be a UR recognized component and bear the UR label.
iii. The energy recovery wheel shall comply with the requirements of UL 723. The media shall have flame spread index (SPI) of less than 25 and a smoke developed index (SDI) of less than 50 when rated in accordance with ASTM E84.
iv. The energy recovery wheel shall comply with the IBC Certification and OSHPD Seismic Qualifications.

b. Performances – Effectiveness, Pressure Drop, Exhaust Air Transfer Ratio (EATR) and Outdoor Air Correction Factor (OACF)

i. Sensible, latent and total effectiveness along with pressure drop, EATR and OACF ratings, shall be clearly documented in the

AHRI 1060 Certified Directory (http://www.ahridirectory.org/ahridirectory).

ii. To reduce fan operating costs, the energy recovery wheel shall not exceed an OACF of 1.15 for rotors up to 70" and 1.08 for rotors up to 120" at 5" w.c. pressure differential when no purge is used. The result shall be clearly shown in the AHRI 1060 Directory.

c. Rotor Media and Desiccant

i. The rotor media shall be made of 2 mils minimum thickness aluminum. The media shall be coated to prohibit corrosion and shall be suitable for seacoast applications. Non-metallic substrates made from paper, plastic, synthetic or glass fiber media are not acceptable.
ii. All surfaces shall be coated with a non-migrating desiccant specifically developed for water transfer in vapor phase. Etched or oxidized surfaces are not acceptable.
iii. Desiccant must be a polymer hygroscopic or 3 angstroms molecular sieve (3A).
iv. Desiccant shall be bactericide and non-corrosive.
v. The rotor shall be constructed of equal width, alternate layers of corrugated and flat aluminum sheet material to create a flat and smooth surface and ensure laminar flow thus preventing any dust or particle accumulation inside the rotor.
vi. Corrugation pattern shall be of closed triangular shape to prevent any cross leakage between airstreams. Open type corrugation or embossments, since they increase fan operating costs, are not acceptable.
vii. Dry particles up to 800 microns shall freely pass through the media to minimize air pressure drops and prefiltering requirements.
viii. Furnish spare rotor belt.

d. Seals

i. The rotor shall be supplied with AirLoop™ labyrinth seal facing the media, polymer contact seal along the depth of the wheel and S-type labyrinth seal along the wheel's periphery. Wheels using less effective seals like brush seals or standard 4 pass labyrinth seals are not acceptable.
ii. The AirLoop labyrinth seals shall be installed with no gap between the seal and media. Labyrinth seals that require an installation gap or seals that will damage the media if they come in contact with it are not acceptable.
iii. All seals shall be designed to withstand pressure differentials of up to 10" w.c.
iv. The AirLoop labyrinth seals shall be factory adjusted. Field adjustments shall be possible using common tools.

e. Options:

i. Wheel shall be segmented to allow removal in pieces.
ii. Wheel shall be provided with a field adjustable purge section.

11. Heat Pipe Heat Exchanger: Energy transfer ratings shall be AHRI Certified to Standard 1060 and bear the AHRI certification seal for AHRI Air-to-Air Energy Recovery Ventilation Equipment Program based on AHRI 1060. Ratings in accordance with AHRI 1060 without certification are not acceptable. Heat exchanger shall be tested in accordance with ASHRAE 84-91. Heat pipe shall transfer heat between airstreams in a counter flow configuration. Core shall be 1" ID seamless, integrally finned aluminum 1,350 tube with a 0.166" minimum wall thickness. The maximum center-to-center spacing shall be 2-1/8" for tubes and 1-7/8" for rows. Fins shall be extruded from and integral with the tube wall and shall have a 0.017" minimum fin thickness. Fin density shall be 11 per inch. Fin surface from the root to the tip of the fin should have a minimum of 0.437" between fin heights. Expanded and or wrapped fin and tube design construction is not acceptable. Tube shall have an integral internal circumferential capillary wick structure. Capillary structure shall not interfere with tube wall integrity. Tubes shall be individually processed, charged with refrigerant, hermetically sealed and factory tested. Heat pipe frame shall be fabricated from galvanized steel. Intermediate tube supports shall be furnished if required. A partition made from galvanized steel shall isolate the two airstreams and not allow cross-contamination. End covers made of galvanized steel shall be provided to protect tube ends. A drain pan shall be provided in the exhaust section for condensate collection.

a. Options:

i. Heat pipe shall be coated with heresite corrosion resistant coating on supply and exhaust sides.
ii. Drain pans shall be provided on each side of the heat pipe for condensate collection or servicing.

12. Unit Fans: Fan assemblies shall be designed for heavy duty industrial applications. All fans shall meet the airflow performance specified and shall not exceed the break horsepower or sound power levels specified on the mechanical equipment schedule. Fan performance shall be based on testing and be in accordance with AMCA 210 for performance and AMCA 300 for sound. Fans shall be selected for stable operation, at least 20% under the first critical speed of the fan, with a steep pressure/volume curve. Fan shaft shall be turned, ground and polished solid steel, finished off with a corrosion resistant coating and rated at maximum rpm below critical speed. Fan wheel and sheaves shall be keyed to the shaft. Fan drives shall be designed for a 1.3 service factor. Pulleys shall be factory mounted with final alignment and belt adjustment completed before unit start-up. Motor (driver) and fan (driven) pulleys shall be of fixed pitch. Bearings shall be heavy duty, grease lubricated, self-aligning ball or pillow block type, selected for a minimum average bearing life (L-50) in excess of 200,000 hours at maximum operating speed in accordance with AFBMA 9 Standards. Inlet cones shall be precision spun or die formed. Inlet cones shall be aerodynamically matched to the wheel side plate to provide streamlined airflow in the wheel and ensure full loading of the blades. Fan and motor assemblies shall be mounted

inside the unit casing, on a base equipped with 1" deflection spring vibration isolators and supplied with flexible connections. Fans shall be balanced per ANSI/AMCA 204-96 fan application category BV-3 using a digital signal analyzer at the design rpm with belts and drives in place to a vibration velocity less than or equal to 0.157" per second measured horizontal and vertical at each bearing pad. Vibration amplitudes are in inches per second-Peak. All values are filter-in at the fan speed. Removable shipping restraints shall be provided to protect the fan, motor and base during shipment.

a. Plug Fan (PF) SWSI Fans

i. Fan shall be single width single inlet arrangement 3 plenum fan. Fan blades shall be hollow airfoil in shape, welded to the center and wheel side plates. Fan bearings shall be heavy duty type. Rigid support for the inlet bearing must be removable for access to the wheel. Inlet cone shall be precision spun.

b. Motors shall be invertor duty rated, heavy duty, constructed to NEMA Standard MG 1, general purpose, continuous duty, Design B. Temperature rating shall be 122°F, maximum temperature rise at 104°F [40°C] ambient for continuous duty at full load (Class B Insulation). Motors shall be T-frame mounted on an adjustable steel base that allows for belt alignment and tensioning, within the unit casing. All motors shall be tested to IEEE Standard 112 test method B and rated per NEMA MG1, Part 31 "Inverter Fed Motors". Motor bearings shall be ball or roller type with inner and outer shaft seals, grease lubricated and designed to resist thrust loading where belt or other drives produce lateral or axial thrust in motors. All motors shall be specifically designed to meet or exceed all EPAct requirements for energy efficiency and include Class F insulation. Motor shall be of minimum size as indicated in the equipment schedule, 1,800 rpm, open drip proof (ODP) and have a 1.15 service factor. Motor torque shall efficiently accelerate the drive loads. Unless indicated, motor shall not operate in the service factor range.

c. Provide shaft grounding rings for all variable frequency drive motors.

d. Variable Frequency Drives (VFDs)

i. Each variable air volume supply and exhaust air fan shall be provided with separate variable frequency drives with bypass. Drives shall be factory mounted with adequate ventilation provided. The variable frequency drive shall convert input voltage (with +/−10% tolerance), three-phase, 60 Hz (+/−2 Hz.) utility power to adjustable voltage/frequency, three-phase, A–C power step less motor control from 5% to 105% of base speed. The variable frequency drive shall produce an adjustable A–C voltage/frequency output of complete motor speed control and an input power factor near unity over the entire speed range. The VFD shall be automatically controlled by a control signal. The VFD shall be self-contained, totally enclosed in a NEMA 1

ventilated cabinet and capable of operation between 0°C and 40°C. The VFD shall be UL listed. Components used in all options shall be UL listed. The VFD shall have a hand/off/auto operator switch, drive switch with run or stop command and panel mounted digital display capable of indicating unit status, frequency and fault diagnostics. Variable frequency drives shall comply with all requirements specified under Part 2 "Variable Speed Drives" of this specification section.

e. Fan assemblies shall be provided with the following options:

i. Fan drives shall be equipped with adjustable motor sheaves.
ii. Extended lubrication lines with copper tubing mounted on the fan assembly access side.
iii. One spare set of fan belts.
iv. Motors shall be premium efficiency.
v. Motors shall be inverter duty rated.

13. Chilled Water and Hot Water Coils – General Information: Coils shall be submerged in water and tested to a minimum dry air/nitrogen pressure of 300 psig standard copper tube coils. Coils shall display a tag with the Inspector's identification as proof of testing. Tubes shall have a nominal thickness of 0.020" unless otherwise specified. Fins shall be made of 0.0075" thick aluminum unless otherwise specified. Tubing, return bends and headers shall be made of seamless UNS 12200 copper meeting ASTM B75 and ASTM B251 Standards. Coil return headers shall be equipped with factory installed 1.2" FPT air vent connections placed at the highest point available on the face of the header (except for evaporator coils). Casings and endplates shall be made of 16 gauge galvanized steel, meeting ASTM A527 Standard unless otherwise noted. Double flanged casings on the top and bottom of finned height shall be provided to allow for coil stacking. Piping, control valve and valve operator shall be supplied and installed by others.

14. Hydronic Coils: Hydronic coils shall be designed to withstand 250 psig maximum operating pressure and a maximum water temperature of 300°F for standard duty copper tube coils. Standard construction fluid MPT connections shall be made from red brass meeting ASTM B43 Standard or Schedule-40 steel pipe as a minimum. Provide intermediate drain pans on all stacked cooling coils. The intermediate pan shall drain to the main drain pan through a copper downspout.

Fins shall be made of 0.0075" thick aluminum and mechanically bonded to copper tubes.

15. Filters: Provide filters of the type indicated on the schedule. Factory fabricated filter sections shall be of the same construction and finish as the unit. Outside and exhaust air inlets shall be equipped with galvanized steel racks that permit filter slide out removal (side access) for units equal or less than 78" tall and universal holding frames with upstream access (face loading) for units taller than 78". Face loaded pre and final filters shall have Type 8 frames as manufactured by AAF, FARR or equal. Side service filter sections shall include hinged access doors.

Internal blank-offs shall be provided by the air unit Manufacturer as required to prevent air bypass around the filters. The filters shall be as manufactured by Farr, Purolator, AAF or equal. Filters shall be in compliance with ANSI/UL 900: Test Performance of Air Filters. Filter air velocity shall not exceed 500 fpm through each filter bank. Units shall be equipped, to a minimum, with 2" thick, MERV 13 pleated filters.

a. High Efficiency Rigid Filters

i. Filters shall be 12" deep high performance, pleated, totally rigid and totally disposable type. Each filter shall consist of high density glass fiber media, media support grid, contour stabilizers and enclosing frame. Filter media shall be laminated to a non-woven synthetic backing to form a lofted filter blanket. The filter media shall have an average efficiency of 85% (MERV 13). The media support shall be a metal grid with an effective open area of not less than 96%. The metal grid shall be bonded to the filter media to eliminate the possibility of media oscillation and media pull-away. The metal grid shall be formed in such a manner that it affects a tapered radial pleat design. The grid shall be designed to support the media both vertically and horizontally. Filters shall be listed Class II under UL Standard 900. Filters shall be tested per ASHRAE Standard 52.1-76. Contour stabilizers shall be permanently installed on both entering air and exit airsides of the filter media pack to ensure that the tapered radial pleat configuration is maintained throughout the life of the filter. The filter shall be capable of withstanding a 10" w.g. pressure drop without noticeable distortion of the media pack. The enclosing frame shall be constructed of galvanized steel. It shall be constructed and assembled in such a manner that a rigid and durable enclosure for the filter pack is affected. The periphery of the filter pack shall be continuously bonded to the inside of the enclosing frame, thus eliminating the possibility of air bypass. The enclosing frame shall be equipped with protective diagonal support members on both the entering air and air exit sides of the filters.

16. Dampers: Unit shall be equipped with all necessary dampers required for the system as shown on the mechanical drawings. Dampers shall be designed for operating temperatures between −40°F and 212°F. Air leakage through a 48" x 48 damper shall not exceed 10.3 cfm/sq. ft. against 4" w.g. differential static pressure at standard air condition. Standard air leakage data to be rated in accordance with AMCA certified rating program. Outside air dampers shall be opposed blade motorized and exhaust air dampers shall be parallel blade motorized type. For other dampers, see Manufacturer's recommendations. Damper actuators drive voltage shall be with 24 VAC for 2 position or 0–10V for modulation. Flat or formed metal blades are not acceptable.

Damper construction shall be as follows: damper frame shall be of extruded aluminum or galvanized steel; damper blades shall be of extruded aluminum;

dampers shall be of opposed blade type or parallel blades where indicated; damper blade ends shall be sealed with neoprene edge seals with bottom and top blade wiper seals.

a. Provide the following:

i. Outside air damper (motorized, spring return)
ii. Exhaust air damper (motorized, spring return)

17. Rain Hoods: Rain hoods shall be fabricated from same material as unit casing with ¼" wire mesh inlet screen. Hoods sized to minimize moisture carry over and shall be same color as unit.

18. Roofcurbs: Roofcurb shall be supplied by the unit Manufacturer for field assembly. Manufacturer's curb shall be standard double wall, 18" height, 2" thick fiberglass insulation. Curb shall consist of formed 18 gauge galvanized steel sections.

a. Options:

i. Pitch roofcurb shall match building roof.
ii. Curb can be provided with wood nailor.
iii. Curb shall be arranged so all hydronic pipes enter unit within roof curb to protect the same from freezing.

D. Electrical Power and Controls

1. All wiring and electrical connections shall be of copper wires, copper bus bars and copper fittings throughout. Power supply terminals shall be identified with permanent markers.

2. All high voltage wiring conduit shall consist of flexible metal conduit. All low voltage and signal wiring shall consist of Belden cable.

a. All high and low voltage wiring shall be run in Liquidtite flexible metal conduit.

3. When unit section splits are present, low voltage wiring shall be split using quick connectors for quick and easy field installation. Additionally, for each set of quick connector, the male branch in one unit section and the corresponding female branch in the next unit section shall be identified with the use of a color coded or numbered label. At each high voltage line split, a junction box shall be provided in one of the sections; the wiring in the section where the junction box is located and the matching wiring in the next section shall be identified with the use of a color coded or numbered label.

4. The unit shall feature a mounted permanent nameplate displaying, at a minimum, the Manufacturer, serial number, model number, date of manufacture and current and voltage readings. The unit must have an ETL or UL Listing and bear the appropriate mark.

5. A recessed integral electrical control compartment shall be furnished on the end of the unit. The compartment shall be constructed to NEMA 3R requirements for outdoor units, provided with a hinged access door and a locking device. All components, except those not mounted directly in the unit, shall be factory mounted and wired to a labeled terminal strip. All components shall be identified using printed self-adhesive labels, consistent with the numbering used in the wiring diagrams. Control components shall include, but are not limited to, single-point connection power distribution block, sub and control circuit fuses or circuit breakers, control transformers, motor starters and overloads for single-speed operation. The control system shall be factory mounted in the control compartment and shall be a stand alone microprocessor-based Direct Digital Control system, with necessary sensors and interfaces to monitor and operate all functions as outlined in the equipment/control schedule, flow schematic, sequence or required for complete unit operation. A unit mounted intelligent programmable interface device shall be included for communication, display and setpoint control. Control panel compartment heaters and thermostats or cooling fans with grilles or registers shall be provided if control panel components cannot be protected from their minimum or maximum ambient temperature ratings. For automatic unit start-up an external dry contact must be provided by others (ex: building management system (BMS), BACnet, time clock, etc.). The DDC controller shall be factory programmed and factory run tested prior to shipment to verify functions and logic.

6. A flow schematic with sensor and component identification and location, interlocks and sequence of operation shall be included with submittals.

7. A wiring schematic and a bill of materials shall be completed in ladder/logic format, with component labeling according to line numbers, once a release for production has been received. The wiring schematic, bill of materials and flow schematic shall be included within the units control compartment.

8. The unit shall be provided with fluid furnished and installed, Direct Digital Control system, including all provisions. All safety controls shall be manual reset.

9. The units shall be provided with the following features:

    a. Unit shall be provided with a fused disconnect or circuit breaker mounted within the control enclosure with a door interlocked handle (weatherproof) on the exterior.

        i. The unit Manufacturer shall provide a field start-up by a qualified Factory Technician (to be covered as part of the unit pricing from the Manufacturer).
        ii. The control system with necessary sensors and interfaces shall be field supplied, programmed, mounted, wired and run tested by the Control Contractor. The Control Contractor shall coordinate sensors, interfaces, mounting locations and logic with the unit Manufacturer. The control system shall be mounted in the control compartment.
        iii. Unit shall have a 120 VAC GFI receptacle for a separate 120

volt power supply. Electrical power wiring shall be provided by under Division 26.

iv. Fan motors shall have variable frequency drive with drive bypass and line reactors.

10. Provide factory wired, fused disconnect.

E. Demand Control Ventilation Components:

1. Energy recovery ventilator fans shall be controlled by a variable frequency drive, as manufactured by Yaskawa or approved equal. Outdoor air and exhaust air fans shall be controlled simultaneously to maintain desired building pressure. Variable frequency drive shall be pre-programmed at the factory and shall assure that minimum outdoor air and exhaust air volumes are always maintained. The variable frequency drive shall be factory mounted in the unit cabinet and wired.

2. Energy recovery ventilator shall be equipped with demand control ventilation capabilities that enable the varying of outdoor air and exhaust air volumes based on building occupancy. A sensor shall be located in the exhaust air stream to monitor average CO2 levels of the occupied spaces. A variable frequency drive shall receive a 0-10 volt signal from the CO2 sensor and control the outdoor air volume to maintain a maximum of 1,000 ppm of CO2 in the occupied space. Outdoor air and exhaust air fans shall be controlled simultaneously to maintain desired building pressure. Variable frequency drive shall be pre-programmed at the factory and shall assure that minimum outdoor air and exhaust air volumes are always maintained. The sensor and variable frequency drive shall be factory mounted and wired. Additional space CO2 sensors shall be required (refer to plans for quantity and location) and interlock with ERV and demand controlled ventilation.

3. Furnish each energy recovery ventilator with the following:

a. Supply air fan variable frequency drive.
b. Exhaust air fan variable frequency drive.
c. Phase loss protection.

4. The CO2 sensors shall modulate air flow rates in a linear fashion from minimum to maximum based on CO2 measurement and reset schedule. Coordinate with ATC Subcontractor.

F. Extra Materials:

1. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

2. Filters: Furnish one set of each type of filter.

3. Fan Belts: Furnish one set of link type belts for each belt drive fan in energy recovery ventilator.

4. Wheel Belts: Furnish one set of belts for each belt driven energy wheel.

G. BAS Interface: Field-installed hardware and software to enable the BAS to monitor, control, and display Variable Frequency Drives status and alarms. Allows VFD to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.

1. Network Communications Ports: Ethernet and RS-422/485.

2. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet; protocols accessible via the communications ports.

H. Rooftop unit shall be provided with a pipe chase to enclose field piping and valves.

1. Pipe chase shall be sized to accommodate all chilled water and hot water pipes and no less than 5 feet deep.

2. Pipe chase shall be of double wall construction and have 2 access doors.

I. Rooftop unit shall be provided with a pipe chase to enclose field piping and valves.

1. Pipe chase shall be sized to accommodate all chilled water and hot water pipes and shall be no less than 5 feet deep.

2. Pipe chase shall be of double wall construction and have 2 access doors.

2.40. HEATING AND VENTILATING UNITS, INDOOR TYPE WITH ENERGY RECOVERY WHEEL (H&V-1, 2, 3, 4, 5, 6 & 7)

A. Provide and install H & V units with integral energy recovery wheels as shown on contract drawings. H & V units with integral energy recovery wheels shall be Aaon Model H3, Venmar, Daikin, Addison, JCI/York, or approved equal.

1. Performance to be as scheduled on plans.

2. Unit shall be of internal frame type construction of galvanized steel. All frame and panel shall be G90 galvanized steel. Where top panels are joined there shall be a standing seam to insure positive weather protection. All metal-to-metal surfaces shall be sealed, requiring no caulking at job site. Unit base to be designed for mounting or an interior concrete housekeeping pad.

3. Unit casing to be insulated with minimum thermal resistance R-value of 13. Foam insulation shall have minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D-1929 for minimum flash ignition temperature of 610 degrees Fahrenheit. Insulation in accordance with NFPA 90A and tested to meet UL 181 erosion requirements and secured to unit with water proof adhesive and permanent mechanical fasteners.

4. All components shall be easily accessible through removable hinged doors for both return fan, supply fan, filter, refrigerant components, enthalpy wheel, cooling coil, heating coil, and damper compartments.

5. All piping within the unit enclosure shall be insulated with insulation type, thickness and jacketing as specified in Division 23 Section, "HVAC Insulation".

6. Furnish and install motor bearing protective rings at all variable frequency drive motors. Refer to Division 23 Section, "Common Work Results for HVAC".

B. Fans

1. Fans shall be direct drive unhoused, backward curved plenum fans. All blower wheels shall be statically and dynamically balanced. Ground and polished steel fan shafts shall be mounted in permanently sealed ball bearing pillow blocks. Bearings shall be selected for a minimum life in excess of 200,000 hours at maximum cataloged operating speeds. Blowers shall enable independent balancing of exhaust and supply airflow with adjustable sheaves for motors 10 horse power and below. Fans shall be located in draw-through position in referenced to the energy recovery wheel. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be inverter duty premium efficiency. Furnish units with extended lube lines with grease plugs.

2. All internal electrical components shall be pre-wired for single point power connection. All electrical components shall be UL listed, approved or classified where applicable and wired in compliance with the National Electrical Code. The control center shall include a disconnect switch, motor starters, variable frequency drives, control circuit fusing, control transformer for 24 VAC circuit and motor starters. Motor starters shall consist of a contactor and Class 20 adjustable overload protection and shall be provided for all motors in the unit.

3. Housings shall be factory primed and painted in color as selected by Architect.

4. Return air stream shall be filtered prior to coils. Furnish and install MERV-13 pleated filters, filter racks and access panels. Provide one (1) set of additional filter media to Owner for each unit.

5. Furnish and install filter housings with 2-inch thick filters on both air streams of the energy recovery wheel.

6. Unit shall include 2 inch thick, pleated panel outside air and return air filters with MERV rating of 13, upstream of the wheels.

7. Furnish relief air outlet and outside air inlet with flanged duct connections and field installed flexible duct connections.

8. Furnish and install energy recovery wheel bypass dampers.

C. Heating Water Heating Coil

1. Furnish each unit with an insulated, stainless steel IAQ drain pan under the coil extending past the coil to ensure condensate retention.

2. Coil shall be certified in accordance with AHRI Standard 410 and be hydrogen or helium leak tested.

3. Coil shall be designed and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.

4. Coil shall have half serpentine circuitry, 1 row and 12 fins per inch.

5. Coil shall have right hand external piping connections. Supply and return connections shall be sweat connection. Coil connections shall be labeled, extend beyond the unit casing, and be factory sealed on both the interior and exterior of the unit casing to minimize air leakage.

6. Control valves shall be field supplied and field installed.

7. Coils shall be located as indicated on Contract Documents.

D. Outside Air/Economizer

1. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 15 CFM of leakage per sq. ft. of damper area when subjected to 2 inches w.g. air pressure differential across the damper. Damper assembly shall be controlled by spring return sensible temperature activated fully modulating actuator.

2. Economizer shall be furnished with return air CO2 override.

3. During economizer mode the energy recovery wheel shall be bypassed.

E. Energy Recovery Section:

1. Unit shall contain a factory mounted and tested energy recovery wheel(s). The energy recovery wheel(s) shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.

2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.

3. Wheels shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop-to-efficiency ratios. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.

4. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel

shall be connected to the shaft by means of taper locks.

5. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.

6. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.

7. Energy recovery wheel cassette shall carry a 5 year non-prorated warranty.

8. Hinged service access door shall allow access to the wheel(s).

9. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.

10. Energy recovery wheel rotation detection sensors shall be provided under Division 23 Section, “Instrumentation and Controls of HVAC and Plumbing Systems”.

F. Extra Materials:

1. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

    a. Filters: Furnish one set of each type of filter.
    b. Belts: Furnish one set of belts for each belt drive including energy recovery wheel in unit.
    c. During flush out operation prior to opening, install a minimum MERV-8 filter in outside air and exhaust air filter housing.

G. Demand Control Ventilation Components:

1. Unit shall be equipped with demand control ventilation capabilities that enable the varying of outdoor air and return air volumes based on building occupancy. A sensor shall be located in the spaces to monitor average CO2 levels of the occupied spaces. A variable frequency drive shall receive a 0-10 volt signal from the CO2 sensors and control the outdoor air volume to maintain a maximum of

1,000 ppm of CO2 in the occupied space. Supply air and return air fans shall be controlled simultaneously. Variable frequency drive shall be pre-programmed at the factory and shall assure that minimum outdoor air and return air volumes are always maintained. The variable frequency drive shall be factory mounted and wired. CO2 sensors (space and outside air) shall be provided and interlocked by Division 23 Section, "Instrumentation and Controls of HVAC and Plumbing Systems".

2. Furnish each unit with the following:

   a. Supply air fan variable frequency drive.
   b. Return air fan variable frequency drive.
   c. Space temperature sensor shall be provided under Division 23 Section, "Instrumentation and Controls of HVAC and Plumbing Systems"
   d. Space humidity sensor shall be provided under Division 23 Section, "Instrumentation and Controls of HVAC and Plumbing Systems"
   e. All controls necessary for economizer operation.
   f. All motor operated dampers (outside air, relief air, economizer, ERV wheel bypass, and return).
   g. Outside air flow monitoring station and exhaust air flow monitoring station shall be furnished and installed by the contractor in the ductwork.

H. Air Flow Monitoring Station (Field Installed in Ductwork)

1. Install air flow monitoring station in outside air duct and exhaust duct to control O.A. damper and exhaust fan speed to match outside air flow rate with exhaust air flow rate.

I. Controls

1. All controls shall be provided and field installed by the ATC subcontractor.

J. Electrical

1. Unit shall be provided with standard power block for connecting power to the unit.

2. Unit shall be provided with factory installed and factory wired, fused disconnect switch.

3. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 10% out of balance on the voltage, the voltage is more than 10% under design voltage, or on phase reversal.

4. Unit shall be provided with manual reset low temperature limit controls which shut off the unit when the discharge temperature reaches a field adjustable setpoint.

K. Sequence of Operation

1. Refer to Division 23 Section, "Instrumentation and Controls of HVAC and

Plumbing Systems" for sequences of operation.

L. Warranty

1. Furnish unit with two (2) year parts and labor warranty.

2.41. HEATING AND VENTILATING UNIT, INDOOR TYPE (H&V UNIT #8)

A. Provide and install central station air handling units as shown and scheduled on the plans. The units shall be installed in a neat and workmanship like manner in strict accordance with specifications. Air Handling units shall be Trane IAQ Modular Climate Changers, JCI/York Airpack, Carrier, Daikin, Venmar, Addison, or approved Equal. Provide components as detailed on the contract drawings.

B. General

1. Central station air handling units shall be certified in accordance with the Air Conditioning and Refrigeration Institute (ARI) Standards 430 for Central Station Air Handling unit and 410 for coils.

2. Units shall be provided with nominal 1-inch deflection spring isolators, as required, or as recommended by the unit manufacturer.

3. The units shall be furnished complete with double wall insulated casings, centrifugal fans, coils as scheduled, insulated drain pan, motor, drive belt guard, and accessories as required. Coils shall not exceed specified face velocities.

4. Adequate space around all sides of the air handling unit shall be provided for proper service and maintenance.

5. All units shall be horizontal draw through medium pressure units. Construct casing section located upstream of supply fan for operation at a minimum 4 inches W.G. negative static pressure and downstream section for operation at a minimum of 6 inches water gauge positive static pressure.

6. All units shall be factory primed and finished in colors as selected by Engineer.

7. Provide unit mounting legs to support all sections of unit and raise unit for proper trapping. Unit mounting devices not constructed of galvanized steel shall be chemically cleaned, coated with rust inhibiting primer, and finished with rust inhibiting enamel. Contractor shall be responsible for all steel supports and hangers for hung units.

8. Fan discharge arrangements shall be coordinated with ductwork layout to minimize "system effect" per AMCA-Publication 201-90.

9. Provide 6-inch high unit mounting legs or base rail to support all sections of unit and raise unit for proper trapping. Unit mounting devices shall be galvanized steel and a minimum of 10 gauge. Unit mounting devices not constructed of galvanized steel shall be chemically cleaned, coated with rust inhibiting primer and finished with rust inhibiting enamel. Contractor shall be responsible for all

steel supports and hangers for hung unit.

10. All heating coil capacities shall be based on scheduled percentage of propylene glycol.

11. Fan motors shall be inverter duty rated when utilized with variable frequency drives.

C. Construction

1. Unit casing shall be constructed of minimum 18 gauge galvanized metal, formed and reinforced to provide a rigied assembly. Formed panels shall be removable to provide easy access to internal components. Each of the sectionalized modules and accessories shall be factory assembled. Removal of side panels shall not affect the structural integrity of the unit.

2. All exterior panels and structural frames shall be constructed of G90-U galvanized steel. Casings not constructed of G90-U galvanized steel, casings with welds on exterior surfaces, or casings with welds on interior surfaces the have burned through to exterior sufaces shall be chemically cleaned, coated with rust inhibiting primer, and finished with rust inhibiting enamel in order to prevent premature corrosion and microbial growth.

3. Seal and gasket all joints between exterior panels and strucutal frames with closed-cell foam gasketing for air seal and acoustical break.

4. Casing shall have full size removal access doors as shown on drawings. Access doors shall have 2-inch double wall construction. Provide automotive style neoprene gasketing around full perimeter of access doors to prevent air leakage. Provide “ventlock” style non-corrosive alloy latches operable from the inside or outside of unit. If access doors open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement.

5. Insulate casing sections with 2-inch thick 1 ½ pound per cubic foot density fiber glass insulation or equivalent. Provide double wall casing construction and encase insulation between solid exterior and double wall interior casing panels such that no insulation is exposed to airstream. Foil facing on insulation is not acceptable as alternate to double wall construction. Insulation shall comply with NFPA 90A.

6. Coils sections with two or more coils shall have a 4-inch spacer between each adjacent coil.

7. Fan sections with internally mounted motors shall be provided with a standard full size access door allowing easy access to the fan/motor assembly. Units with externally mounted motors shall be provided with an expanded metal belt guard with hole for tachometer.

D. Fans

1. Units shall be provided with double width double inlet, centrifugal-type wheels. Fans shall be Standard or Class II (as required by total static pressure) forward curved wheels or air foil type as scheduled. Every fan shall be rated in accordance with AMCA Standards and the fan section shall be certified in accordance with ARI Standard 430. Fan shafts shall be selected to operate well below the first critical speed and each shaft shall be factory coated after assembly with an anti-corrosion coating. After the pre-balanced fan is installed in the air handler the entire fan section shall be run to assure smooth and trouble free operation.

2. Fan bearings shall be self-aligning, pillow block or flanged-type regreasble ball bearings and shall be supplied for an average life (L50) or 200,000 hours. All bearings shall be factory-lubricated and equipped with standard hydraulic grease fittings and extended lube lines. Provide dust caps on all hydraulic grease fittings.

3. Mount fans on isolation bases. Internally mount motors on same isolation bases and internally isolate fans and motors with spring isolators. Install flexible canvas ducts between fan and casings to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A.

4. Fan section shall have full height, double wall, hinged, removable access doors for inspection and maintenance of internal components.

5. Weigh fan and motor assembly at AHU manufacturer's factory for isolator selection. Statically and dynamically balance fan section assemblies. Fan section assemblies include fan wheels, shafts, bearings, drives, belts, isolation bases and isolators. Allow isolators to free float when performing fan balance. Measure vibration at each fan shaft bearing in horizontal, vertical and axial directions. Balance at design RPM's as scheduled on drawings.

6. Furnish each unit with the following:

    a. Supply air fan variable frequency drive.
    b. Space temperature sensor shall be provided under Division 23 Section, "Instrumentation and Controls of HVAC and Plumbing Systems"
    c. All motor operated dampers (outside air, relief air, economizer, and return) shall be provided under Division 23 Section, "Instrumentation and Controls of HVAC and Plumbing Systems".
    d. Outside air flow monitoring station shall be furnished and installed by the contractor in the ductwork.

E. Air Flow Monitoring Station (Field Installed in Ductwork)

1. Install air flow monitoring station in outside air duct and exhaust duct to control O.A. damper.

F. Controls

1. All controls shall be provided and field installed by the ATC subcontractor.

G. Electrical

1. Unit shall be provided with standard power block for connecting power to the unit.

2. Unit shall be provided with factory installed and factory wired, fused disconnect switch.

3. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 10% out of balance on the voltage, the voltage is more than 10% under design voltage, or on phase reversal.

4. Unit shall be provided with manual reset low temperature limit controls which shut off the unit when the discharge temperature reaches a field adjustable setpoint.

H. Sequence of Operation

1. Refer to Division 23 Section, "Instrumentation and Controls of HVAC and Plumbing Systems" for sequences of operation.

I. Motors and Drives

1. Fan motors shall be externally mounted or as indicated on contract drawings. Air handling units with internal motors shall be provided with additional cooling capacity to compensate for motor heat added to airstream. Total cooling capacity, as scheduled, shall be increased by 2500 btuh per motor horsepower for units with internally mounted motors.

2. Units shall be provided with the motor efficiencies as specified in Division 23.

3. Motors shall be open NEMA Design B, rigid base, open drip proof, with Class B insulation.

4. Fan drives shall be selected for a 1.5 service factor and anti-static belts shall be furnished. One additional set of belts shall be provided for each air handling unit and delivered to the Owner's representative at the completion of the project.

5. Fan sections shall be equipped with double width double inlet, centrifugal type wheels.

6. Drives shall be variable pitch and suitable for adjustment within plus or minus 15 percent of specified RPM but not to exceed the maximum RPM of the unit.

J. Coils

1. Heating coils shall be furnished to meet the performance requirements set forth in the schedule. All coils shall have performance certified in accordance with ARI Standard 410. Coils shall be arranged in the unit for horizontal air flow and selected for a maximum face velocity as scheduled. Install coils such that headers and return bends are enclosed by unit casings. Low temperature coils

(40 degrees F EPT) shall be properly circulated to prevent laminar flow at part load conditions.

2. Coil casing shall be constructed of heavy gauge galvanized metal with aluminum die-formed corrugated fins and guide channels to create turbulent wiping behind the tube. The fins shall have drawn collars, be belled and mechanically expended to firmly bound the copper tube to the fins. All coils shall be installed on tracks for easy removal from the air handling unit.

3. Drainable water coils shall be designed to operate at 250 psig design working pressure and up to 300 degrees F and shall be tested with 325 psig compressed air under water. Circuiting shall provide free draining and venting when installed, counter flow of air and water with water velocities not to exceed seven feet per second and without exceeding the water pressure drops schedule. All coils must have same end connections regardless of the number of rows deep. Clearly label supply and return headers on outside of units such that direction of coil water flow is counter to direction of unit airflow.

4. Construct coils of configuration plate fins and seamless tubes. Fins shall have collars drawn, belled and firmly bonded to tubes by means of mechanical expansion of tubes. Do not use soldering or tinning in bonding process.

5. Construction coil casings of Galvanized G90-U Steel with formed end supports and top and bottom channels. If two or more coils are stacked in unit, install intermediate drain channels between coils to drain condensate to main drain pans without flooding lower coils or passing condensate through airstream.

6. Coil grommets shall be provided on all coils to completely seal the area between the coil connection and the unit casing.

K. Filters

1. Filters shall be nominal 2-inch standard size filters; MERV8 pleated media type. Filters shall be Farr, medium efficiency pleated type 30/30 with welded wire media support grid.

2. Provide one additional set of filter media for each air handling unit to be delivered to the Owner’s representative upon completion of the project.

L. Access Sections and Access Doors

1. Fully insulated, access sections shall be provided as indicated on the drawings. Sections provide a minimum of 18 inch accessible space with full-size access doors. Access for inspection and cleaning of the unit drain pan, coils, and fans sections shall be provided.

2. Access doors shall be provided in all sections as indicated on the drawings. Access doors shall be double wall construction.

3. Panels shall be fully removable to allow for a proper way to thoroughly clean panels of microbial growth and to access internal parts.

M. Filter/Mixing Box

1. Provide factory fabricated filter/mixing box section of the same construction and finish as unit casing. Filter/mixing box sections shall be filter guides, and full height double wall, hinged, removable access door for filter removal. Provide filter blockoffs as required to prevent air bypass around filters. Angle filters shall be accessible from either side with hinged access doors.

2. Outside air dampers shall be supplied by ATC contractor and install by mechanical contractor in adjacent ductwork. Damper blades shall be parallel acting and shall rotate in nylon bearings providing smooth action and requiring no lubrication. Dampers shall be sectionalized to limit blade length, prevent warpage and assure a tight closure. Actuators shall be provided and installed by the ATC contractor.

3. Provide field installed differential pressure gauge, two static pressure tips, vent valves, and red pointer flag and air filter gauge accessory package to measure filter resistance. Accuracy shall be 2 percent of full scale 0 to 1.0 inch w.g. range. Gauges shall be 2003 magnahelic by Dwyer Instruments or approved equal.

N. Blender/Air Mixer

1. Provide factory fabricated blender/air mixer to provide proper air mixing and distribution of the outside and return air streams. Provide proper spacing in the direction of air flow as recommended by the blender manufacturer.

O. Installation

1. Install make-up air units where shown, in accordance with equipment manufacturer's written instructions, and with recognized industry practices, to ensure that units comply with requirements and serve intended purposed.

P. Air Handling System Efficiency

1. Because it is important to the Owner to minimize the operating cost of equipment where applicable, the unit manufacturer's selected air handling unit shall not exceed the maximum cumulative break horsepower indicated on the plans.

Q. Fan-Section Source quality Control: the following factory tests are required:

1. Sound Power Level Ratings: Comply with AMCA 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data. Test fans according to AMCA 300, Reverberant Room Method for Sound Testing of Fans. Fans shall bear AMCA-certified sound rating seal.

2. Factory test fan performance for flow rate, pressure, power, air density, rotation speed, and efficiency. Establish ratings according to AMCA 210, Laboratory Methods of Testing Fans for Rating.

2.42. INDUSTRIAL AIR CLEANERS

A. Furnish and install industrial air cleaners of the size, capacity, and electrical characteristics as scheduled on the contract drawings. All components shall be U.L. Listed.

B. Each air cleaner shall be provided with a 3-speed selector switch. Air cleaner shall not function with switch in "OFF" position.

C. Fans shall have continuous heavy duty motor totally enclosed with automatic thermal overload switch and fuse.

D. Air cleaner cabinet shall be of 18 gauge galvanized steel and the finish shall be pearl white epoxy, baked on, and oil resistant.

E. A 3-way wrap-around pre-filter rated at 35% shall be utilized on all units. A 95% Bag filter shall be downstream of the pre-filter and upstream of fan as shown in the detail on the contract drawings.

F. Provide all units with a magnehelic gauge to indicate when filters need changing. Remote mount Magnahelic gauge in locations as determined by Owner.

G. All units shall be suspended from structure in space. Provide all hardware necessary for suspending unit from roof joist structure or wall bracket. Install speed selector switches and wire to units.

H. Units shall be as manufactured by Monoxivent Series 3011, Trion, Inc. Model M2500, or approved equal.

I. Provide unit with 6 foot cord and plug for 120 volt outlet.

2.43. ABOVE GROUND WASTE OIL AND AUTOMOTIVE ANTIFREEZE TANKS WITH DIKES

A. General

1. Provide complete above ground waste oil and anti-freeze tanks as detailed on the mechanical and plumbing drawings and as specified hereinafter. All materials shall be compatible for use with Automotive Antifreeze and automotive oil. Refer to details on the drawings.

2. The complete above ground waste oil tank shall be in accordance with the latest editions of NFPA Standards No. 30 and No. 31, EPA, BOCA, and all local regulations. All materials shall be UL listed for use with automotive waste oil and automotive antifreeze. Complete system shall comply with all requirements of COMAR 26.10.

3. The installing contractor shall have successfully completed manufacturer's training in aboveground waste oil/antifreeze systems for tanks, piping, and have experience in the installation of waste oil/antifreeze tanks; and meet the licensing requirements in the State.

B. Single-Wall Horizontal Steel Tanks with Dike for Waste Oil/Antifreeze Storage (Above Grade)

1. Waste oil/antifreeze storage tank: Furnish and install single wall above grade waste oil/antifreeze tanks of the size, diameter, type, quantity and capacity as indicated on the contract drawings. Tanks shall be of welded single wall Type I steel construction, with flat flanged heads, fabricated in accordance with Underwriters Laboratories Standard U.L. 142, and so labeled. Tank materials shall be carbon steel. Provide tanks with above ground steel dike, saddles and support legs.

2. The tanks shall meet all applicable Federal and State codes and regulations, and shall be compatible with the products to be stored.

3. Tank installations shall be in accordance with the Maryland Department of Environment and all applicable codes and regulations.

4. Tanks shall be supplied with fittings and accessories as shown on the plans including but not limited to the following:

   a. Normal and emergency venting connections.
   b. Hinged, 10 gallon fill opening with expanded metal screen.
   c. Provide at least one (1) 24-inch U.L. listed access manway on the top center line of the tank.
   d. Lifting lugs of adequate number, size and capacity.
   e. Standard tank saddles supports and dike supports in quantity as determined by tank manufacturer.
   f. Hold down anchor clips.
   g. Pump out, gauge, and vent connections
   h. Rainshields

5. The contractor shall submit a "Notification for Above Ground Storage Tank" form and notify the Maryland Department of the Environment prior to tank installation. The contractor shall validate the installation by completing the Installation Checklist provided with the tank. The contractor shall give a copy of this completed check list to the Owner and Engineer.

6. Tank shall be tested in accordance with U.L. requirements.

7. Exterior tank surfaces shall be primed coated with red oxide. In addition provide factory finish in color as determined by Architect.

8. All vents shall be sized per NFPA-30 and U.L.-142.

9. Tank shall be located a minimum of 5 Ft. from building exterior.

10. Quality Assurance

    a. Acceptable Manufacturers: Beta Tank, Highland, or approved equal.

11. Governing Standards

a. U.L. 142. Underwriters Laboratories, Inc., Standard for Steel above Ground Tanks for Flammable and Combustible Liquid.
b. National Fire Protection Assoc. (NFPA 30) Flammable and Combustible Liquids Code and (NFPA 31) Standards for Installation of Oil Burning Equipment.

12. Submittals

a. Shop Drawings: Contractors shall submit shop drawings for each tank all components, and accessories. Drawings shall include all critical dimensions and show locations of all fittings and accessories,
b. Catalog Data: Contractor shall submit manufacturer's literature.
c. Certification Plate: U.L. labels for waste oil/antifreeze products shall be affixed to each tank.
d. Installation Instructions: Contractor shall submit manufacturer's latest installation instructions.
e. Calibration charts: Contractors shall submit manufacturer's latest calibration charts.
f. Warranty: Contractor shall submit manufacturer's standard two (2) year warranty.
g. Training: Contractor shall submit proof of training in proper installation techniques from the manufacturer. Training Certificate shall prove that the contractor completed his training prior to the contract "Notice to Proceed" date. Contractor shall additionally be certified by the State of Maryland.
h. Independent Testing: Contractor shall submit manufacturers documentation of precision test capabilities as verified by a recognized independent testing agency.

13. Tank Accessories

a. Tank Connections: NPT fittings as indicated on drawings.
b. Provide for each tank:
   i. All caps shall have #727 adapters and #728 cap as manufactured by Universal Valve Co., or approved equal.
   ii. Vent Cap: Universal Model #45, Emco Wheaton Model A-785 or approved equal.
   iii. Wooden Dip Stick: Calibrated in inches with storage conduit.
   iv. Pump out drop tube.
   v. Emergency Vents: Morrison Model 244, Universal or approved equal. Provide screens as required.
   vi. Whistler: Emco, Universal, Morrison or approved equal.
   vii. Tank Gauges: Scully, Hersey or approved equal. Polypropylene double float type.

PART 3. EXECUTION

3.1. EXAMINATION

A. Verify all dimensions by field measurements. Verify that all equipment may be installed in accordance with pertinent codes and regulations, the original design, and the

referenced standards.

B. Verify structure, mounting supports and membrane installations are completed to the proper point to allow installation of roof mounted equipment, where applicable.

C. Examine rough-in requirements for all piping systems to verify actual locations of piping connections prior to installation.

D. Verify that electrical work installation is in accordance with manufacture's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until electrical work is acceptable to equipment installer. Coordinate sizes of all thermal overloads with Division 26.

E. Do not proceed until unsatisfactory conditions have been corrected.

F. Provide wiring diagrams of all equipment as specified in Division 23 Section, Common Work Results for HVAC.

3.2. GENERAL INSTALLATION REQUIREMENTS

A. Install all equipment in accordance with manufacturer's installation instructions, in accordance with state and local code requirements, and in accordance with the contract drawings. Install all equipment plumb and level, to tolerances as required by the manufacturer of each item of equipment. Maintain manufacturer recommended clearances around and over all equipment. Boiler and water heater minimum clearances shall be provided per the State Requirements.

B. Coordinate vibration isolation requirements with all equipment in accordance with Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment.

C. Coordinate all electrical requirements with Division 26.

D. Coordinate all indoor and outdoor equipment pad locations and sizes with approved shop drawing submittals. Provide operating weights of equipment to Structural Engineer for review. Coordinate equipment pad locations and sizes with the Concrete Contractor or General Contractor. Furnish anchor bolts which are to be inserted in concrete pads to concrete installer.

E. Verify piping arrangements of all equipment with the contract drawings. Piping details shall be strictly adhered to concerning valves, fittings, components, etc.

F. Connect all equipment, devices and components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.

G. Testing: After installing HVAC equipment, devices and components and after electrical circuitry has been energized, demonstrate product capability and compliance with

requirements.

H. Remove and replace malfunctioning units with new units and retest.

I. All mechanical penetrations or terminations in exterior walls shall be flashed and caulked watertight. Furnish and installed lintels as required.

J. Arrange for equipment such as boilers, air handling units, energy recovery units, H & V Units, makeup air units, rooftop units, single zone VAV units, and kitchen make-up air units to be shipped to project in modules where space constraints require the same. Field erect components as required.

3.3. FIELD QUALITY CONTROL

A. Where indicated provide the services of a factory authorized service representative to examine the field assembly of components, installation, piping, electrical connections, controls, and clearances. Submit factory start-up check list to Engineer for information purposes. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer, and forwarded to Testing and Balancing Agency.

B. Where factory start-up of equipment is not specified, provide field start-up by qualified technician to examine the field assembly of components, installation, piping, electrical connections, controls and clearances. Record equipment manufacturers standard start-up information and submit to Engineer for review. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer, and forwarded to Testing and Balancing Agency.

C. Charge all refrigerant systems with refrigerant and oil and test for leaks. Repair leaks and replace lost refrigerant and oil.

D. Fill all hydronic systems with water and/or antifreeze (when required after flushing and test for leaks. Repair leaks and replace lost water and/or antifreeze. Coordinate with water treatment contractor.

E. Submit to Engineer a written table of all relief valve and make-up water valve settings for each system. Provide an additional copy in the Operations and Maintenance Manuals.

F. Verify proper motor sizes, voltages, thermal overloads, nameplate data, etc. All equipment voltages and current shall be recorded to insure that motors are operating below their service factors. Test and Balance Engineer shall record electrical data before continuous or permanent operation.

3.4. DEMONSTRATION

A. Provide the services of a factory authorized service representative to provide start-up and to demonstrate and train the Owner's maintenance personnel.

B. Place equipment into operation and adjust controls and safeties. Replace damaged or malfunctioning components and controls.

C. Training:

1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, lubrication, servicing procedures and preventative maintenance schedules/procedures. Review with the Owner's personnel, the contents of the operation and maintenance data specified in Division 23 Section, Common Work Results for HVAC.

2. Submit operation and maintenance data as soon as possible prior to project close-out. Operations and maintenance data shall be submitted to the Owner for review and comment prior to submission to the Engineer.

3. Schedule training with the Owner through the Architect and/or Engineer with at least seven (7) days prior notice.

D. Contractor shall demonstrate removal and replacement of filters at all pieces of equipment with filters in the prescence of the Owners representative.

3.5. CLEANING

A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Clean fan and equipment interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering air face.

3.6. AIR HANDLING UNIT INSTALLATION REQUIREMENTS

A. Install in conformance with ARI 435. Install air handling units level and plumb, according to manufacturer's written instructions.

B. Install AHU's with resilient mounting and flexible electrical leads.

C. Install flexible connections as hereinafter specified at all duct connections.

D. Comb out fins on AHU coils where deformed or bent. Replace or repair broken fins.

E. Install coils level. Install cleanable tube coils with 1:50 pitch.

F. Make connections to coils with unions and flanges.

G. Provide air tight seals between coils and duct or casings. Gasket all access panels, door openings and inspection windows. Seal all joints between sections.

H. Insulate all headers outside air flow as specified for piping.

I. Arrange installation of units to provide access space around air handling units for service and maintenance.

J. Adjust damper linkages for proper damper operation.

K. Install air tight seals at all air handling penetration points, including pipe penetrations at

the coils, unused maintenance - only drain openings, and any penetrations for electrical wiring.

3.7. CHILLER INSTALLATION REQUIREMENTS

A. Align chiller package on steel or concrete foundations as indicated. Adjust and level chiller.

B. Arrange chiller piping for easy dismantling to permit heat exchanger and tube cleaning.

C. Supply initial charge of refrigerant and oil as required.

D. Comb out fins on air cooled chillers where deformed or bent. Replace or repair broken fins.

E. Install chillers according to manufacturer's written instructions. Comply with manufacturer’s requirements for rigging and handling chiller.

F. Install chillers plumb and level, and anchor. Anchor housekeeping pads to building floor. Anchor chiller and vibration isolators to housekeeping pad.

G. Install vibration isolators according to isolator manufacturer's written instructions.

H. Maintain manufacturer's recommended clearances for service and maintenance.

I. Install piping connections maintaining clearances for service and maintenance of chillers.

J. Manufacturer's Field Service: Provide services of a factory authorized service representative to supervise field assembly of components and installation of chillers, including piping and electrical connections, and to report results in writing.

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

K. Touch up scratches in unfinished surfaces to restore corrosion resistance.

L. Touch up scratches in finished surfaces to restore finish.

M. Provide services of a factory trained service technician to start chiller and train Owner on the chiller operation.

N. Interlock chiller with automatic temperature control system. Coordinate requirements with automatic temperature control contactor.

O. Install, wire, and interlock fluid flow switch. Interface with automatic temperature control system.

P. Install flexible connectors, valves, fittings, thermostats, gauges, balance valves, etc… as indicated on flow diagram.

Q. Test flow switches.

R. Install manufactured supplied strainer in the chilled water return line at the evaporator inlet. Strainer shall be maximum mesh opening size per chiller manufacturer.

S. Install vent and drain piping adjacent to evaporator per manufacturer's requirements.

T. Interlock chiller pump freeze protection control signal with BAS system.

3.8. DUCTLESS UNITS EQUIPMENT INSTALLATION REQUIREMENTS

A. Mount indoor and outdoor units as detailed on contract drawings.

B. Supply initial charge of refrigerant and oil as required.

C. Install all interlock and control wiring between indoor units, outdoor units thermostats, and condensate pumps.

D. Install indoor ceiling cassette on vibration isolators.

E. Install outdoor units on concrete pads or on roof curbs as indicated on drawings.

F. Comb out fins on condensing unit where deformed or bent. Replace or repair broken fins.

G. Install condensate lift pumps, float switches, alarm, unit shut down wiring and detection block units per manufacturer's recommendations.

H. For wall mounted units, locate condensate pumps above ceiling. Install all piping, tubing between indoor unit, adapter, detection block, and condensate pump.

I. For wall mounted units field wire power wiring, alarm circuits, control cable, safety circuit connection, alarm, and condensate pump. Condensate pump shall be powered from indoor unit power wiring. Coordinate condensate pump electrical characteristics with indoor unit electrical characteristics.

J. Install wind baffles when required for low ambient operation. Locate wind baffles facing the predominant wind direction in winter.

3.9. ELECTRIC HEATING EQUIPMENT INSTALLATION REQUIREMENTS

A. Examine heating units for compliance with requirements for installation tolerances and other conditions affecting performance of units. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Connect heating units and components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.

C. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris; repair damaged finishes,

including chips, scratches, and abrasions.

D. Install and mount electric radiant heat panels from building structure as required to accommodate ceiling type. Field furnish all accessories necessary to mount radiant heat panels.

E. Install and interlock all electric duct heating coil air flow proving switches and high limit temperature safeties with the ATC system.

3.10. FAN INSTALLATION REQUIREMENTS.

A. Install fans with resilient mounting and flexible electrical leads.

B. Install flexible connections and vibration isolators as specified in Division 23 Section, Common Work Results for HVAC and Division 23 Section Vibration Controls for HVAC, Plumbing and Fire Protection Equipment. Ensure metal band of connectors are parallel with minimum one inch flex between ductwork and fan while running.

C. Provide safety screens/guards on all fans and permanently mount after final testing and balancing.

D. Where indicated, pipe scroll drains with valve, full size to nearest floor drain. Pipe material shall be 316 stainless steel. Where indicated install and pipe grease collectors with valve, union, and discharge to closest floor drain.

E. For fume hood exhaust fans pipe scroll drains, and curb drains with trap, full size to roof. Pipe material shall be 316 stainless steel. Install trap on drain opening and fill with water per manufacturer’s requirements.

F. For UL 762 Kitchen Hood exhaust fans the wiring shall be routed outside of airstream through the breather tube**.**

G. Do not operate fans for any purpose until ductwork is clean, filters in place, bearings lubricated, and fans have been test run under operation.

H. Provide sheave required for final air balance.

I. Install fans according to manufacturer's written instructions.

J. Adjust damper linkages for proper damper operation.

K. Adjust belt tension.

L. Lubricate bearings.

M. Replace fan and motor pulleys and belts as required to achieve design conditions.

N. Mount, install, and wire speed controllers for direct drive fans. Speed controllers for direct drive fans shall be mounted adjacent to fan and wired in accordance with the NEC.

3.11. BOILER INSTALLATION REQUIREMENTS

A. Install boilers in accordance with NFPA-54, Boiler and Pressure Vessel Safety Act including ASME CSD-1, Amendments and Addenda, latest edition, State of Delaware Requirements. Coordinate inspection of boiler by local Boiler Inspector or authority having jurisdiction. Correct any and all violations noted by Boiler Inspector at no additional cost to the Owner.

B. Install boilers on concrete housekeeping pads.

C. Provide connections of fuel source piping in accordance with codes listed above. All gas regulators and gas pressure relief valves shall be piped to the building exterior and terminated with a gooseneck and vermin screen as required in CSD-1. Gas regulator and gas relief valve pipe material shall be in accordance with A.S.M.E. Code.

D. Provide piping connections and accessories as specified and detailed on drawings. For hot water piping all piping up to the first OS&Y gate valve on each side of the boiler shall be welded, flanged or screwed. Grooved joint piping is not acceptable until after the OS&Y gate valve on each side of the boiler.

E. Pipe all relief valves to nearest floor drain. Support relief valve piping in accordance with A.S.M.E. requirements. Relief valve pipe material shall be in accordance with A.S.M.E. Code. Install no more than one (1) elbow on safety relief valve discharge pipe located close to the valve outlet downstream of the union.

F. Provide for connection to electrical services.

G. Provide for connection to gas pilot piping including strainer, shut-off valve, unions, and regulators!

H. Install boilers level and plumb, according to manufacturer's written instructions and referenced standards.

I. Assemble boiler sections in sequence and seal between each section. Assemble boiler trim according to manufacturer's written installation instructions.

J. Install electrical devices furnished with boiler, but not specified to be factory mounted. Mount, install, and wire low water cutoffs and gas train valves. Low water cut offs and gas train valves shall be installed per manufacturers recommendations and wired in accordance with the National Electric Code.

K. Connect breeching to boiler outlet, full size of outlet.

L. Electrical: Comply with applicable requirements in Division 26.

M. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

N. Manufacturer's Field Service: Engage a factory authorized service representative to supervise the field assembly of components and installation of boilers, including piping

and electrical connections. Report results in writing.

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

2. Submit flue gas and combustion analysis reports to Engineer.

3. Record design and actual draft available at appliance vent connection.

O. Hydrostatically test assembled boiler and piping, according to applicable sections of the ASME Boiler and Pressure Vessel Code.

P. Flush and clean boilers on completion of installation, according to manufacturer's written instructions.

Q. After completing boiler installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes including chips, scratches, and abrasions with manufacturer's touch up paint.

R. Furnish and install condensate neutralizers with lime chips and pipe discharge as indicated. Connect condensate neutralizers to boilers and flue pipes.

S. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

T. Examine mechanical spaces for suitable conditions where boilers will be installed.

U. Proceed with installation only after unsatisfactory conditions have been corrected.

V. Equipment Mounting:

1. Install boilers on cast-in-place concrete equipment base(s).

2. Mount valves and devices at heights required by the Boiler Inspector.

W. Install gas-fired boilers according to NFPA 54.

X. Assemble and install boiler trim.

Y. Install electrical devices furnished with boiler but not specified to be factory mounted.

Z. Install control wiring to field-mounted electrical devices.

AA. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. All boiler relief valve and drain piping shall be Type L copper piping.

BB. Install piping adjacent to boiler to allow service and maintenance.

CC. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve. Drain valves shall be brass, ball type and not less than 1-inch. Pipe ends shall be cut at 45 degree angle to prevent a cap or plug from being installed.

DD. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. All relief valve discharge piping shall be fully supported to prevent undue stress or strain.

EE. Connect gas piping to boiler gas-train inlet with union and shut-off valve. Piping shall be at least full size of gas train connection. Provide a reducer if required. Furnish and install gas pressure regulators as required by the Boiler Manufacturer.

FF. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

GG. Connect flow switch to hot water piping and interlock with boiler and ATC system.

HH. Install piping from safety relief valves to nearest floor drain.

II. Boiler Venting:

1. Install flue venting kit, flue stack thermometer, condensate piping, condensate neutralizers, roof curbs, cleanouts, and combustion-air intake.

2. Connect full size to boiler connections.

3. For condensing boilers connect flue and combustion air ducts full size to boiler.

JJ. Ground equipment according to Division 26, Section "Grounding and Bonding."

KK. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

LL. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.

2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.

3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

a. Check and adjust initial operating set points and high- and low-limit

safety set points of fuel supply, water level and water temperature.

b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

MM. Remove and replace malfunctioning units and retest as specified above.

NN. Prepare test and inspection reports.

OO. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

PP. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.

2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.

3. Perform field performance tests to determine capacity and efficiency of boilers.

a. Test for full capacity.
b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.

5. Provide analysis equipment required to determine performance.

6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.

7. Notify Architect in advance of test dates.

8. Document test results in a report and submit to Architect.

QQ. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain boilers.

3.12. HVAC PUMP INSTALLATION REQUIREMENTS

A. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

B. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches (102 mm) and over.

C. Provide drains for bases and seals, piped to and discharging into floor drains.

D. Check, align, and certify alignment of base mounted pumps prior to start-up. Prior to starting pumps, the alignment of the pumps and their motors or other drivers shall be carefully checked. Alignment should be checked for both offset and angularity. Alignment by means of a Laser for all pumps. Alignment by straight edge across the pump couplings shall not be acceptable. Submit laser pump shaft alignment results to Engineer for review and insert a copy in the Operation and Maintenance Manuals.

E. Install close coupled and base mounted pumps on concrete housekeeping pads, with anchor bolts, set and level, and grout in place. See Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment for inertia pad requirements. After alignment is correct, tighten foundation bolts evenly but not too firmly, completely fill baseplate with non shrink, non metallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

F. Lubricate pumps before start-up.

G. Provide side-stream filtration system for base mounted pumps. Install across pump with flow from pump discharge to pump suction from pump tappings. Install flow indicator, filter housing with cartridge filter, shut-off valves, and flow control valves. Install 30 micron filter for start-up and 5 micron filter for system operation.

H. Install pumps according to manufacturer's written instructions.

1. Install pumps according to HI 1.1 1.5, Centrifugal Pumps for Nomenclature, Definitions, Application and Operation.

I. Install pumps to provide access for periodic maintenance, including removing motors, impellers, couplings, and accessories.

J. Suspend in line pumps using continuous thread hanger rod and vibration isolation hangers. Install kindorf pump supports for vertical in-line pumps and maintain clear space above for future motor replacement.

K. Set base mounted pumps on concrete foundation. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.

1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1 1/2 inches between pump base and foundation for grouting.

2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

3.13. HYDRONIC EQUIPMENT AND SPECIALTIES INSTALLATION REQUIREMENTS

A. Where large air quantities can accumulate, provide enlarged air collection standpipes.

B. Provide manual air vents at system high points and as indicated.

C. For automatic air vents provide vent tubing to nearest drain.

D. Provide air separator on suction side of system circulation pump and connect to expansion tank.

E. Provide valved drain and hose connection on strainer blow down connection.

F. Provide pump suction fitting on suction side of base mounted centrifugal pumps. Remove temporary strainers after cleaning systems.

G. Support pump fittings with floor mounted pipe and flange supports.

H. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment and in accordance with ASME requirements.

I. Pipe all relief valve outlets to nearest floor drain.

J. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

K. Perform test determining strength of antifreeze and water solution and submit written test results. At Project completion close the make-up water valve train and open the glycol feeder valve train and turn on glycol feeder to prevent dilution of the antifreeze concentration in the system.

L. Install equipment exposed to finished area after walls and ceiling are finished and painted. Avoid damage.

M. Protection: Provide finished cabinet units with protective covers during balance of construction.

N. Baseboard Radiation: Locate on outside walls and run cover continuously wall-to-wall unless otherwise indicated. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window. Install end caps where units butt against walls.

O. Finned tube Radiation: Locate on outside walls and run cover wall-to-wall unless otherwise indicated. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window. Align cabinet joints with window mullions. Install wall angles where units butt against walls.

P. Unit heaters: hang from building structure, with pipe hangers anchored to building, not from piping. Mount as high as possible to maintain greatest headroom unless otherwise indicated.

Q. Cabinet Unit Heaters: Install as indicated. Coordinate to assure correct recess size for recessed units. Recessed units shall be provided with cabinet but shall also have an Architectural screen.

R. Install baseboard and sill convector units level and plumb, according to manufacturer's

written instructions, rough in drawings, the original design, and referenced standards.

1. Center units under windows.

2. Install continuously around corners, using manufacturer's outside and inside corner fittings.

3. Join with manufacturer's splicer sets to provide continuous cabinet.

4. Install manufacturer's access fitting in cabinets for access to valves and other fittings.

5. Use manufacturer's filler pieces and end caps.

S. Install convector units level and plumb, according to manufacturer's written instructions, rough in drawings, the original design, and referenced standards.

T. Install finned tube radiation units level and plumb, according to manufacturer's written instructions, rough in drawings, the original design, and referenced standards.

1. Use methods and accessories to accommodate thermal expansion.

2. Install cabinet continuously around corners, using manufacturer's outside and inside corner fittings.

3. Use manufacturer's standard wall trim.

4. Install manufacturer's access fitting for access to valves and other fittings.

5. Install air seal gasketing between wall and enclosure mounting channel.

6. Terminate unit enclosures with manufacturer's end caps.

U. Install panel radiators units level and plumb, according to manufacturer's written instructions, rough in drawings, the original design, and referenced standards.

1. Center units under windows.

2. Install continuously around corners, using manufacturer's outside and inside corner fittings.

3. Join with manufacturer's splicer sets to provide continuous cabinet.

4. Install manufacturer's access fitting in cabinets for access to valves and other fittings.

5. Use manufacturer's filler pieces and end caps.

V. Testing: After installing and connecting units, demonstrate product capability and compliance with requirements.

W. Remove and replace malfunctioning units with new units and retest.

3.14. INCREMENTAL EQUIPMENT INSTALLATION REQUIREMENTS

A. Coordinate installation of all incremental units (fan coil units) with architectural and electrical work.

B. Units with Cooling Coils: connect drain pan to condensate drain

C. Coordinate cover openings for all thru-the-wall units with architectural work. Coordinate installation of wall sleeves in finished wall assembly; seal and weather proof.

D. Vacuum out all units and replace filters prior to turning over the same to the owner.

E. Electrical: Connect units to wiring systems and to ground as indicated and instructed by manufacturer.

F. Ground equipment

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

G. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

H. Lubricate bearings on fan.

I. Check fan-wheel rotation for correct direction without vibration and binding.

J. Start unit according to manufacturer's written instructions.

1. Complete manufacturer's startup checks.

K. After starting and performance test, change filters.

L. Prior to installing all fan coil units provide mock-up for 1 unit. Installation shall be reviewed by Owner’s Mechanical Inspector and Engineer of Record. Provide three (3) days notice.

3.15. KITCHEN VENTILATION EQUIPMENT INSTALLATION REQUIREMENTS

A. Install all kitchen ventilation equipment in accordance with NFPA-96, NFPA-90A, NFPA-90B, and the requirements of the local Health Department.

B. Provide flexible duct connectors on outlet from makeup air unit.

C. Rooftop units shall be installed on curbs and shall be leveled.

D. Indoor units shall be installed on housekeeping pads and shall be leveled.

E. The installer of the kitchen hood equipment shall submit a certification of installation to the Delaware Office of State Fire Marshal.

F. Provide factory start-up and training. Submit start-up reports to Engineer.

G. Interlock air flow monitoring station with ATC system.

H. Interlock make-up air unit with kitchen hood exhaust fan hood suppression system and gas solenoid valve.

I. Verify and record minimum and maximum air flow rates for the supply and exhaust air fan.

J. Verify and record the minimum and maximum supply/exhaust fan speeds/ hertz and incorporate into the fan tracking sequence of operation.

K. Verify and record temperature rise across all heating coils or furnaces.

L. Verify and record dry bulb and wet bulb temperatures across all cooling coils.

M. For gas fired equipment verify and record gas pressure at burner manifold.

N. Test all freeze protection pumps.

3.16. ROOFTOP UNITS INSTALLATION REQUIREMENTS

A. Verify that roof is ready to receive work and opening dimensions are as required.

B. Mount unit on factory built roof mounting curb providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.

C. Coordinate installation of roof curbs, equipment supports and roof penetrations with roof construction. Service platform shall bolt to curb per manufacturer’s requirements with stainless steel hardware.

D. Examine roof for compliance with requirements for conditions affecting installation and performance of rooftop units. Do not proceed with installation until unsatisfactory conditions have been corrected.

E. Install units according to manufacturer's written instructions.

F. Install units level and plumb, maintaining manufacturer's recommended clearances.

G. Curb Support: Install roof curb on roof structure, level, according to NRCA's written installation instructions. Install and secure rooftop units on curbs and coordinate roof penetrations and flashing with roof construction. Where service platform is indicated bolt to curb per manufacturers requirements with stainless steel hardware.

H. Unit Support: Install unit on structural curbs and level. Coordinate wall penetrations and flashing with wall construction.

I. Provide factory start-up and training. Submit start-up reports to Engineer.

J. Examine areas to receive units for compliance with requirements for installation tolerances and other conditions affecting performance of energy recovery units. Do not proceed with installation until unsatisfactory conditions have been corrected.

K. Install CO2 sensor/control/interlock wiring to variable frequency drives and to ATC system. Install global CO2 sensor to monitor ambient outside air CO2 level.

L. Install and interlock space CO2 sensors.

M. Install heat wheels so supply and exhaust flow in opposite directions and rotation is from exhaust side to purge section to supply side.

1. Provide access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.

2. Provide removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.

N. Install and interlock outside air flow monitoring station.

O. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

P. Ducts and fan installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

Q. Ground Equipment

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

R. After completing system installation, including outlet fittings and devices, inspect and clean exposed finishes. Remove dirt and construction debris and repair damaged finishes.

S. Startup Services: Engage a factory-authorized service representative to commission units as specified below.

1. Energize and verify correct rotation of heat wheels and fans.

2. Adjust seals and purge.

3. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

4. Verify sequence of operation.

5. Record fluid temperatures and flow rates for hot water coil.

6. Test variable air flow operation.

7. Test demand control ventilation system.

8. Test economizer and relief air fan operation.

9. Test dehumidification system and hot gas re-heat coil operation.

10. Test freeze protection pumps and all interlock wiring/controls.

11. Verify sequence of operation.

12. Record fluid temperatures and flow rates for hot water coil.

13. Test fan tracking of air flow operation as filter load.

14. Test and interlock duct smoke detectors.

15. Test heat pipe operation.

T. Training

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventative maintenance.

2. Review data in the operation and maintenance manuals. Refer to Division 01 Section, Demonstration and Training.

3. Schedule training with Owner, through Architect, with at least 7 days advance notice.

3.17. WATER TREATMENT INSTALLATION REQUIREMENTS

A. Systems shall be operational, filled, started, flushed, and vented prior to cleaning. Use water meter to record capacity in each system. All strainers shall be pulled and cleaned.

B. Place terminal control valves in open position during cleaning. Open bypass valves on coils and close isolation valves on coils during initial flushing.

C. Verify that electric power is available and of the correct characteristics.

D. Use neutralizer agents on recommendation of system cleaner supplier and approval of Architect.

E. Flush open systems and closed systems with clean water for four (4) hours minimum. Drain completely and refill. Where indicated add antifreeze.

F. Remove, clean, and replace strainer screens.

G. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

H. Test and submit antifreeze concentration where the same is utilized and submit concentration at substantial completion.

3.18. ENERGY RECOVERY VENTILATOR INSTALLATION REQUIREMENTS

A. Examine areas to receive energy recovery units for compliance with requirements for installation tolerances and other conditions affecting performance of energy recovery units. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Install energy recovery units as indicated, according to manufacturer's written instructions.

C. Install CO2 sensor/control/interlock wiring to variable frequency drives and to ATC system. Install global CO2 sensor to monitor ambient outside air CO2 level.

D. Install and interlock space CO2 sensors.

E. Install heat wheels so supply and exhaust flow in opposite directions and rotation is from exhaust side to purge section to supply side.

1. Provide access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.

2. Provide removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.

F. Install and interlock air flow monitoring stations as indicated on the contract drawings.

G. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

H. Ducts and fan installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

I. Ground Equipment

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

J. After completing system installation, including outlet fittings and devices, inspect and clean exposed finishes. Remove dirt and construction debris and repair damaged finishes.

K. Startup Services: Engage a factory-authorized service representative to commission units as specified below.

1. Energize and verify correct rotation of heat wheels and fans.

2. Adjust seals and purge.

3. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

4. Verify sequence of operation.

5. Record fluid temperatures and flow rates.

6. Verify and record minimum and maximum air flow rates for the supply and exhaust air fan.

7. Verify and record the minimum and maximum supply/exhaust fan speeds/ hertz and incorporate into the fan tracking sequence of operation.

8. Test A/C condensate overflow safety switch.

9. Test flow switches.

10. Test hot gas re-heat coil operation.

11. Verify and record the minimum and maximum supply/exhaust fan speeds/hertz and incorporate into the fan tracking sequence of operation.

12. Test freeze protection pumps.

L. Training

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventative maintenance.

2. Review data in the operation and maintenance manuals. Refer to Division 01 Section, Demonstration and Training.

3. Schedule training with Owner, through Architect, with at least 7 days advance notice.

3.19. INDUSTRIAL AIR CLEANER INSTALLATION REQUIREMENTS

A. Examine areas to receive industrial air cleaners for compliance with requirements for installation tolerances and other conditions affecting performance of industrial air cleaners. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Install industrial air cleaners as indicated, according to manufacturer's written instructions.

C. Install heat wheels so supply and exhaust flow in opposite directions and rotation is from exhaust side to purge section to supply side.

1. Provide access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.

2. Provide removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.

D. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

E. Ground Equipment

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

F. After completing system installation, including outlet fittings and devices, inspect and clean exposed finishes. Remove dirt and construction debris and repair damaged finishes.

G. Startup Services: Engage a factory-authorized service representative to commission units as specified below.

1. Energize and verify correct rotation of fan.

2. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

3. Verify sequence of operation.

H. Training:

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventative maintenance.

2. Review data in the operation and maintenance manuals.

3. Schedule training with Owner, through Owner, with at least 7 days advance notice.

3.20. SINGLE ZONE VAV UNITS INSTALLATION REQUIREMENTS

A. Examine areas and conditions for compliance with requirements for installation tolerances, other specific conditions, and other conditions affecting performance of single zone VAV units. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine piping and electric rough installations for single zone VAV units to verify actual locations of piping connections before installation.

C. Install single zone VAV units according to manufacturer's written instructions.

D. Install units level and plumb, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

E. Piping Connections: Drawings indicate the general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Connect supply and return piping to hot water, and chilled water coils, with unions, shutoff valves, control valve, flow meter fittings, and autoflow valves.

2. Connect cooling coil drain pan to nearest indirect waste connection, roof drain, air conditioning condensate pump or as indicated.

F. Duct Connections: Connect supply, return, exhaust and outside air ducts to single zone VAV units with flexible duct connections. Provide transitions to match unit duct-connection size. Completely seal and insulate where ductwork connects to unit and filter rack.

G. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

H. Connect low voltage safety switch wiring to units where air conditioning condensate pumps are indicated.

I. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

J. Replace filters used during construction. Seal all return air ducts to filter racks. Seal air tight all filter racks.

K. Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of water-source heat pumps, including piping and electrical connections. Report results in writing.

1. Test and adjust controls and safeties.

2. Replace damaged and malfunctioning controls and equipment.

3. Test and record refrigerant pressures, air flow rates, water flow rates, electrical characteristics. Start-up company and Test and Balance Engineer must both be present during start-up to simultaneously record the above data.

L. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

2. Review data in the maintenance manuals specified in Division 01.

3. Schedule training with Owner, through Architect, with at least 7 days' advance notice.

M. Maintain minimum of 24 inches clear space at unit filter access. Provide manufacturer required clearances for service at ATC control panel, fan section, compressor section and electrical section. Maintain sufficient clear space below units to allow lowering and raising of units in the future.

N. All single zone VAV units shall be provided with auto-restart in the event of a power outage. Units shall automatically be enabled to re-start when power is restored.

O. Install CO2 sensor/control/interlock wiring to variable frequency drives and to ATC system. Install global CO2 sensor to monitor ambient outside air CO2 level.

P. Install and interlock space CO2 and relative humidity sensors.

Q. Install and interlock outside air flow monitoring station and exhaust air flow monitoring station.

R. Startup Services: Engage a factory-authorized service representative to commission units as specified below:

1. Energize and verify correct rotation of heat wheels and fans.

2. Adjust seals and purge.

3. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

4. Test refrigerant circuit and controls

5. Record refrigerant pressures.

6. Verify sequence of operation.

7. Record fluid temperatures and flow rates.

8. Verify and record minimum and maximum air flow rates for the supply and exhaust air fan.

9. Verify and record the minimum and maximum supply/exhaust fan speeds/ hertz and incorporate into the fan tracking sequence of operation.

10. For water cooled equipment test flow switch.

11. Test hot water coil control valve and freeze protection pump.

12. Test chilled water coil control valve and freeze protection pump.

S. Install and interlock outside air flow monitoring station. Interlock with ATC system.

T. Install and interlock exhaust air flow monitoring station. Interlock with exhaust fan variable frequency drive.

U. Install CO2 sensor/control/interlock wiring to variable frequency drives and to ATC system.

V. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

W. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

X. Install piping adjacent to machine to allow service and maintenance.

Y. Condensate drain piping: Conform to applicable requirements of Division 23 Section, HVAC Piping, Fittings, & Valves. Pipe as indicated on contract drawings.

Z. Electrical: Conform to applicable requirements of Division 26 Sections.

AA. Install electrical devices furnished with heaters but not specified to be factory mounted.

BB. For water source heat pump units, coordinate head pressure control valve requirements and interlock requirements with the ATC Subcontractor and BMS.

3.21. ABOVE GROUND WASTE OIL AND ANTIFREEZE TANK INSTALLATION REQUIREMENTS

A. Install concrete bases of for all tanks. Refer to Division 3 Section, Cast in Place Concrete and Division 23 Section, Common Work Results for HVAC.

B. Install accessories adjacent to equipment to allow service and maintenance.

C. Connect piping to equipment with oil shutoff valve and union. Install union between valve and equipment.

D. Review data in maintenance manuals. Refer to Division 01 Section, Contract Closeout.

E. Schedule training with Owner, through Architect, with at least seven days' advance notice.

1. Assemble equipment, piping, accessorites and connections.

2. Use adequate size equipment to lift and lower tanks without dragging and dropping to ensure no damage to tanks.

a. Carefully lift and lower tanks using cables or chains of adequate length attached to lifting lugs.
b. Do not use chains or slings around tank shell.

3. Tank Cleaning:

a. Before tank is filled, pump all accumulated water and condensate from tank.

b. Mop tank dry.

4. Testing:

a. After all piping has been installed, temporarily cap vent piping, all pipe joints and tank connections.
b. Test with maximum of 5 PSI air, using soap suds on all joints.
c. Test all connections and prove tight at operating pressure.

F. Install waste and antifreeze storage tanks according to manufacturer's written instructions and standards specified.

G. Install piping connections.

H. Construct tank and equipment bases according to supported tank and equipment manufacturer's setting templates for anchor bolt and tie locations. Use 3000 psi 28 day compressive strength concrete.

I. Connect vent, fill, sounding, pump out connections, gage, and other piping to fittings and specialty devices.

J. Piping Connections: Make piping connections as follows, unless otherwise indicated:

1. Install unions, in piping 2 inch NPS DN50 and smaller, adjacent to each valve and at final connection to each piece of equipment having threaded pipe connection.

2. Install flanges, in piping 2 1/2 inch NPS DN65 and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.

3. Install dielectric unions to connect piping of dissimilar metals.

3.22. HEATING AND VENTILATING UNIT AND MAKE-UP AIR UNIT INSTALLATION REQUIREMENTS

A. Examine areas and conditions for compliance with requirements for installation tolerances, other specific conditions, and other conditions affecting performance of H & V/make-up air units. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine piping and electric rough installations for H & V and make-up air units to verify actual locations of piping connections before installation.

C. Install H & V/make-up air units according to manufacturer's written instructions.

D. Install units level and plumb, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

E. Piping Connections: Drawings indicate the general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Connect supply and return piping to unit with unions, shutoff valves, control valve, flow meter fittings, and pressure independent control valve.

F. Duct Connections: Connect supply, return, exhaust and outside air ducts to H & V unit/make-up air units with flexible duct connections. Provide transitions to match unit duct-connection size. Completely seal and insulate where ductwork connects to unit and filter rack.

G. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

H. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

I. Replace filters used during construction. Seal all return air ducts to filter racks. Seal air tight all filter racks.

J. Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of water-source heat pumps, including piping and electrical connections. Report results in writing.

1. Test and adjust controls and safeties.

2. Replace damaged and malfunctioning controls and equipment.

3. Test and record air flow rates, hot water flow rates, electrical characteristics. Start-up Company and Test and Balance Engineer must both be present during start-up to simultaneously record the above data.

K. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

2. Review data in the maintenance manuals specified in Division 01.

3. Schedule training with Owner, through Architect, with at least 7 days' advance notice.

L. Maintain minimum of 24 inches clear space at unit filter access. Provide manufacturer required clearances for service at ATC control panel, fan section, energy recovery wheel and electrical section.

M. All H & V units and make-up air units shall be provided with auto-restart in the event of a power outage. Units shall automatically be enabled to re-start when power is restored.

N. Install and interlock outside air flow monitoring station.

O. Startup Services: Engage a factory-authorized service representative to commission units as specified below:

1. Energize and verify correct rotation of heat wheels and fans.

2. Adjust seals and purge.

3. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

4. Verify sequence of operation.

5. Record fluid temperatures and flow rates.

6. Verify and record minimum and maximum air flow rates for the supply and exhaust air fan.

7. Test hot water coil control valve and freeze protection pump.

P. Install and interlock air flow monitoring stations.

Q. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

3.23. FUME HOOD INSTALLATION AND TESTING REQUIREMENTS

A. Examination:

1. Verify equipment rough-in before proceeding with work.

2. Coordinate with other trades for the proper and correct installation of plumbing and electrical rough-in and for rough opening dimensions required for the installation of the hood.

B. Installation:

1. Install according to manufacturer's instructions.

2. Install according to standards required by authority having jurisdiction.

3. Install equipment plumb, square and straight with no distortion and securely anchor as required.

4. Sequence installations to ensure utility connections are achieved in an orderly and expeditious manner.

5. Touch up minor damaged surfaces caused by installation. Replace damaged components as directed by Architect.

C. Adjusting:

1. Adjust operating equipment, to efficient operation for its intended use, and as required by the manufacturer.

D. Cleaning:

1. Clean equipment, casework, countertops and all other surfaces as recommended by the manufacturer, rendering all work in a new and unused appearance.

2. Clean adjacent construction and surfaces that may have been soiled in the course of installation of work in this section.

E. Protection of Finished Work:

1. Provide all necessary protective measures to prevent exposure of equipment and surfaces from exposure to other construction activity.

2. Advise contractor of procedures and precautions for protection of material and installed equipment and casework from damage by work of other trades.

F. Demonstration:

1. Provide systems demonstration and demonstrate all equipment operations and functions.

G. Testing Criteria:

1. Reverse Airflows and Containment - When tested as "As Manufactured" ("AM"), the hood shall provide containment less than or equal to 0.10 ppm when tested per ASHRAE Standard 110-2016.

2. Test Criteria: The following test criteria apply when determining the AM performance rating.

3. Face velocity: 100 feet per minute ±20% with only one sash open. Ambient temperature: 68 to 74 degrees F

4. Containment per ASHRAE 110-2016 - At a tracer gas release rate of 4 liters per minute, the AM leakage shall not exceed 0.10 ppm (rating = 4 AM 0.10)

5. Flow Visualization - The following excerpt sections of ASHRAE 110-2016 are used to define the AM test criteria for reverse airflow and exhaust capacity.

a. Flow Visualization - Swab a strip of titanium tetrachloride along both walls and the hood floor in a line parallel to the hood face and 6 inches (152 mm) back into the hood. (Titanium tetrachloride is corrosive to the skin and extremely irritating to the eyes and respiratory system.) Define air movement toward the face of the hood as reverse airflow and define lack of movement as dead air space. Swab the work surface, making sure to swab lines around all equipment in the hood. All smoke should be carried to the back of the hood and out. Test the operation of the lower air bypass air flow opening by running the cotton swab under the air foil.

Before going on to the next test, move the cotton swab around in the face of the hood. If there is any outfall, the exhaust capacity test should not be made.

b. Exhaust Capacity - Ignite and place a 30-second smoke bomb near the center of the work surface, making sure that the hole on the side of the smoke bomb faces into the hood. After the smoke bomb begins to work, pick it up with tongs and move it around in the hood. There should be no visual or odor indications of smoke outside the hood.

c. Installed Performance - Per ASHRAE 110-2016, the "AU" (As Used) requirement involves the design of the room supply system and the toxicity of the materials handled in the hood. The AU specification should be tailored to suit the needs of the laboratory room location.

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HVAC INSULATION
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SECTION 23 07 01
HVAC INSULATION

PART 1. GENERAL

1.1. REFERENCE

A. The Conditions of the Contract and other General Requirements apply to the work specified in this Section. All work under this Section shall be subject to the requirements of Division 23 Section, Common Work Results for HVAC.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. DESCRIPTION

A. All piping, ductwork, and equipment installed under this Contract shall be covered as specified.

1.3. SCOPE

A. The work covered by this specification consists of furnishing all labor, equipment, materials and accessories, and performing all operations required, for the correct fabrication and installation of thermal insulation applied to all piping, equipment, and duct systems, in accordance with applicable project specifications and drawings, subject to the terms and conditions of the contract.

1.4. STANDARDS

A. Thermal insulation materials shall meet the property requirements of one or more of the following specifications as applicable to the specific product or use:

1. American Society for Testing of Materials Specifications:

a. ASTM C 547, "Standard Specification for Mineral Fiber Preformed Pipe Insulation".
b. ASTM C 533, "Standard Specification for Calcium Silicate Pipe & Block Insulation".
c. ASTM C 55, "Standard Specification for Mineral Fiber Blanket and Felt Insulation".
d. ASTM E 96, “Standard Test Methods for Water Vapor Transmission of Material”.
e. ASTM C 585, "Recommended Practice for Inner and Outer Diameters of Rigid Pipe Insulation for Nominal Sizes of Pipe and Tubing (NPS System)".
f. ASTM C 612, "Standard Specification for Mineral Fiber Block and Board Thermal Insulation".
g. ASTM C 1136, "Standard Specification for Barrier Material, Vapor, "Type 1 or 2 (Jacket only).

2. ASHRAE 90.1 "Energy efficient design of new buildings except low-rise

residential buildings", latest edition.

3. International Energy Conservation Code, latest edition.

B. Insulation materials, including all weather and vapor barrier materials, closures, hangers, supports, fitting covers, and other accessories, shall be furnished and installed in strict accordance with project drawings, plans, and specifications.

1.5. SYSTEM PERFORMANCE

A. Insulation materials furnished and installed hereunder should meet the minimum economic insulation thickness requirements of the North American Insulation Manufacturers' Association (NAIMA) (formerly known as TIMA), to ensure cost-effective energy conservation performance. Alternatively, materials should meet the minimum thickness requirements of National Voluntary Consensus Standard 90.1, (latest edition) and "Energy Efficient Design of New Buildings," of the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), latest edition. However, if other factors such as condensation control or personnel protection are to be considered, the selection of the thickness of insulation should satisfy the controlling factor. As minimum, all insulation thicknesses shall be as hereinafter specified.

B. Insulation materials furnished and installed hereunder shall meet the fire hazard requirements of any one of the following specifications:

1. American Society for Testing of Materials ASTM E 84

2. Underwriters' Laboratories, Inc. UL 723

3. National Fire Protection Association NFPA 255

4. ASTM E 96, “Standard Test Methods for Water Vapor Transmission of Materials”.

C. Calcium silicate products shall include a visual identification system to permit positive field determination of their asbestos-free characteristics.

1.6. QUALITY ASSURANCE

A. Insulation materials and accessories furnished and installed hereunder shall, where required, be accompanied by manufacturers' current submittal or data sheets showing compliance with applicable specifications listed in Section 1.4 above.

B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work.

1.7. DELIVERY AND STORAGE OF MATERIALS

A. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification.

B. The Contractor shall use whatever means are necessary to protect the insulation materials

and accessories before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The Contractor shall also use all means necessary to protect work and materials installed by other trades.

C. If any insulation material has become wet because of transit or job site exposure to moisture or water, the Contractor shall not install such material, and shall remove it from the job site. An exception may be allowed in cases where the Contractor is able to demonstrate that wet insulation when fully dried out (either before installation, or afterward following exposure to system operating temperatures) will provide installed performance that is equivalent in all respects to new, completely dry insulation. In such cases, consult the insulation manufacturer in writing for technical assistance.

D. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements. Protect all insulation from water, construction traffic, dirt, chemical and mechanical damage.

1.8. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. GENERAL

A. All materials to be insulated shall be thoroughly cleaned, after completion of successful tests, and shall be covered as specified below. Fiberglass insulation shall be Owens-Corning, Manville, Armstrong, or P.P.G, or as approved equal.

2.2. PIPE INSULATION MATERIALS

A. Unless otherwise noted, insulation shall be one piece or half sectional molded fibrous glass with "K" rating of .23 at 75 degrees Fahrenheit mean temperature, for service temperatures between -60 degrees Fahrenheit and +450 degrees Fahrenheit with all service poly-encapsulated jacket. Pipe insulation shall be fiberglass ASJMax SSL II with double closure system as manufactured by Owens Corning, Johns Manville, Knauf or approved equal.

B. Exterior refrigerant pipe insulation fume hood exhaust fan drain/trap insulation shall be Armacell, or approved equal, foam insulation with exterior field applied aluminum jacketing. Interior refrigerant piping shall be Armacell or approved equal foam insulation. Where interior refrigerant piping is exposed also install field applied PVC jacketing.

C. Unless otherwise noted, pipe insulation jacket shall be factory-applied vinyl coated, embossed and reinforced vapor barrier laminate, with a perm rating of not more than 0.02 perms. All hot and cold, concealed and exposed butt strips shall be of the same material as the jacket. Jacket and butt strips shall be sealed with field-applied Foster 85-20/85-60 or Childers CP-82 (5 gal cans only) adhesive. Jacket and butt strips shall be off-white color and shall be equivalent to Owens-Corning Fiberglass 25-ASJ.

D. Indoor pipe insulation shall be ASJ Max with SSL-II closure system pipe insulation as manufactured by Owens Corning or approved equal. Pipe insulation shall be composed of

heavy density fiberglass insulation with an organic binder. The insulation shall include a white, factory jacketed, resilient, tough, soil resistant polymer facing that matches standard PVD fitting covers. Furnish all accessories and matching butt joints sealing tape for system closure. Insulation shall be suitable for operating temperatures between 32 degrees Fahrenheit and 220 degrees Fahrenheit. Flame spread rating of 25 or less, and smoke development rating of 50 or less to comply with building codes for installation in return air plenums. The maximum thermal conductivity (K-value) at a mean temperature of 50 shall be .22 BTU-in/hr-Ft²-degress Fahrenheit.

E. For fittings on all piping, valves and flanges, apply fiberglass molded or segmented insulation equal in thickness to the adjoining insulation and securely fasten in place using wire. Cold piping: Apply a tack coat of vapor barrier coating and reinforcing mesh. After ½ hour, apply second coat of same vapor barrier coating, UL labeled, Type C, for cold water piping, Hot piping Type H for hot water piping: Apply tack of breather mastic. Wrap fitting with fiberglass reinforcing cloth overlapping adjoining sections of pipe insulation by 2-inches. Apply a second coat of breather mastic over the reinforcing cloth, working it to a smooth finish.

1. Vapor Barrier Coating: Foster 30-65; Childers CP-34 or Vimasco 749. Permeanie shall be 0.03 perms or less at 45 mils dry as test by ASTM E96.

2. Breather mastic: Foster 46-50; Childers CP-10/11 or Vimasco WC-5

3. Reinforcing Mesh: Foster Mast a Fab; Childers Chil Glas #10 or Vimasco Elastafab

F. All pipe insulation, jackets, or facings, and adhesives used to adhere jacket or facing to the insulation, including fittings and butt strips, shall have non-combustible fire and smoke hazard system rating and label as tested by ASTM E-84, NFPA 225, and UL 73, not exceeding Flame Spread 25, Fuel Contributed 50, Smoke Developed 50. Accessories such as adhesives, mastic cements, tapes and cloth for fittings shall have the same ratings as listed above. All products or their shipping cartons shall bear the Underwriter's label indicating that flame and smoke ratings do not exceed the above criteria.

G. For piping having a vapor barrier insulation and for all insulated piping requiring supports, hangers and supports shall be installed outside the insulation. Wherever hangers and supports are installed outside the insulation, pipe insulation protecting shields shall be provided. Where insulation is a load bearing material, of sufficient strength to support the weight of the piping, pipe shields one-third the circumference of the insulation and of a length not less than three times the diameter of the insulation (maximum length 24-inches) shall be provided. Insulation of 7-1/4 pound or greater density will be considered as load bearing for pipe sizes up to and including 2-inches. Where insulation is not of sufficient strength to support the weight of the piping, a half section of high density fiberglass or foam inserts, shall be provided. Vapor barrier and finish shall be applied as required to match adjoining insulation. In addition, shields shall be furnished as specified above.

H. For piping located outside of the building, a corrugated aluminum weatherproof jacketing system shall be provided. This system shall be Micro-Lot ML as manufactured by Manville, Polyweld by Pabco Metals Corp., Childers, or as approved equal, and installed per the manufacturer's recommendations. Where outdoor piping is receiving electric heat tape, the insulation shall be oversized so that the heat tape is not compressed tightly to the

pipe. Pipe jacketing shall be corrugated (3/16-inch) deep aluminum, .016-inch thickness of H-14 temper with aluminum strapping of .75-inch width and .020 inch thickness with moisture barrier. Aluminum jacketing elbows shall be smooth, .016-inch thickness and 1100 alloy. All jacketing shall have an integrally bonded moisture barrier over the entire surface in contact with the insulation. Longitudinal joints shall be applied so they will shed water and shall be sealed completely with metal jacketing sealant. Sealant shall be Foster 95-44 or Childers CP-76. Circumferential joints shall be closed using preformed butt strips following manufacturer's recommendations for securement. Jacket seams shall be located on the bottom side of the horizontal piping. Where project has walk-in boxes provided by a Food Service Supplier, insulate and jacket all refrigerant piping serving walk-in coolers and freezers.

I. On cold systems such as refrigerant piping, chilled water piping, cooling coil drain piping, glycol piping, vapor barrier performance is extremely important. All penetrations and seams of the ASJ and exposed ends of insulation must be sealed with vapor barrier coating. The ASJ must be protected with either a coating or a suitable vapor retarding outer jacket. Vapor seals at butt joints shall be applied at every fourth pipe section joint and at each fitting to provide isolation of water incursion. Vapor Barrier Coating: Foster 30-65; Childers CP-34 or Vimasco 749. Permeance shall be 0.03 perms or less at 45 mils dry as test by ASTM E96.

J. Fittings and valves shall be insulated with pre-formed fiberglass fittings, fabricated sections of fiberglass pipe insulation, Fiberglass pipe and tank insulation, Fiberglass blanket insulation, or insulating cement. Thickness shall be equal to adjacent pipe insulation. Finish shall be with pre-formed PVC fitting covers or as otherwise specified on contract drawings. Where applicable, Victaulic PVC fitting valve and coupling covers shall be utilized. Victaulic PVC covers shall be installed with matching pipe insulation jacketing material, vinyl tape solvent weld adhesive and appropriate fasteners.

1. Flanges, couplings and valve bonnets shall be covered with an oversized pipe insulation section sized to provide the same insulation thickness as on the main pipe section. An oversized insulation section shall be used to form a collar between the two insulation sections with low density blanket insulation being used to fill gaps. Jacketing shall match that used on straight pipe sections. Rough cut ends shall be coated with a suitable weather or vapor-resistant mastic as dictated by the system location and service. Finish valve installation with a Tyvac jacket with ends that secure to adjacent piping.

2. On hot systems where fittings are to be left exposed, insulation ends should be beveled away from bolts for easy access.

3. On cold systems, particular care must be given to vapor sealing the fitting cover or finish to the pipe insulation vapor barrier. All valve stems must be sealed with caulking which allows free movement of the stem but provides a seal against moisture incursion. All gauge and thermometer penetrations and extensions shall be correctly sealed and insulated to prevent surface condensation. Install oversized hangers to prevent penetrations of pipe insulation vapor barrier.

K. All piping shall be supported in such a manner that neither the insulation or the vapor/weather barrier is compromised by the hanger or the effects of the hanger. In all cases, hanger spacing must be such that the circumferential joint may be made outside the

hanger. On cold systems, vapor barrier must be continuous, including material covered by the hanger saddle.

1. Piping systems 3-inches (7.5cm) in diameter or less, insulated with Fiberglass insulation, may be supported by placing saddles of the proper length and spacing, as designated in Owens-Corning Pub. 1-IN-12534, under the insulation. Hangers saddles shall be minimum 16 gauge with a saddle arc of 120 degrees minimum.

2. For hot or cold piping systems larger than 3-inches (7.5 cm) in diameter, operating at temperatures less than +200 degrees F (93 degrees C) and insulated with fiber glass, high density inserts such as foam or wood blocks with sufficient compressive strength shall be used to support the weight of the piping system. At temperatures exceeding +_200 degrees F (93 degrees C), Owens-Corning Pink Calcium Silicate, IIG, or approved equal pipe insulation shall be used for high density inserts.

3. Owens-Corning Pink Calcium Silicate pipe insulation may be used to support the entire weight of the piping system provided the hanger saddle is designed so the maximum compressive load does not exceed 100 psi (7kg/cm).

4. Where pipe shoes and roller supports are required, insulation shall be inserted in the pipe shoe to minimize pipe heat loss. Where possible, the pipe shoe shall be sized to be flush with the outer pipe insulation diameter.

5. Thermal expansion and contraction of the piping and insulation system shall generally be taken care of by utilizing double layers of insulation and staggering both longitudinal and circumferential joints. Where long runs are encountered, expansion joints may be required where single layers of insulation are being used and should be so noted on the contract drawings.

6. On vertical runs, insulation support rings shall be used.

L. The direct buried heating water piping (PEX) serving the finned tube radiation or panel radiators shall be insulated with closed - cell phenolic - foam insulation. Insulation shall be in accordance with ASTM C1126 and shall exhibit low water - absorption characteristics. High density (5lb/cu.ft) shall be utilized for underground installations. Insulation shall be as manufactured by Kooltherm, Imcoa, Armstrong, Dyplast, ITW Insulation, or approved equal.

2.3. PIPING INSULATION THICKNESSES SCHEDULE

A. All piping shall be insulated with pipe insulation of the thicknesses indicted below:

PIPING INSULATION THICKNESS SCHEDULE SERVICES	THICKNESS
Automatic Glycol Feeder Piping	1 inch thickness
Chilled Water Piping 2 ½-inches & Larger	2-inch thickness
Chilled Water Piping 2-inches & Smaller	2-inch thickness
All Branch Runouts to Unit Heaters/Fin Tube/Convectors	½-inch thickness
Horizontal portions of Stormwater piping that collects A/C condensate	1-inch thickness

PIPING INSULATION THICKNESS SCHEDULE SERVICES	THICKNESS
Direct Buried Heating Water Piping (PEX)	1-inch thickness
Heating Hot Water Piping 2-inches & Larger	2 –inch thickness
Heating Hot Water Piping 1-½ -inches & Smaller	1 ½ -inch thickness
All Drain Piping from Cooling Coils/Evaporators including pump and condensate piping.	1-inch thickness
Chemical Feed System	1-inch thickness
All Above Grade Floor Drain Piping Serving AHU Condensate Drains include Drain Sumps and Auxiliary Drain Pipes from Auxiliary Pans	1-inch thickness
All Refrigerant Piping	1-inch thickness
Kitchen Walk-in Box Refrigerant Pipes (Refer to Food Service Contract Drawings for location)	1-½ inch thickness
Piping within Fan Coil Unit Enclosures	½-inch thickness
Fume hood exhaust fan drain/trap piping	1-inch thickness
Boiler/Water Heater Combustion Air Intake Pipes/Ducts	1-inch thickness

2.4. EQUIPMENT INSULATION MATERIALS AND THICKNESSES

A. The following equipment shall be insulated with Fiberglass Rigid Board Insulation or Foam Plastic Insulation:

1. Chilled Water Pump and Hot Water Pump Bodies.

2. Air Separators.

3. Expansion Tanks.

4. Chiller Heads.

5. Chemical Feed Tanks.

6. Supply and Return Air Fan Scrolls (where not factory insulated).

7. Freeze Protection Pump Bodies.

8. All Pump Volutes and Strainers.

B. Insulation for cold surfaces shall be 1-1/2-inch thickness, 6 lb. density, 705 FRK with a "K" rating of .23 at 75 degrees F mean temperature. Insulation for hot surfaces except as otherwise noted shall be 1-1/2-inch thickness, 6 lb. density, 705 with a "K" rating of .23 at 75 degrees F mean temperature. Insulation shall be applied with staggered joints firmly butted and joined. The insulation shall be held in place by steel bands. Bands shall be 1-inch by 25 gauge galvanized steel spaced on not over 12-inch centers. All joints and voids shall be filled with Owens-Corning #110 cement, well troweled into openings. For 705 FRK insulation, all joints and voids shall be FRK taped and vapor sealed. There shall be applied over the insulation surface 1-inch galvanized wire netting laced together at all edges and wired to the steel bands with 16 gauge soft annealed wire. Over this shall be applied 2-inch thick layer of Owens-Corning #110 cement applied in two layers. Install

metal corner beads at all corners and edges in order to provide a permanent installation. Onto the dry cement surface apply a brush coat of Foster Sealfas 30-36 or Childers CP-50AMV1 lagging adhesive at the rate of 60-70 square feet per gallon. Cleanouts, nameplates, and manholes shall not be insulated, and the insulation on surrounding surfaces shall be neatly beveled off at such openings.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.

2. Fabricate boxes from aluminum at least 0.040 inch (1.0 mm) thick.

3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

D. Boards shall be scored to allow them to conform to curved or irregular surfaces.

E. Mechanical fasteners shall be utilized to hold insulation to surface with bands as required to hold the curvature of the material.

F. Support rings shall be provided to support the top head insulation where required.

G. Outdoor installations require a weather barrier for protection of the insulation jacketing.

H. Insulation types materials shall be suitable for temperatures encountered by each item of equipment.

2.5. DUCTWORK INSULATION MATERIALS AND THICKNESSES

A. Insulate all supply, paint spray booth intake ductwork, paint spray booth exhaust air ductwork, return, relief, combustion air, plenums, exhaust, (for equipment with energy recovery wheel) and outside air intake ductwork with fiberglass exterior duct insulation with factory-applied foil facing. All exposed fiberglass duct insulation shall be 2-inch rigid or non-flexible board type 3.0 pcf minimum density, 0.23 max. "K" factor at 75 degrees F mean temperature, with white vinyl A.S.J. max, polymer coating vapor barrier facing. All concealed fiberglass duct insulation shall be 2-inch flexible blanket type, 1.0 pcf minimum density. All concealed insulation shall be 0.27 max. "K" factor at 75 degrees F mean temperature with reinforced foil-scrim Kraft vapor barrier facing. Unless otherwise noted, the minimum installed R-value shall be 6.0 HR x ft2 x ºF/btu.

B. Refer to Division 23 Section, HVAC Air Distribution System and contract drawings for location of all sound-lined ductwork. Sound-lined ductwork from the discharge or supply side of all H & V units, air handling units, energy recovery units, make –up air units, rooftop units, H&V units, and single zone VAV unit shall require external insulation in addition to internal lining specified hereinafter. All other ducts indicated to be provided with interior lining shall not require additional exterior insulation.

C. Where exhaust ducts carrying moisture-laden air dishwasher exhaust, shower exhaust, etc. are routed in unconditioned spaces, insulation is required as described above. Insulation shall be continuous through the unconditioned area. The vapor barrier shall be tightly sealed to prevent condensation. Exhaust ducts located within conditioned spaces do not require insulation unless otherwise noted.

D. Where a vapor barrier is required, all joints, seams, tears, punctures, and other penetrations shall be closed with 3-inch (7.5cm) pressure-sensitive tape matching the facing or with vapor barrier coating reinforced with 3-inch (7.5cm) glass scrim tape.

E. Exposed dual wall ductwork located in finished areas shall not require additional exterior insulation. Exposed dual wall supply ductwork located in mechanical room, fan rooms, penthouse, mezzanines and boiler rooms shall require additional rigid exterior insulation as hereinafter specified.

F. Contractor-applied internal linings shall be as specified and installed as hereinafter specified.

G. For exposed Fiberglass duct insulation, tightly butt all edges and seams. Secure insulation with flush mechanical fasteners spaced not less than one per square foot. Insulation may be secured with 100 percent coverage of adhesive with mechanical fasteners on the underside of the duct only, in addition to adhesive. Adhesive shall be water based Foster 85-60 or Childers CP-127. Cover all seams, joints and fasteners with not less than 3-inch wide tape matching the insulation facing. Pre-finished white fastener caps may be left exposed if the spacing and pattern is uniform in appearance. Staples will not be permitted.

H. All dual wall exterior ductwork shall be insulated with 2-inch rigid type 6.0 pcf minimum density, .25 max "K" factor with white vinyl A.S.J. vapor barrier facing. Insulation shall be sandwiched between inner galvanized ductwork and exterior aluminum ductwork.

I. All supply air diffusers and supply air registers shall be fully insulated on the rear exposed surface to prevent condensation. Insulation shall be 1 ½" inch flexible blanket type 1 ½ pcf minimum density with reinforced foil-scrim-Kraft vapor barrier facing, .25 max "k" factor.

J. All airflow monitoring stations shall be externally insulated similar to adjacent ductwork as hereinbefore specified.

2.6. ACCESSORY MATERIALS

A. Accessory materials installed as part of insulation work under this section shall include, but not be limited to:

1. Closure Materials - Butt strips, bands, wires, staples, mastics, adhesives; pressure-sensitive tapes.

2. Field-applied jacketing materials - sheet metal, plastic, canvas, fiber glass cloth, insulating cement; PVC fitting covers, PVC jacketing.

3. Support Materials - Hanger straps, hanger rods, saddles.

4. Fasteners, weld pins/studs, speed clips, insulation washers.

5. Metal mesh or expanded metal lagging.

B. All accessory materials shall be installed in accordance with project drawings and specifications, manufacturer's instructions, and/or in conformance with the current edition of the Midwest Insulation Contractors Association (MICA) "Commercial & Industrial Insulation Standards."

2.7. EXTERIOR ROOF MOUNTED DUCTWORK INSULATION SYSTEM

A. Insulate all exterior ductwork with an interlocking, four-piece, Techna-Duc insulation panel system as manufactured by P.T.M. Manufacturing, L.L.C., Fabrite as manufactured by County Group, or Flex Clad – 400 jacketing system as manufactured by Tri-State Insulation, Foster Vapor Fas 62-05 as manufactured by MFM Building Products, Weatherguard as manufactured by MKT Metal Manufacturing, or an approved equal. Insulation system shall be constructed of glass-reinforced polyisocyanurate foam insulation encased in 1.25 mil aluminum foil vapor barrier facing. All insulation shall be a combined minimum thickness of 2-inch rigid or non-flexible board type, 2.0 pcf minimum density, .25 max "K" factor at 75 degrees Fahrenheit mean temperature. Exterior weather barrier shall be fabricated of embossed aluminum sheeting, minimum 0.032-inches in thickness, and laminated to insulation foil facing. Total installed R-value shall be R-16 at 2 inch thickness.

B. Refer to Division 23 Section, HVAC Air Distribution and contract drawings for location of all exterior roof mounted ductwork.

C. All roof mounted ductwork shall meet the specifications set forth in Division 23 Section, HVAC Distribution before installation of the insulation system, to include sealing of joints, testing and duct leakage and installation of duct accessories.

D. All vapor barrier joints, seams, tears, punctures, and other penetrations shall be closed with 3-inches by 1.25 mil minimum aluminum foil faced tape, and/or non-setting vapor barrier coating as applicable. Material shall be fitted so that the vapor barrier seal is continuous and does not allow for water vapor infiltration.

E. Insulation panel system shall be fitted into place on the ductwork. Each insulation panel shall be constructed so that all vertical and horizontal insulation seams shall have an interlocking and overlapping shiplap style joint to provide a thermal seal. The overlap shall be a minimum of 2-inches thick. Fasten panel system together at overlapping joints using #10 self tapping, stainless steel, vapor seal screws with weather seal washers on a maximum of 12-inches center. For ducts wider than 48-inches, a bottom fastener should be utilized.

F. At all circumferential joints, apply butyl compound putty using a laminate roller. The butyl compound shall be covered with a 3-inch wide cap of embossed aluminum sheeting, minimum 0.032-inches in thickness. All seams of the aluminum cap and all weather barrier abutments shall be sealed with a bead of RTV caulk, colored to match the panel system.

G. Insulation and jacketing shall cover all duct flanges to prevent collection of water or leaks.

H. All exterior access doors shall be covered with removable insulation system and shall be labeled.

I. All exterior air flow monitoring stations and duct smoke detectors shall be installed so as to be waterproof.

J. At all static pressure measurement points and pitot tube traverse points install inspection plugs as manufactured by Inspection Plug Strategies. Inspection plugs shall be installed in ductwork per manufacturer's requirements and shall be located where indicated by the Test/Balance Engineer. The inspection plugs shall comply with the following:

1. 50 Durometer EPDM Rublen rated for 340°F.

2. Temperature resistant range= -67°F to 340°F.

3. U.V. resistant.

4. Ozone resistant.

5. Comply with ASTM D470 0624 D2132 D865 D395. Furnish each inspection plug with EPDM sealing flange, EPDM cap, and stainless steel attached lanyard.

6. Provide waterproof label identifying all inspection plugs.

2.8. GREASE DUCT ENCLOSURE WRAP

A. Provide listed grease duct enclosure wrap on all kitchen hood exhaust ducts. Duct wrap shall comply with ASTM E 2336-01 "Standard Test Method" for Fire Resistive Grease Duct Enclosure System. Duct wrap shall be Fire Master as manufactured by Thermal Ceramics, Fyerewrap as manufactured by Unifrax, and Fire Barrier as manufactured by 3M, Schebbler, or approved equal.

B. Duct wrap shall be foil-encapsulated, non-combustible, inorganic, flexible fire proofing wrap. Duct wrap shall be utilized in combination with Fire Master or approved equal, Putty and Fire Master or approved equal, bulk fiber to fire rate kitchen hood exhaust ducts. Duct wrap shall be capable of withstanding 2300 degrees F temperatures and protect combustible construction at zero clearance.

C. Two (2) layers of duct wrap shall be applied directly to the duct to provide a two (2) hour fire resistance enclosure for both vertical and horizontal duct runs. Apply putty and bulk fiber in conjunction with duct wrap at all duct penetrations of fire rated walls and ceilings. Insulate all duct access doors per U.L. listing and label per N.F.P.A.-96.

D. Furnish and install all material per manufacturer's installation requirements and per U.L. listing. Install support hangers, duct access door enclosures, and through penetration systems in accordance with NFPA-96, A.S.T.M. listing, and manufacturer's installation requirements.

E. Insulate all access doors and pitot tube openings. Install signs indicating either "access door" or "pitot tube".

2.9. FIELD-APPLIED JACKET

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto PVC Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.

3. Color: High gloss white.

4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

2.10. HANGER BLOCKS

A. For all pipes larger than 3 inches in diameter the hanger blocks shall be high compressive strength foam or wood blocks. Wood blocks shall be precision cut thickness to match specified insulation and shall include flared edge hanger saddle as manufactured by Buckaroo.

B. The wood blocks shall be suitable for temperatures from -120 degrees Fahrenheit to 200 degrees Fahrenheit. Do not utilize the wood blocks for piping systems operating outside of the indicated temperature range.

C. Wood blocks are not acceptable for use at refrigerant pipe hangers.

PART 3. EXECUTION

3.1. WORKMANSHIP

A. The Contractor shall take special care to prevent soiling equipment below or adjacent to areas being insulated. He shall be completely responsible for removing insulation cement splashes and smears and all surfaces that he mars or otherwise soils or defaces, and he will be totally responsible for restoring these damaged surfaces to their like-new condition when delivered to the site.

3.2. SITE INSPECTION

A. Before starting work under this section, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of materials and accessories under this section can begin.

B. Verify that all materials and accessories can be installed in accordance with project drawings and specifications and material manufacturers' recommendations.

C. Verify, by inspecting product labeling, submittal data, and/or certifications which may accompany the shipments, that all materials and accessories to be installed on the project comply with applicable specifications and standards and meet specified thermal and physical properties.

3.3. PREPARATION

A. Ensure that all pipe and equipment surfaces over which insulation is to be installed are clean and dry.

B. Ensure that insulation is clean, dry, and in good mechanical condition with all factory-applied vapor or weather barriers intact and undamaged. Wet, dirty, or damaged insulation shall not be acceptable for installation.

C. Ensure that pressure testing of piping or duct systems has been completed prior to installing insulation.

3.4. INSTALLATION

A. Piping Systems

1. General:

a. Install all insulation materials and accessories in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.
b. Install insulation on piping subsequent to installation of heat tracing, painting, testing, and acceptance tests.
c. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other. Butt insulation joints firmly to ensure complete, tight fit over all piping surfaces.
d. Maintain the integrity of factory-applied vapor barrier jacketing on all pipe insulation, protecting it against puncture, tear or other damage. Seal all tears, punctures and other penetrations of the pipe insulation vapor barrier coating.
e. On exposed piping, locate insulation and cover seams in least visible location.

2. Fittings: Cover valves, fittings, unions, flanges, strainers, flexible connections, expansion joints, pump bodies, drain valves, strainers, blowdowns, backflow

preventers, autoflow valves and similar items in each piping system using one of the following:

a. Mitered sections of insulation equivalent in thickness and composition to that installed on straight pipe runs.
b. Cold pipe fittings: Apply a tack coat of vapor barrier coating and reinforcing mesh to produce a smooth surface. After ½ hour, apply a second coat of same vapor barrier coating, UL labeled, Type C, for cold water piping.
c. Hot pipe fittings and Type H for hot water piping: Apply tack of breather mastic. Wrap fitting with fiberglass reinforcing cloth overlapping adjoining sections of pipe insulation by 2-inches. Apply a second coat of Type C or Type H breather mastic over the reinforcing cloth, working it to a smooth finish.
d. Insulation cement equal in thickness to the adjoining insulation.
e. PVC fitting covers insulated with material equal in thickness and composition to adjoining insulation.

3. Penetrations: Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise specified.

4. Joints:

a. Butt pipe insulation against hanger inserts. For hot pipes, apply 3-inch (7.5cm) wide vapor barrier tape or bank over butt joints. For cold piping, apply wet coat of vapor barrier lap cement on butt joints, and seal joints with 3-inch (7.5cm) wide vapor barrier tape or band.
b. All pipe insulation ends shall be tapered and sealed, regardless of service.

5. For heat traced piping, insulate fittings, joints, and valves with insulation of like material, thickness and finish as adjoining pipe. Size insulation large enough to enclose pipe and heat trace. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

6. Indoor piping shall be ASJ max with SSL-II closure system as manufactured by Owens Corning, Johns Manville, Knauf or approved equal.

7. Exterior above ground piping shall be insulated with ASJ max SSL-II closure system insulation. Fiberglass insulation with aluminum jacketing shall be utilized for exterior above ground applications. Seal all aluminum jacketing laps with 1/8” bead of metal jacketing sealant to prevent water entry.

8. All floor drain piping that is indicated to receive A/C condensate shall be fully insulated to prevent condensation.

B. Equipment Insulation:

1. General:

a. Install insulation in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended

purpose.

b. Install insulation on equipment after installation of heat tracing, painting, testing, and acceptance tests.

c. Install insulation materials with smooth, even surfaces. Rework poorly fitted joints. Do not use joint sealer or mastic as filler for joint gaps and excessive voids resulting from poor workmanship. Apply insulation using staggered joint method for both single and double layer installation, applying each layer of insulation separately.

d. Coat insulated surfaces where specified on contract drawings with layer of insulating cement, troweled in a workmanlike manner, leaving a smooth and continuous surface. Fill in seams, broken edges, and depressions. Cover over wire mesh and joints with cement sufficiently thick to remove surface irregularities.

e. Maintain the integrity of factory-applied vapor barrier jacketing on all insulation, protecting it against puncture, tears or other damage. Seal all tears, punctures and other penetrations of equipment insulation facing.

f. Where specification calls for field-applied all-service vapor barrier jacketing, it shall be neatly fitted and tightly secured. Lap seams 2-inches (5cm) (min.). Seal all joints with adhesive. Tape with 3-inches (7.5cm) matching pressure-sensitive tape or 3-inch (7.5cm) glass fabric and vapor barrier coating.

g. On exposed equipment, locate insulation and cover seams in least visible location.

2. Removable Insulation: Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance, such as vessel covers, fasteners, flanges, frames accessories, manholes, handholes, cleanouts ASME stamp, and manufacturer nameplates.

3. Areas Left Uninsulated: Items such as boiler manholes, handholes, clean-outs, ASME stamp, and manufacturers' nameplates should be left uninsulated unless omitting insulation would cause a condensation problem. When such is the case, provide removable insulation and appropriate tagging to identify the presence of these items. Provide neatly beveled edges at interruptions of insulation.

4. Equipment Exposed to Weather: Protect outdoor insulation from weather by installation of weather barrier mastic protective finish or jacketing as recommended by the jacketing manufacturer.

C. Ductwork Insulation:

1. General:

a. Before installing insulation, ensure that all seams and joints in ductwork have been sealed and leak tested by the contractor responsible for the duct system. Before applying duct insulation, air ducts shall be clean and dry.

b. Install insulation in accordance with manufacturer's published instructions and recognized industry practice to ensure that it will serve its intended purpose.

c. Install insulation materials with smooth and even surfaces. Butt joints firmly together to ensure complete and tight fit over surfaces to be covered.

d. Maintain the integrity of factory-applied vapor barrier jacketing on all insulation, protecting it against puncture, tears or other damage. All staples used on ductwork insulation shall be coated with suitable sealant to maintain vapor barrier integrity and covered with pressure sensitive vapor barrier tape and vapor barrier coating as specified.

e. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and exposed joints. All portions of duct designated to receive duct wrap shall be completely covered with duct wrap.

f. To ensure installed thermal performance, duct wrap insulation shall be cut to "stretch-out" dimensions. Maintain specified duct insulation thickness and vapor barrier at all fittings, obstructions, and duct flanges.

g. A 2-inch (50mm) piece of insulation shall be removed from the facing at the end of the piece of duct wrap to form an overlapping stapling and taping flap.

h. Install duct wrap insulation with facing outside so that the tape flap overlaps the insulation and facing at the other end of the piece of duct wrap. Adjacent sections of duct wrap insulation shall be tightly butted with the 2-inch (50mm) stapling and taping flap overlapping. If ducts are rectangular or square, install so insulation is not excessively compressed at corners. Seams shall be stapled approximately 6-inches (150mm) on center with 2-inch (13mm) (min) steel outward clinching staples.

i. Seams, joints and staples shall be sealed with pressure-sensitive tape matching the insulation facing (either plain foil or FRK backing stock) and glass fabric and vapor barrier coating. Cloth duct tape of any color or finish using reclaimed rubber adhesives shall not be utilized on duct wrap insulation. Adjacent sections of duct wrap shall be tightly butted with the 2-inch (50mm) tape flap overlapping.

j. Where rectangular ducts are 24-inch (600mm) in width or greater, duct wrap insulation shall be additionally secured to the bottom of the duct with mechanical fasteners such as pins and speed clip washers, spaced on 18-inch (425mm) centers (maximum) to prevent sagging of insulation.

k. Seal all tears, punctures and other penetrations of the duct wrap facing using one of the above methods to provide a vapor tight system.

l. Upon completion of installation of duct wrap and before operation is to commence, visually inspect the system and verify that it has been correctly installed.

m. Open all system dampers and turn on fans to blow all scraps and other loose pieces of material out of the duct system. Allow for a means for removal of such material.

n. Check the duct system to ensure that there are no air leaks through joints.

o. No ductwork insulation shall be supported utilizing tie wire or bailing wire. Penetrations of ductwork insulation vapor barrier are prohibited.

p. Bevel and terminate insulation at access doors. Paint edges with vapor barrier mastic.

q. Install insulation board between volume dampers and sheet metal standoffs.

r. Provide removable insulation section at all pitot tube traverse points. Insulation section shall contain tether that attaches to adjacent ductwork.

2. Penetrations: Extend ductwork insulation without interruption through walls,

floors and similar ductwork penetrations, except where otherwise specified.

3. Ductwork Exposed to Weather: Protect outdoor insulation from weather by installing outdoor weather barrier mastic or jacketing as recommended by the insulation manufacturer.

4. Rigid Insulation:

   a. Rigid duct insulation may be impaled over welded pins and secured with insulation caps and washers matching the color of the vapor barrier facing. All seams shall be firmly butted and sealed with pressure-sensitive vapor barrier tape matching the facing and vapor barrier coating.
   b. Corner angles shall be installed on all external corners of rigid duct insulation in exposed finished areas before jacketing, except oven and hood exhaust duct insulation, which shall have no corner angles.

5. Duct Wrap Insulation: Duct wrap insulation shall be applied with all joints butted firmly together. All joints in the insulation covering shall be sealed with adhesive. Duct wrap insulation shall be secured to bottom of rectangular or oval ducts over 24inches (60cm) wide with mechanical fasteners on 16-inch (40 cm) (approx.) centers to prevent sagging.

6. Duct Lining Insulation: Duct liner insulation shall be applied with all joints tightly butted using 90 percent coverage of adhesive meeting the requirements of ASTM C 916 plus mechanical fasteners spaced according to the liner manufacturer's schedule for the interior width of the plenum, housing, or air shaft. (Also refer to Division 23 Section, HVAC Air Distribution System.)

3.5. FIELD QUALITY ASSURANCE

A. Upon completion of all insulation work covered by this specification, visually inspect the work and verify that it has been correctly installed. This may be done while work is in progress, to assure compliance with requirements herein to cover and protect insulation materials during installation.

3.6. PROTECTION

A. Replace damaged insulation which cannot be satisfactorily repaired, including insulation with vapor barrier damage and moisture-saturated insulation.

B. The insulation contractor shall advise the general and/or the mechanical contractor as to requirements for protection of the insulation work during the remainder of the construction period, to avoid damage and deterioration of the finished insulation work.

3.7. SAFETY PRECAUTIONS

A. Insulation contractor's employees shall be properly protected during installation of all insulation. Protection shall include proper attire when handling and applying insulation materials, and shall include (but not be limited to) disposable dust respirators, gloves, hard hats, and eye protection.

B. The insulation contractor shall conduct all job site operations in compliance with applicable provisions of the Occupational Safety and Health Act, as well as with all state and/or local safety and health codes and regulations that may apply to the work.

3.8. INSULATION COVERING

A. Unless otherwise noted, all exposed duct and equipment insulation shall have a field applied PVC jacket cover neatly cut and pasted over ductwork and equipment insulation. PVC shall be high gloss white and shall be 20 mils thick.

B. Unless otherwise noted, all exposed pipe insulation required to be insulated shall be jacketed with a PVC Jacketing with fitting covers. PVC jacket shall be color fade resistant, white high gloss, U.S.D.A. authorized as manufactured by Proto Corporation or approved equal. PVC jacketing shall be high impact, ultraviolet resistant PVC. Minimum thickness shall be 20 mils, roll stock ready for shop or field cutting and forming.

C. Exposed areas include, but are not limited to, all mechanical equipment rooms/fan rooms, mezzanines, penthouses, boiler rooms, kitchens, electric rooms, storage rooms, janitor closets, IDF rooms, fire pump rooms, and stairwells piping and ductwork, exposed in an occupied space.

D. Where PVC jackets are indicated, install with 1 inch overlap at longitudinal seams and end joints, for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

E. Exterior exposed pipe insulation required to be insulated shall be jacketed with a corrugated aluminum jacketing system as previously described. Seal all laps with 1/8” bead metal jacketing sealant.

END OF SECTION

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DUST COLLECTION SYSTEM
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SECTION 23 07 10
DUST COLLECTION SYSTEMS

PART 1. GENERAL

1.1. GENERAL

A. For general mechanical requirements, see Division 23 Section, Common Work Results for HVAC and Division 01 General Requirements.

B. Industrial exhaust system for duct collection shall be constructed with materials recommended herewith and shall be installed in a permanent and workmanlike manner.

C. Interior of all ducts shall be smooth and free from obstructions, with all joints, fittings, and connections welded airtight. Duct construction shall be Class II. All duct construction shall be in accordance with the references hereinafter specified.

D. All duct sizes shown are net inside clear dimensions. Unless otherwise indicated size runouts, drops, and connections to dust collectors, floor sweeps, filters and other equipment to the full size of the equipment connection.

E. Minor changes may be made in duct sizes where required to fit the available space, provided the indicated net free area and approximate aspect ratio are maintained.

F. Smoothly transition all ductwork to prevent excessive or unnecessary turbulence or pressure loss.

G. All exposed ductwork in finished areas shall be painted in color as selected by Architect/Engineer. All ductwork requiring paint shall be constructed of paint grade material with a paintable surface.

1.2. REFERENCES

A. ACGIH - Industrial Ventilation, A Manual of Recommended Practice.

B. AMCA 99 - Standards Handbook.

C. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

D. AMCA 300 - Test Code for Sound Rating Air Moving Devices.

E. AMCA 301 - Method of Calculating Fan Sound Ratings from laboratory Test Data.

F. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Sheet Articles.

G. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.

H. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.

I. AASTM A 527 - Steel Sheet, Zinc Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.

J. ASTM A 569 - Steel, Carbon (0.15 Maximum Percent), Hot-Rolled Sheet and Strip, Commercial Quality.

K. AWS D9.1 - Welding of Sheet Metal.

L. MNB PS 15 - Voluntary Product Standard for Custom Contact-Molded Reinforced-Polyester Chemical-Resistant Process Equipment.

M. NFPA-69 – Standard on Explosion Prevention Systems.

N. NFPA 91 - Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal or Conveying.

O. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

P. SMACNA - Round Industrial Duct Construction Standard.

Q. SMACNA - Rectangular Industrial Duct Construction Standard.

R. UL 181- Factory-Made Air Ducts and Air Connectors.

S. UL 214 - Test for Flame Propagation of Fabrics and Films.

1.3. QUALITY ASSURANCE

A. Fans

1. Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.

2. Sound Ratings: AMCA 301, tested to AMCA 300 and bear AMCA Certified Sound Rating Seal.

3. Fabrication: Confirm to AMCA 99.

1.4. REGULATORY REQUIREMENTS

A. Products requiring electrical connection: Listed and classified by Underwriters' Laboratories Inc, suitable for the purpose specified and indicated.

1.5. EXTRA MATERIALS

A. Provide one (1) set of additional filter media for cyclone dust collector.

1.6. ALTERNATES

A. Refer to Division 01 Section, Alternates - Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. DUST COLLECTOR

A. Furnish as complete intermittent duty, shaker fabric filter dust collector as shown on the contract drawings and/or listed on the equipment schedule. The system shall provide cleaning for a volumetric flow rate as scheduled on the contract drawings. The collector system shall have a minimum of 8 oz woven polyester filter media operating.

B. The collector shall include a fan section, filter section and hopper(s) with legs and quick release seal mechanism for connection to integral dust bin. The collector housing, hopper(s) and supports shall be constructed of carbon steel and the housing shall be reinforced for maximum pressure of the integral fan.

C. Exterior surfaces shall have a durable, textured multi-coat urethane finish which passes a 2000-hour salt spray test. Interior surfaces shall be primed only. The collector will have the scheduled cubic foot dust bin(s) sealed to the hopper bottom(s) by a hand operated quick release seal mechanism or shall have mechanism designed to accept 55-gallon drum (no fasteners or clamps are required). Color selection shall be by the Architect.

D. The hopper(s) shall have a deflector plate at the dirty air inlet to direct large particles directly into the dust bin and distribute the air. The hopper shall be supplied with covered openings so air inlets may be located on either side or the rear. Dust laden air will flow upward into the filter section which shall contain a single, multi-envelope filter with spring steel wire mesh inserts fitted with wear liners.

E. The slide out filter assembly shall be supported on runners retained by a quick release lever. The filtered air shall flow into the fan section.

F. The fan shall be a wheel design directly driven by a TEFC motor. Filter cleaning shall occur after each fan shut down. Filter shaking shall be via an eccentric mounted on TENV motor located on the side of the housing.

G. A controller shall be furnished, consisting of start/clean pushbuttons, timer and motor contactors with overloads for the fan and shaker motors, all in a NEMA 12 enclosure. The controller shall automatically activate the filter shaker motor for 35 seconds each time the fan is shut off. Furnish with magnehelic gauge, spark detection, inductive position sensor and associated alarms. Provide “remote start” button also inside building. Interlock with control panel.

H. The collector shall be supplied with lift-off hinged doors for access to the fan and filter chamber. No tools shall be required for filter removal and replacement.

I. The fan shall discharge into a special fan chamber designed for noise reduction. The noise level shall not exceed the scheduled db(A) at 1 meter radius from the collector housing.

J. The collector shall be a Donaldson Torit® Unimaster Model UMA as manufactured by Donaldson Company, Inc. or approved equal.

K. Provide and install high pressure NFPA-90A approved flexible connections on the dust collector inlet and outlet ducts. The entire unit shall be mounted on vibration isolators and

installed on a concrete housekeeping pad.

L. Furnish with inlet explosion isolation valve and return air kit.

2.2. DUCTWORK AND DUCT ACCESSORIES

A. Material

1. Galvanized coated carbon steel ducts: ASTM A 525 or ASTM A 527 galvanized steel sheet, lock-forming quality, having G90 zinc coating in conformance with ASTM A90 and suitable for 12-inch pressure class.

2. Stainless steel ducts: ASTM A167, Type 316 suitable for 12-inch pressure class.

B. Ductwork

1. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible 12-inch pressure class, round industrial duct construction, Standard and Rectangular Industrial Duct Construction Standard and ACGIH Industrial Ventilation Manual, except as indicated.

2. Construct T's, bends, and elbows with radius of not less than 1½ times the width of the duct on centerline.

3. Increase duct sizes gradually, not exceeding 25 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

4. Fabricate continuously welded round and oval duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Prime coat welded joints.

5. Use crimp joints with or without bead for joining round duct sizes 8 inches and smaller, with crimp in direction of air flow, with liquid adhesive plus sheet metal screws.

6. Joints: Minimum 4-inch (100mm) cemented slip type, brazed, or electric welded to AWX D9.1.

7. Provide standard 45-degree lateral wye branch fittings unless otherwise indicated.

8. Use double nuts and lock washers on threaded rod supports.

9. All exterior industrial exhaust ducts shall be constructed of Type 316 stainless steel.

10. The following metal thickness shall be supplied:

DIAMETER OF STRAIGHT DUCTS	US STANDARD GAUGE FOR 316 STAINLESS STEEL DUCTS
To 8 inches	20

Over 8 inches to 18 inches	18
Over 18 inches to 30 inches	16
Over 30 inches	14

11. All motor-operated dampers located in stainless steel ductwork shall be constructed of Type 316 stainless steel. All motor-operated dampers shall be provided by ATC subcontractor and installed by Mechanical Contractor.

12. Longitudinal joints of ducts shall be continuously welded with seams up.

13. Girth joints of duct shall be made with inner lap in direction of air flow, with 1 inch lap, diameters to 19 inches, and 1-1/4 inch laps for diameters over 19 inches. All joints shall be continuously welded.

14. Elbows and angles shall have a centerline radius of 2.5 pipe diameters. Construct elbows 6 inches or less in diameter of at least five sections, over 6 inches diameter of seven sections. Prefabricated elbows of smooth construction may be used. Angles shall be pieced proportionately. Prefabricated elbows shall be industrial duct fittings manufactured by United McGill, or as approved equal.

15. Hoods must be free of sharp edges or burrs and reinforced to provide necessary stiffness.

16. All welds shall be by gas fusion using rods of similar material.

17. Hangers shall be Type 316 stainless steel hanger; and support spacing shall be in accordance with SMACNA's standards for round industrial ducts.

18. Connect duct to fan inlet with split sleeve drawband at least one pipe diameter long, but not less than 12 inches.

19. Transitions in mains and sub-mains to be tapered; taper 5 inches long for each 1inch change in diameter. Transitions shall be eccentric: Flat on bottom.

20. All branches shall enter main at the large end of transition at an angle not to exceed 30 degrees. Connect branches only to top or sides of main with no two branches entering diametrically opposite.

21. Provide dead-end caps within 6 inches from last branch of all mains and sub-mains.

22. Provide access openings or cleanouts every 10 feet and near each elbow, angle or duct junction in horizontal sections, except for non-corrosive gauges and vapors containing no particulate matter.

23. Support ducts sufficiently to place no load on connecting equipment and to carry weight of system if plugged with material. Maximum supporting interval 12 feet for 8 inch or smaller ducts, 20 feet intervals for larger ducts.

24. Provide 6 inch minimum clearance between ducts and ceiling, wall or floors.

25. Where blast gates are used for adjustment of system, place near connection of branch to main. Provide means of locking after adjustments have been made. Butterfly-type dampers shall not be permitted.

26. Fire dampers, explosion vents, etc., should be installed in accordance with National Fire Protection Association Codes or local fire ordinances.

27. Where state or local laws conflict with above specifications, the more stringent regulation shall be followed. Any other deviation must be approved before installation.

C. Flexible Connections: UL 214 listed, fire-retardant chloroprene or chlorsulfonated polyethylene impregnated fabric, minimum density 36 oz. per square yard, approximately 6 inches wide, crimped into metal edging strip.

D. Angle Rings: Carbon Steel, unpainted, leg out, drilled with bolt holes.

E. Flat Back Elbows: Long radius rectangular elbow at duct material with heavy gauge, removable, stainless steel back strip.

F. Ball Joints: Cast iron -- spun galvanized steel -- with tubular studs for connecting ducts, allowing 25 degree angle off center.

2.3. INLET FITTINGS

A. Fabricate of minimum 16 gauge galvanized coated carbon steel.

B. Fabricate with hemmed edges, closed corners, and reinforced for span and attachment; with duct connection prime-coated enameled finish.

2.4. WOOD WORKING DUST COLLECTION EQUIPMENT

A. Floor Sweeps: Shall be Car-Mon Series 55-F, AQC Dust Collection Systems, or approved equal. Floor sweeps shall be constructed of 18 gauge galvanized steel, welded construction and floor mounting bracket with 3/8 inch diameter holes for permanent attachment. Assembly shall be complete with built-in hinged damper with foot-operated damper door opener, including linkage pivots.

B. Blast Gate Dampers: Provide and install where indicated on Contract Drawings Car-Mon Series BG, AQC Dust Collection Systems, or approved equal. Blast gate dampers shall be 2-piece cast construction with fully adjustable sliding gate and set screw for permanent damper settings. Select blast gate size to match duct system in which damper is installed.

C. Flexible Tubing: For use with wood working equipment shall be Car-Mon Type NE, AQC Dust Collection Systems, or approved equal. Tubing shall be scuff-resistant type, constructed of a fire-retardant fabric with interior and exterior surfaces impregnated with neoprene. The tubing wall shall be two ply, triple overlap construction, having a total wall thickness of .045 inches. It shall be completed with a bonded exterior scuff strip to provide abrasion resistance. Tubing shall have an interior steel wire reinforcing spiral encased within the neoprene and fabric lamination to prevent the collapsing of the tubing and to help retain its shape. Tubing shall be of diameter and length as indicated on Contract

Drawings.

D. Lock Couplers: For capping off unused pieces of equipment shall be Car-Mon CM Series, AQC Dust Collection Systems, or approved equal. Lock couplers shall be constructed of 20 gauge stainless steel, seam-welded, designed for quick connection of flexible tubing to straight pipe. Provide chain and cap assembly for capping off connections when not in use. Lock coupler shall be suitable for connection to Car-Mon Type NE flexible tubing, AQC Dust Collection Systems, or approved. Provide quantity and size as indicated on Contract Drawings.

2.5. DUST COLLECTOR SOUND ENCLOSURE

A. Dust Collector Sound Enclosure: Equipment casings and enclosures shall be constructed of APT-O-LITE panel systems manufactured by APT Industries, Inc., AQC Dust Collection Systems, or approved equal.

B. Panels shall be 2" thick with a core of 2 ½ lb./cu. ft. density fire retardant U.L. Class I modified polyisocyanurate/polyurethane closed-cell non-absorptive, non-sagging, non-settling, vermin proof rigid foam insulation sandwiched between two metal skins. The panels shall be completely free of any type of internal framing or stiffeners. To ensure a completely purged core, free of any voids, the foam shall be expanded in-place in a vertical direction from the panel bottom. The panel skins shall be .032" embossed aluminum.

C. The panel system shall be joined by interlocked no-thru metal extruded aluminum thermal structural members, specifically designed to ensure an insulated, air-tight joint while simultaneously reinforcing the panels for high pressure and high loading applications.

D. All panel joints shall be sealed air and watertight with a specially formulated silicone sealer and shall be mechanically fastened with drill point screws (pop rivets).

E. The assembled panel system shall comply with the requirements of NFPA-90A. Independent lab tests shall be available upon request.

F. APT-O-LITE type ENT access doors shall be sized as required for access with the door construction & material matching that of the panels. Access doors shall be completely factory-mounted, using heavy-duty stainless steel hinges & chrome-plated cam-type lever latches, operable from both sides. Doors shall be mounted to open against air pressure and seal against a heavy neoprene gasket around the full perimeter. Each access door shall include an inspection window.

G. A complete package including piece-marked panels, extrusions, trim angles, fasteners, sealer, and detailed CAD erection drawings shall be provided by the panel manufacturer. For applications requiring additional structural reinforcement, the installing contractor shall provide structural supports as recommended by the panel manufacturer.

H. Acoustical Absorption treatment shall be added to the interior surface of the panels to provide sound absorption for equipment housed inside the panel enclosure. The acoustical treatment shall consist of 2 inches of acoustical fiber completely encased with perforated material mechanically attached to panel surface.

I. A one-piece blanket membrane roofing system, sized to cover the entire enclosure, shall

be provided by the panel manufacturer. The roofing system shall include all necessary adhesives, sealers, and trim pieces as required for a complete installation by the contractor.

PART 3. EXECUTION

3.1. INSTALLATION

A. Install equipment in accordance with manufacturer's instructions.

B. Install in accordance with NFPA 91, SMACNA HVAC Duct Construction Standards - Metal and Flexible 12-inch pressure class, Round Industrial Duct Construction Standard and Rectangular Industrial Duct Construction Standard and ACGIH Industrial Ventilation Manual, except as indicated.

C. Do not operate fans for any purpose until ductwork is clean, filters are in place, bearings have been lubricated, and fan has been test-run under observation.

D. Install fans with resilient mountings and flexible electrical leads.

E. Install flexible connections at dust collector inlet and discharge. Ensure metal bands of connectors are parallel with minimum one-inch (25mm) flex between ductwork and fan while running.

F. Provide pitot tube openings where required for testing of systems, complete with metal cap with spring device or screw to ensure against air leakage.

G. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

H. Connect to fire protection system with a shut-off valve, flow switch, and tamper switch. Interlock with fire protection system.

3.2. TESTING AND BALANCING

A. Testing: measure the air flow in the system with a standard pitot tube to determine whether it is functioning in accordance with design specification. All branch ducts shall be tested to assure design air flow rates as schedule on contract documents. Static pressure profiles shall be conducted at all fan systems as indicated in Division 23 Section, Testing Adjusting & Balancing for HVAC & Plumbing.

3.3. LEAKAGE TESTS

A. All sheet metal ductwork shall undergo leakage test at 10 inch W.G. Test shall be accomplished under this section and witnessed as specified under Division 23 Section, Testing Adjusting & Balancing for HVAC & Plumbing.

B. Leakage from each duct system shall not exceed 1 percent for high pressure of the nominal dust collection capacity of the system. If the system ductwork is tested in sections, the leakage shall not exceed ½ of 1 percent of the CFM to be handled by that section; and the total leakage of the system shall not exceed 1 percent of the total system CFM. Test pressure shall not exceed the pressure limits of the duct construction as defined in

SMACNA High Pressure Duct Construction Standards. Repair all leaks which are audible, regardless of the leakage rate of the duct system as a whole, by remaking the entire defective joint or seam. Spot sealing of ducts in place will not be acceptable.

C. Submit a complete report of the ductwork leakage test to the Architect/ Engineer and include final approved copies in the Test and Balance Reports.

END OF SECTION

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DIVISION 23 SECTION 23 09 00
INSTRUMENTATION AND CONTROLS OF HVAC AND PLUMBING SYSTEMS
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SECTION 23 09 00
INSTRUMENTATION AND CONTROLS OF HVAC AND PLUMBING SYSTEMS

PART 1. GENERAL

1.1. SUMMARY

A. For General Mechanical Requirements, see Division 23 Section, Common Work Results for HVAC, and Division 01 Sections.

B. Comply with all code requirements and fire safety requirements as specified in Division 23 Section, Common Work Results for HVAC.

C. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

D. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory wired controls.

E. The automatic temperature control system ATC and central control and monitoring system (CCMS) shall be electric/electronic direct digital control (DDC), Alerton as installed by Albireo Energy, Johnson Controls (Metasys), Johnson Controls FX (Facility Explorer) as installed by Modern Controls, Honeywell, Siemens, Automated Logic Corporation, Reliable Controls, Schneider Electric as installed by Tri-M, Advanced Power, Trane, and TAC Controls by Schneider Electric installed by Automation and Control Concepts or Niagara. All work associated with the automatic temperature control system shall be performed by personnel regularly and directly employed by the Automatic Temperature Controls Contractor. Control System shall be web based, allowing the client access via a standard web browser.

F. Coordinate controls with controlled equipment. Upon completion of the work, calibrate and adjust all controls for proper function. Electric wiring, including interlock wiring for all equipment shall be furnished and installed under this section. All electrical work shall conform to the applicable requirements of Division 26.

G. All automatic temperature control dampers, valves and separable wells for immersion elements furnished by the Control Manufacturer shall be installed by the Mechanical Contractor or his sheet metal subcontractor under the Control Manufacturer's supervision.

H. Reference is hereby made for this contractor to become familiar with Division 26 of these specifications. Familiarization is for coordination purposes only. The control contractor shall provide all necessary relays, contacts, interlock wiring etc. not provided under Division 26 for the automation of the ATC and CCMS systems as required by the sequence of operation and input/output schedule. The control contractor shall coordinate all requirements with the building Fire Alarm System. The control contractor shall provide all additional devices and interlock wiring required for the automation of the ATC system and monitoring of the CCMS system.

I. Furnish all labor, materials, software, equipment and services necessary for and incidental to furnishing and installing a complete direct digital control, automatic temperature control

system to meet the requirements of the sequence of operation described on the Drawings.

J. Unless the necessary items are specified to be provided with mechanical equipment by Division 23, the ATC contractor shall coordinate with Division 23, Mechanical, and shall furnish and install all items necessary to meet the requirements of the Sequence of Operation and the Central Control and Monitoring System (CCMS) indicated on the drawings and as required in this specification.

K. The control system shall include all necessary and specified control equipment properly installed in accordance with the specifications and drawings and shall include, but not be limited to the automatic temperature control and energy management system of the following:

1. Air Handling Units, Heating and Ventilating Units
2. Airflow Monitoring Stations
3. Air Curtains
4. Automatic Glycol Feeder
5. Baseboard Radiators
6. Boilers
7. Building Facilities
8. Building Demand and Energy Consumption
9. Carbon Monoxide Ventilation Systems
10. Carbon Monoxide Systems
11. Carbon Dioxide Sensors
12. Chilled Water Systems
13. Clothes Dryer
14. Condensate Overflow Safety Switches
15. Condensing Units
16. Control Valves
17. Differential Bypass Valves Transmitters
18. Dish Machine Exhaust Fan
19. Domestic Hot Water Systems

20. Domestic Booster Pump System
21. Domestic Water Consumption/Meters
22. Duct Heating Coils
23. Ductless Units
24. Dryer Duct Booster Fans
25. Duct Detector Fan Interlocks
26. Dust Collector Systems including Spark Detection/Extinguisher and Control Panel Wiring
27. Economizer Systems
28. Energy Recovery Ventilators
29. Elevator Sump Pumps
30. Electric Radiant Heat Panels
31. Electric Heating Equipment
32. Exterior Lighting Systems
33. Fan Coil Units.
34. Flow Measuring Stations
35. Flow Switches
36. Freeze Protection Pumps
37. Fume Hood Systems
38. General Exhaust Systems
39. Generator Monitoring
40. Glycol Feed Systems
41. Heat Pipes
42. Heating System
43. High Temperature Alarms
44. Hot Water Coils
45. Industrial Exhaust Fans

46. Industrial Air Cleaners
47. Kitchen Ventilation System
48. Lighting Systems (Interior and Exterior)
49. Make-up Water Systems Interlocks and Alarms
50. Make-up Air Units
51. Mechanical Room Heat and Ventilation Control
52. Miscellaneous interlocks required for gas systems, ventilation systems, etc.
53. Plug Load Management
54. Plumbing Systems
55. Pumps
56. Relief Air Fans/Dampers
57. Rooftop Units.
58. Radiant Heat Panels
59. Relative Humidity/Temperature Sensors
60. Sensors (i.e., temperature, relative humidity, CO_2, etc.)
61. Smoke Removal Assist System
62. Paint Spray Booth/Fans/Heat
63. Solenoid Valves
64. Single Zone VAV Units
65. Static Pressure Controllers
66. Unit Heater/Baseboard Radiation/Panel Radiator Control
67. Variable Speed Drives
68. Ventilation Systems
69. 100% Outside Air Units
70. Water Heaters
71. Welding Ventilation Systems

L. All labor, material, equipment and software to meet the functional intent of the system, as specified herein and as shown on the drawings, shall be included. Drawings are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans, that are required to meet the functional intent, shall be provided without additional cost to the owner.

M. Where equipment is specified to be provided by equipment manufacturer or where packaged controls are specified map out all points provided by the manufacturer so the same can be viewed by ATC system. As a minimum all points indicated in the point list and control diagram must be viewable and adjustable from the ATC system. Coordinate with equipment manufacturer.

1.2. DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Main tracking/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

H. UPS: Uninterruptible Power Supply.

I. NAE: Network Automated Engine.

1.3. SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.

2. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.

3. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.

4. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.

5. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.

6. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.

7. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

a. Water Temperature: Plus or minus 1 deg F (0.5 deg C).
b. Water Flow: Plus or minus 5 percent of full scale.
c. Water Pressure: Plus or minus 2 percent of full scale.
d. Space Temperature: Plus or minus 1 deg F (0.5 deg C).
e. Ducted Air Temperature: Plus or minus 1 deg F (0.5 deg C).
f. Outside Air Temperature: Plus or minus 2 deg F (1.0 deg C).
g. Dew Point Temperature: Plus or minus 3 deg F (1.5 deg C).
h. Temperature Differential: Plus or minus 0.25 deg F (0.15 deg C).
i. Relative Humidity: Plus or minus 5 percent.
j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
l. Air Pressure (Space): Plus or minus 0.01-inch wg (2.5 Pa).
m. Air Pressure (Ducts): Plus or minus 0.1-inch wg (25 Pa).
n. Carbon Monoxide: Plus or minus 5 percent of reading.
o. Carbon Dioxide: Plus or minus 50 ppm.
p. Electrical: Plus or minus 5 percent of reading.

1.4. DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.5. COORDINATION

A. Coordinate location of temperature sensors, humidity sensors, CO_2 sensors, dewpoint sensors, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 28 Section, “Fire Alarm System” to achieve compatibility with equipment that interfaces with that system.

C. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

D. Coordinate equipment with Division 26 Section, Electricity Metering to achieve compatibility of communication interfaces.

E. Coordinate equipment with Division 26 Section, Panelboards to achieve compatibility with starter coils and annunciation devices.

1. Coordinate equipment with Division 26 Section, Motor-Controllers to achieve compatibility with motor starters and annunciation devices.

1.6. WORK BY OTHERS

A. Automatic temperature control valves, air flow stations, pipe taps, flow meters, and separable wells for immersion elements furnished by the control manufacturer shall be installed by the mechanical contractor under the control manufacturer's supervision. The control contractor shall deliver to the mechanical contractor valves and wells for installation within the various systems.

B. All automatic dampers furnished by the control manufacturer shall be installed by the mechanical contractor under the control manufacturer's supervision.

1.7. QUALITY ASSURANCE

A. Supplier shall have an in-place support facility with technical staff, spare parts inventory and all necessary test and diagnostic equipment. The fully staffed and equipped office shall be within a 60 mile radius of the job site.

B. The systems shall be complete in all respects, and shall be installed by skilled personnel. The Control Contractor shall have a successful history in the installation and maintenance of automatic temperature control systems similar in size and performance to that specified herein.

C. Refer to Contract Drawings for sequences of operations, control diagrams, and points lists.

D. All electrical wiring in connection with the Automatic Temperature Control System shall be furnished and installed by the ATC Contractor. This shall include all interlock wiring between the air handling units, kitchen ventilation systems, fans, pumps, heating systems, boilers, chillers, switches, dampers, heat pumps, energy recovery ventilators, ductless units, condensing units, static pressure controllers, and H&V units, single zone VAV units, industrial ventilation systems, flow measuring stations, airflow monitoring stations, etc.

E. Bids by wholesalers, contractors or franchised dealers or any other firm whose principal business is not that of manufacturing or installing automatic temperature control systems, shall not be acceptable. Bid documents that are not complete in their response to these documents or take exception to any of the capabilities defined within these documents shall not be acceptable.

F. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

H. Comply with ASHRAE 135 for DDC system components.

1.8. GUARANTEE AND INSTRUCTION

A. The control system including all components, system software, parts and assemblies herein specified shall be free from defects in workmanship and materials under normal use and

service. After completion of the installation, the Control Manufacturer shall regulate and adjust all thermostats, control valves, control motors, and other equipment provided under this contract. If within two (2) years from the date of acceptance by Owner any of the equipment herein described is proved to be defective in workmanship or materials, it will be replaced or repaired at no additional cost to the Owner. The Control Manufacturer shall, after completion, provide any service incidental to the proper performance of the Control System under guarantees outlined above for a period of two (2) years. Normal maintenance of the system is not to be considered part of the guarantee. All corrective modifications made during warranty service periods shall be updated on all user documentation including "as-built" shop drawings and on user and manufacturer archived software disks.

B. The control contractor shall completely check out, calibrate and test all connected hardware to insure that the system performs in accordance with the approved specifications and sequences of operation submitted.

C. Upon completion of the work, the control drawings encased in heavy plastic shall be provided where directed. Layout shall show all control equipment and the function of each item indicated.

D. The temperature control contractor's office shall be within a 100 mile radius of the job site.

E. The contractor shall respond to the job site with qualified technicians within a 4 hour period for any emergency relating to the control system or energy management systems.

F. This agreement shall include emergency service during normal working hours.

1.9. SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.

2. Schematic flow diagrams showing equipment, fans, pumps, coils, dampers, valves, and control devices.

3. Wiring Diagrams: Power, signal, and control wiring.

4. Details of control panel faces, including controls, instruments, and labeling.

5. Written description of sequence of operation.

6. Schedule of dampers including size, leakage, and flow characteristics.

7. Schedule of valves including flow characteristics.

8. DDC System Hardware:

   a. Wiring diagrams for control units with termination numbers.
   b. Schematic diagrams and floor plans for field sensors and control hardware.
   c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.

10. Controlled Systems:

    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.
    d. Points list.

C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with LonWorks or Bacnet.

D. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.

2. Program Software Backup: On a magnetic media or compact disc, complete with data files.

3. Device address list.

4. Printout of software application and graphic screens.

5. Software license required by and installed for DDC workstations and control systems.

E. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

F. Qualification Data: For Installer and manufacturer.

G. Field quality-control test reports.

H. Submit screen shots of ATC system graphics at substantial completion.

I. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section, Operation and Maintenance Data, and Division 23 Section, Common Work Results for HVAC include the following:

1. Maintenance instructions and lists of spare parts for each type of control device.

2. Interconnection wiring diagrams with identified and numbered system components and devices.

3. Keyboard illustrations and step-by-step procedures indexed for each operator function.

4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

5. Calibration records and list of set points.

J. Upon completion of the work, provide a complete set of “as-built" drawings and application software on CD, USB, or other type of electronic storage device. Drawings shall be provided in format as acceptable to the Owner’s files. Submit as-built drawings and specification to Owner's representative for review and approval prior to final project closeout.

1.10. SOFTWARE LICENSE AGREEMENT

A. The owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software. All software and hardware upgrades shall be included in two (2) year warranty period.

B. Software license agreement shall not apply on projects where existing ATC system is being extended.

C. Minimum of four (4) software license seats shall be provided. Storage of all software shall be coordinated with the New Castle County’s Vocational School District IT Manager.

1.11. ELECTRICAL SURGE PROTECTION

A. It is the responsibility of the ATC/FMS contractor to provide adequate surge protection for all wall mounted control panels required for this project.

1. Devices under surge protection shall be of design that loss of memory will not occur in the event of the surge protection device being activated due to surge/spike conditions.

2. Surge protection devices will be required to be hard wired, with the exception of peripheral devices that use standard 110VAC plugs for connections (i.e. Modems).

3. Surge protection devices are to be rated for 120 VAC single phase, 20 (or greater) amps capacity.

4. Surge Protection devices to include internal fuse protection, audible surge alarm & LED indicators.

5. Surge protectors to have clamping voltage of 480V peak, maximum surge current rating of 50,000 amps. Unit to have NEMA 12 enclosure with wall mounting bracket and conduit connection.

1.12. TRAINING

A. The Automatic Temperature Controls (ATC) Contractor shall include in his bid, provisions for additional computer training at the company's regular school or training center. The ATC contractor shall include in his bid all costs associated with sending two (2) individuals to the ATC contractors school for a period of not less than one (1) week. This training is in addition to the aforementioned training required under the General Provisions.

B. The training time period shall be coordinated with the school system's facility Engineer. The schedule training period shall be arranged at the owner's convenience.

C. Cost shall include all training material, instruction books, and two copies of video tape with sound DVD of training session.

D. Upon completion of the work, the Control Contractor shall have completely adjusted the entire control system. He shall arrange to instruct the Owner's representative on the operation of the control system for a period of not less than two (2) eight (8) hour days. All training shall be by the control contractor and shall utilize specified manuals and as-built documentation.

E. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain control systems and components.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.

2. Provide operator training on data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs. Include a minimum of 40 hours' dedicated instructor time on-site.

3. Review data in maintenance manuals. Refer to Division 01 Section, Contract Closeout.

4. Review data in maintenance manuals. Refer to Division 01 Section, Operation and Maintenance Data.

5. Schedule training with Owner, with at least seven days' advance notice.

6. Control Contractor shall also attend and participate in separate HVAC equipment systems training in addition to ATC training.

1.13. ALTERNATES

A. Refer to Division 01 Section, Alternates for description of work under this section affected by alternates.

1.14. NEW CASTLE COUNTY VOCATIONAL TECHNICAL SCHOOL DISTRICT SPECIFIC REQUIREMENTS

A. The ATC Subcontractor shall include in his bid all costs associated with incorporating the following specific requirements:

1. All holiday schedules shall incorporate a 12 month block. Coordinate exact holidays, schedules, calendars, occupied, unoccupied periods with Owner prior to writing software. All schedules shall be reviewed and approved by the Owner.

2. Relays for ATC equipment shall not be located in ceilings. All relays shall be located in equipment control panels and/or mechanical rooms.

3. All exhaust fans shall be assigned a designated point. Utilizing relays to provide digital point for exhaust fans shall not be acceptable.

4. Graphics on ATC computer shall in addition to basic requirements indicate the percentage open or closed on all valves and dampers.

5. The ATC Computer Graphics shall incorporate the final room numbers actually utilized in the school. All room names utilized in the graphic display shall be reviewed and approved by the Owner.

6. The ATC Computer Graphics shall indicate for each item of equipment the “on” or “off” status and command shall be “run” or “stop”.

7. The ATC Computer Graphic shall indicate for each duct smoke detector the “on” or “off” status and command.

8. All temperature sensors, equipment, relative humidity sensors, current sensors, CO2 sensors, differential pressure sensors, etc. indicated on ATC Control Diagrams and point list shall be displayed on the ATC Computer Graphic. Measured value or status shall be displayed.

9. For any multi-stage HVAC units, the quantity of compressor stages and the quantity of electric heat stages shall be displayed on the Computer Graphics.

10. The exact space temperature set points, relative humidity set points, changeover

set points. etc., shall be coordinated with Owner prior to final data entry. All items indicated in sequences of Operation as "adjustable" shall be reviewed and approved by Owner prior to implementation of the same.

11. The outside air relative humidity and outside air temperature shall be monitored on ATC system and reported on ATC Computer Graphics. See Floor plans for exact locations.

12. Provide a graphic of all floor plans indicating location of all equipment interlocked with ATC System including all control panels.

13. Graphic shall also indicate area of building served by each item of equipment. Graphics shall indicate all global sensor readings.

14. For the heating water system, and chilled water system, provide a single command on the control system to allow all control valves to be manually opened for balancing by activating a single command.

15. All equipment shall be labeled with name of equipment, area served, and area location (room name/number).

16. Scheduling of HVAC equipment/zones shall be such that for afterhours use the ATC system shall allow a temporary override of the pre-set occupied/unoccupied schedule by zone and for specific equipment in a zone. This must allow the school staff the ability to operate as few or many zones as desired without operating entire portions of the building.

17. Provide "Loss of Heat" monitoring and alarm on ATC system if any space temperature sensor in the building drops below 50 degrees Fahrenheit (Adjustable).

18. Provide additional software package and license so that Owner can install software on Owner provided laptop. Assist owner with installation of software.

19. Provide a "demand toggle control" switch on ATC system to automatically reduce HVAC electric demand (power) by automatically modifying setpoints to pre-determined values. Coordinate pre-determined setpoint values with Owner and document in the As-Built Documents.

20. Scheduling of HVAC equipment/zones shall be such that for afterhours use the ATC system shall allow a temporary override of the pre-set occupied/unoccupied schedule by zone and for specific equipment in a zone. This must allow the New Castle County Vocational School District the ability to operate as few or many zones as desired without operating entire portions of the building.

1.15. GLOBAL SENSORS

A. General

1. Furnish and install global sensors and report the same on the automatic temperature control system.

2. Global sensors shall monitor and trend the following conditions:

a. Outside air temperature.
b. Outside air relative humidity.
c. Outside Air CO_2 level in ppm.
d. Chilled water supply temperature
e. Chilled water return temperature.
f. Heating water supply temperature
g. Heating water return temperature.
h. All ventilation fan speeds where variable frequency drives are specified.
i. Outside air carbon dioxide level.
j. All ventilation fan amperage where variable frequency drives are specified.
k. All pump or fan speeds where variable frequency drives are specified.
l. All pump amperage's where variable frequency drives are specified.
m. All fan amperages where variable speed fans are indicated. Graphic shall also indicate area of building served by each item of equipment.
n. Kitchen walk-in refrigerator and freezer space temperatures.
o. Main Distribution Frame (MDF), and I.T. server room space temperature sensor.
p. Global holiday schedules:
   i. Provide all interlock wiring and programming to allow a global holiday schedule for all equipment except the administration equipment. Global holiday schedule shall allow the Owner to shut down the entire building's HVAC systems if an unscheduled event occurs when school is cancelled.
   ii. System shall also be capable of individual scheduling of equipment as specified or all can be globally modified at once.
q. All equipment interlocked with ATC system shall be able to be turned on/off via ATC system as specified. Changing temperature set point alone is not acceptable method for turning equipment on/off.
r. Where valve or damper position is indicated ATC graphic shall indicate percentage open or percentage closed.

PART 2. PRODUCTS

2.1. BUILDING MANAGEMENT SYSTEM

A. The Building Management System (BMS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks.

B. The Building Management System shall consist of the following:

1. Standalone Network Automation Engine(s)

2. Field Equipment Controller(s)

3. Input/Output Module(s)

4. Local Display Device(s)

5. Distributed User Interface(s)

6. Network processing, data storage and communications equipment

7. Other components required for a complete and working BMS

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.

D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

E. Automation Network

1. The automation network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels.

2. The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.

3. Network Automation Engines (NAE) and/or system controllers shall reside on the automation network.

4. The automation network will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.

F. Control Network

1. Network Automation Engines and/or system controllers shall provide supervisory control over the control network and shall support all three (3) of the following communication protocols:

   a. BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9.
   b. LonWorks enabled devices using the Free Topology Transceiver (FTT-10a).
   c. The Johnson Controls N2 Field Bus or equivalent.
   d. Tridium FX-40
   e. Honeywell Webs
   f. TAC Controls by Schneider Electric
   g. Siemens P1/P2 Serial

2. Control networks shall provide either "Peer-to-Peer," Main-Tracking, or Supervised Token Passing communications, and shall operate at a minimum

communication speed of 9600 baud.

3. DDC Controllers shall reside on the control network.

4. Control network communication protocol shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135.

5. A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (main or tracking) that will communicate on the BACnet MS/TP Bus.

6. The Conformance Statements shall be submitted with the BAS Submittals.

G. Integration

1. Hardwired

a. Analog and digital signal values shall be passed from one system to another via hardwired connections.
b. There will be one separate physical point on each system for each point to be integrated between the systems.

2. BACnet Protocol Integration – BACnet

a. The neutral protocol used between systems will be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135-2003.
b. A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.
c. The ability to command, share point object data, change of state (COS) data and schedules between the host and BACnet systems shall be provided.

H. Dedicated Web Based User Interface

1. Where required by the Owner, the BMS Contractor shall provide and install a personal computer for command entry, information management, network alarm management, and database management functions. All real-time control functions, including scheduling, history collection and alarming, shall be resident in the BMS Network Automation Engines to facilitate greater fault tolerance and reliability. Coordinate with Owner to determine computer type (i.e. PC (Windows based) or Macintosh (Apple)).

2. Dedicated User Interface Architecture – The architecture of the computer shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BMS Contractor and by other third party applications suppliers, including but not limited to Microsoft Office Applications. Specifically it must be implemented to conform to the following interface standards.

a. Microsoft Internet Explorer for user interface functions
b. Microsoft Office Professional for creation, modification and maintenance of reports, sequences other necessary building management functions

c. Microsoft Outlook or other e-mail program for supplemental alarm functionality and communication of system events, and reports
d. Required network operating system for exchange of data and network functions such as printing of reports, trends and specific system summaries.

3. Computer Hardware – The personal computer(s) shall be configured as follows:

a. Description: A tower or all-in-one computer designed for normal use at a single, semipermanent location.
b. Performance Requirements:
   i. Performance requirements may dictate equipment exceeding minimum requirements indicated.
   ii. Energy Star compliant.
c. Personal Computer:
   i. Minimum Processor Speed: 3 gigahertz (GHz). Dual Core Processer.
d. RAM:
   i. Capacity: 16GB.
   ii. Speed and Type: 1333 MHz, SDRAM.
e. Hard Drive:
   i. Media: Solid state.
   ii. Number of Hard Drives: One.
   iii. Capacity: 250GB.
f. Optical Read and Write Drive:
   i. Include with at least 2 MB of data buffer.
   ii. Type: SCS1 CD-ROM Drive with Read/Write Capability.
   iii. Average access time of 150 ms or less.
g. At least four expansion slots.
h. Video Card:
   i. Resolution: 1920 by 1200 pixels.
   ii. RAM: 4 GB.
   iii. Controller Speed: 4GHz.
i. Sound Card:
   i. At least 128 voice wavetable synthesis.
   ii. Capable of delivering three-dimensional sound effects.
   iii. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.
j. Two (2) Network Interface Cards: Include cards with connection, as applicable.
   i. 10-100-1000 base TX Ethernet with RJ45 connector port.
   ii. 100 base FX Ethernet with SC or ST port.
k. Wireless Ethernet, 802.11 a/b/g/n.
l. Optical Modem: Full duplex link for connection to optical fiber cable provided.
m. I/O Ports:
   i. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
   ii. One serial port.
   iii. One parallel port.

iv. Two PS/2 ports.
v. One RJ-45.
vi. One stereo line-in and headphone/line-out on back panel.
vii. One microphone and headphone connector on front panel.
viii. One IEEE 1394 on front and back panel with PCI-e card.
ix. One ESATA port on back panel.

n. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

o. Keyboard:
i. 101 enhanced keyboard.
ii. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
iii. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

p. Pointing Device:
i. Either a two- or three-button mouse.
ii. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

q. Flat Panel Display Monitor:
i. Display:
1. Color display with 21 inches diagonal viewable area.
2. Digital input signal.
3. Aspect Ratio: 16 to 9.
4. Antiglare display.
5. Tilt adjustable base.
6. Energy Star compliant.
7. Resolution: 1920 by 1200 pixels at 60 Hz.
8. Number of Displays: One.

r. Speakers:
i. Two, with individual controls for volume, bass and treble.
ii. Signal to Noise Ratio: At least 65 dB.
iii. Power: At least 4 W per speaker/channel.
iv. Magnetic shielding to prevent distortion on the video monitor.

s. I/O Cabling: Include applicable cabling to connect I/O devices.

t. Uninterruptable Power Supply.

I. User Interface Application Components

1. Operator Interface

a. An integrated browser based client application shall be used as the user operator interface program.

b. All Inputs, Outputs, Setpoints, and all other parameters as defined within Part 3 or on the drawings, shown on the design drawings, or required as part of the system software, shall be displayed for operator viewing and modification from the operator interface software.

c. The user interface software shall provide help menus and instructions for each operation and/or application.

d. All controller software operating parameters shall be displayed for the

operator to view/modify from the user interface. These include: setpoints, alarm limits, time delays, PID tuning constants, run-times, point statistics, schedules, and so forth.

e. The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:
   i. User access for selective information retrieval and control command execution
   ii. Monitoring and reporting
   iii. Alarm, non-normal, and return to normal condition annunciation
   iv. Selective operator override and other control actions
   v. Information archiving, manipulation, formatting, display and reporting
   vi. FMS internal performance supervision and diagnostics
   vii. On-line access to user HELP menus
   viii. On-line access to current FMS as-built records and documentation
   ix. Means for the controlled re-programming, re-configuration of FMS operation and for the manipulation of FMS database information in compliance with the prevailing codes, approvals and regulations for individual FMS applications.
   x. The operation of the control system shall be independent of the user interface, which shall be used for operator communications only. Systems that rely on an operator workstation to provide supervisory control over controller execution of the sequences of operations or system communications shall not be acceptable.

2. Navigation Trees

   a. The system will have the capability to display multiple navigation trees that will aid the operator in navigating throughout all systems and points connected. At minimum provide a tree that identifies all systems on the networks.
   b. Provide the ability for the operator to add custom trees. The operator will be able to define any logical grouping of systems or points and arrange them on the tree in any order. It shall be possible to nest groups within other groups. Provide at minimum 5 levels of nesting.
   c. The navigation trees shall be “dockable” to other displays in the user interface such as graphics. This means that the trees will appear as part of the display, but can be detached and then minimized to the Windows task bar or closed altogether. A simple keystroke will reattach the navigation to the primary display of the user interface.

3. Alarms

   a. Alarms shall be routed directly from Network Automation Engines to PCs and servers. It shall be possible for specific alarms from specific points to be routed to specific PCs and servers. The alarm management portion of the user interface shall, at the minimum, provide the following functions:
      i. Log date and time of alarm occurrence.
      ii. Generate a “Pop-Up” window, with audible alarm, informing a user that an alarm has been received.

iii. Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.
iv. Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.
v. Provide the ability to direct alarms to an e-mail address or alphanumeric pager. This must be provided in addition to the pop up window described above. Systems that use e-mail and pagers as the exclusive means of annunciating alarms are not acceptable.
vi. Any attribute of any object in the system may be designated to report an alarm.

b. The FMS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions
c. The FMS shall annunciate application alarms as required.

4. Reports and Summaries

a. Reports and Summaries shall be generated and directed to the user interface displays, with subsequent assignment to printers, or disk. As a minimum, the system shall provide the following reports:
i. All points in the BMS
ii. All points in each BMS application
iii. All points in a specific controller
iv. All points in a user-defined group of points
v. All points currently in alarm
vi. All points locked out
vii. All BMS schedules
viii. All user defined and adjustable variables, schedules, interlocks and the like.
b. Summaries and Reports shall be accessible via standard UI functions and not dependent upon custom programming or user defined HTML pages.
c. Selection of a single menu item, tool bar item, or tool bar button shall print any displayed report or summary on the system printer for use as a building management and diagnostics tool.
d. The system shall allow for the creation of custom reports and queries via a standard web services XML interface and commercial off-the-shelf software such as Microsoft Access, Microsoft Excel, or Crystal Reports.

5. Schedules

a. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:
i. Weekly schedules
ii. Exception Schedules
iii. Monthly calendars
b. Weekly schedules shall be provided for each group of equipment with a specific time use schedule.
c. It shall be possible to define one or more exception schedules for each

schedule including references to calendars

d. Monthly calendars shall be provided that allow for simplified scheduling of holidays and special days for a minimum of five years in advance. Holidays and special days shall be user-selected with the pointing device or keyboard, and shall automatically reschedule equipment operation as previously defined on the exception schedules.
e. Changes to schedules made from the User Interface shall directly modify the Network Automation Engine schedule database.
f. Schedules and Calendars shall comply with ASHRAE SP135/2003 BACnet Standard.
g. Selection of a single menu item or tool bar button shall print any displayed schedule on the system printer for use as a building management and diagnostics tool.

6. Password

a. Multiple-level password access protection shall be provided to allow the user/manager to user interface control, display, and database manipulation capabilities deemed appropriate for each user, based on an assigned password.
b. Each user shall have the following: a user name (24 characters minimum), a password (12 characters minimum), and access levels.
c. The system shall allow each user to change his or her password at will.
d. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.
e. A minimum of five levels of access shall be supported individually or in any combination as follows:
    i. Level 1 = View Data
    ii. Level 2 = Command
    iii. Level 3 = Operator Overrides
    iv. Level 4 = Database Modification
    v. Level 5 = Database Configuration
    vi. Level 6 = All privileges, including Password Add/Modify
f. A minimum of 100 unique passwords shall be supported.
g. Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.
h. The system shall automatically generate a report of log-on/log-off and system activity for each user. Any action that results in a change in the operation or configuration of the control system shall be recorded, including: modification of point values, schedules or history collection parameters, and all changes to the alarm management system, including the acknowledgment and deletion of alarms.

7. Screen Manager - The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.

8. Dynamic Color Graphics

a. The graphics application program shall be supplied as an integral part of the User Interface. Browser or Workstation applications that rely only upon HTML pages shall not be acceptable.
b. The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed.
c. The graphics shall be able to display and provide animation based on real-time data that is acquired, derived, or entered.
d. Graphics runtime functions – A maximum of 16 graphic applications shall be able to execute at any one time on a user interface or workstation with 4 visible to the user. Each graphic application shall be capable of the following functions:
    i. All graphics shall be fully scalable
    ii. The graphics shall support a maintained aspect ratio.
    iii. Multiple fonts shall be supported.
    iv. Unique background shall be assignable on a per graphic basis.
    v. The color of all animations and values on displays shall indicate the status of the object attribute.
e. Operation from graphics – It shall be possible to change values (setpoints) and states in system controlled equipment by using drop-down windows accessible via the pointing device
f. Graphic editing tool – A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all animations, and defining all runtime binding.
    i. The graphic editing tool shall in general provide for the creation and positioning of point objects by dragging from tool bars or drop-downs and positioning where required.
    ii. In addition, the graphic editing tool shall be able to add additional content to any graphic by importing backgrounds in the SVG, BMP or JPG file formats.
g. Aliasing – Many graphic displays representing part of a building and various building components are exact duplicates, with the exception that the various variables are bound to different field values. Consequently, it shall be possible to bind the value of a graphic display to aliases, as opposed to the physical field tags.

9. Historical trending and data collection

a. Each Automation Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:
    i. Any point, physical or calculated, may be designated for trending. Two (2) methods of collection shall be allowed:
        1. Defined time interval
        2. Upon a change of value.
    ii. Each Automation Engine shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends

with different collection parameters.

b. Trend and change of value data shall be stored within the engine and uploaded to a dedicated trend database or exported in a selectable data format via a provided data export utility. Uploads to a dedicated database shall occur based upon one of the following: user-defined interval, manual command, or when the trend buffers are full. Exports shall be as requested by the user or on a time scheduled basis. Trend data shall be available for a minimum of twelve (12) months.

10. Trend data viewing and analysis

a. Provide a trend viewing utility that shall have access to all database points.
b. It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name and associated trend name.
c. The trend viewing utility shall have the capability to define trend study displays to include multiple trends
d. Displays shall be able to be single or stacked graphs with on-line selectable display characteristics, such as ranging, color, and plot style.
e. Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collection of data. This is a zoom capability.
f. Display magnitude shall automatically be scaled to show full graphic resolution of the data being displayed.
g. Trend studies shall be capable of calculating and displaying calculated variables including highest value, lowest value and time based accumulation.

J. Network Automation Engine (NAE)/ System Controllers

1. The Network Automation Engine (NAE)/ System Controllers or approved equal shall be a fully user-programmable, supervisory controller. The NAE shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Automation Engines.

2. Automation network – The NAE shall reside on the automation network and shall support a subnet of system controllers.

3. User Interface – Each NAE shall have the ability to deliver a web based User Interface (UI) as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.

a. The web based UI software shall be imbedded in the NAE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.
b. The NAE shall support up four (4) concurrent users.
c. The web based user shall have the capability to access all system data through one NAE.
d. Remote users connected to the network through an Internet Service Provider (ISP) or telephone dial up shall also have total system access

through one NAE.

e. Systems that require the user to address more than one NAE to access all system information are not acceptable.
f. The NAE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NAE.
g. Systems that support UI Graphics from a central database or require the graphics to reside on the user's personal computer are not acceptable.
h. The web based UI shall support the following functions using a standard version of Microsoft Internet Explorer:
    i. Configuration
    ii. Commissioning
    iii. Data Archiving
    iv. Monitoring
    v. Commanding
    vi. System Diagnostics
i. Systems that require workstation software or modified web browsers are not acceptable.
j. The NAE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.

4. Processor – The NAE shall be microprocessor-based with a minimum word size of 32 bits. The NAE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. NAE size and capability shall be sufficient to fully meet the requirements of this Specification.

5. Memory – Each NAE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.

6. Hardware Real Time Clock – The NAE shall include an integrated, hardware-based, real-time clock.

7. The NAE shall include troubleshooting LED indicators to identify the following conditions:

    a. Power - On/Off
    b. Ethernet Traffic – Ethernet Traffic/No Ethernet Traffic
    c. Ethernet Connection Speed – 10 Mbps/100 Mbps
    d. FC Bus – Normal Communications/No Field Communications
    e. Peer Communication – Data Traffic Between NAE Devices
    f. Run – NAE Running/NAE In Startup/NAE Shutting Down/Software Not Running
    g. Bat Fault – Battery Defective, Data Protection Battery Not Installed
    h. Fault – General Fault
    i. Modem RX – NAE Modem Receiving Data
    j. Modem TX – NAE Modem Transmitting Data

8. Communications Ports – The NAE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.

a. Up to two (2) USB port
b. Up to two (2) URS-232 serial data communication port
c. Up to two (2) RS-485 port
d. One (1) Ethernet port

9. Diagnostics – The NAE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network Automation Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.

10. Power Failure – In the event of the loss of normal power, The NAE shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.

    a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
    b. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.

11. Certification – The NAE shall be listed by Underwriters Laboratories (UL).

12. Controller network – The NAE shall support the following communication protocols on the controller network:

    a. The NAE shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
        i. A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (main or tracking) that will communicate on the BACnet MS/TP Bus.
        ii. The Conformance Statements shall be submitted 10 day prior to bidding.
        iii. The NAE shall support a minimum of 100 control devices.
    b. The NAE shall support the Johnson Controls N2, Tridium FX-40, or Honeywell Webs or approved equal Field Bus.
        i. The NAE shall support a minimum of 100 N2 control devices.
        ii. The Bus shall conform to Electronic Industry Alliance (EIA) Standard RS-485.
        iii. The Bus shall employ a main/tracking protocol where the NAE is the main.
        iv. The Bus shall employ a four (4) level priority system for polling frequency.
        v. The Bus shall be optically isolated from the NAE.
        vi. The Bus shall support the Metasys Integrator System.

2.2. WIRING

A. The multi-conductor cable for field wiring of electronic analog sensors shall be minimum

No. 22 AWG, 300 volt, thermoplastic with stranded copper wire and 100 percent shield coverage. The number of conductors in each sensor cable shall be as determined by the Contractor. 2/c #22 shielded cables shall be Belden Cat. #8451 3/c #20 shielded cables shall be Belden Cat. #9770 or approved equal.

B. Conductors for digital sensors or contact control shall be the same as for the analog sensors, except the grounded shield is not required.

C. Individual conductors shall be color coded and in addition shall be numbered in the field to identify the particular terminal to which attached. Field numbering shall be performed with Brady or approved equal markers wrapped around the wire near the terminal connection. All wires shall be terminated with pressure type connectors suitable for wire size, material and terminal connection.

D. All exposed wiring or wiring concealed in partitions shall be installed in a designated conduit raceway. The conduit shall conform to Division 26 of the specification. Where wiring is installed in an air plenum the same shall be plenum rated cable.

E. All junction boxes shall have covers painted safety green, and be rigid steel.

F. All wiring between differential pressure transmitters and variable frequency drive pump controllers shall be shielded and grounded at the pump controller end. Directly route the variable frequency drive pump controller to the differential pressure transmitter(s).

G. All wiring between static pressure controllers and/or air flow monitoring stations and variable frequency drive fan controllers shall be shielded and grounded at the fan controller end. Directly route the variable frequency drive fan controller to the static pressure controller(s) and/or air flow monitoring stations.

H. Where a motor disconnect is indicated downstream of a variable frequency drive (VFD) provide interlock wiring from the auxiliary contacts on the disconnect to the VFD to de-energize when the disconnect is turned “off”.

2.3. CONTROLLERS

A. Temperature, relative humidity, and CO2 sensor covers shall be stainless steel wire guard type with vandal proof screws. All room relative humidity, CO2, and temperature sensors shall be mounted 4'-0 inches above the finished floor, except in stairways, corridors and toilets, which shall be 7'-0 inches. Provide insulating bases where temperature sensors are located on exterior or unconditioned walls. Each temperature sensor shall have adjustable limit stops and adjustable sensitivity. User adjustment shall be 2 degrees F above and below set points or as determined by the Owner. Room temperature sensors shall include range of 55 degrees F to 85 degrees F set point adjustment. Temperature sensors shall include set-point adjustors, U.L. approved for mounting base in air plenums, and RJ-11 jack for communications. Room temperature sensors shall be fully adjustable and shall display set point and actual temperature.

B. Low Limit Thermostats: Freezestats shall have a minimum 20 foot (averaging sensing element) capillary tube sized to the basis of one linear foot of capillary tube for each square foot of coil surface. Thermostat sensitivity shall be adjustable. Freezestats shall stop all fans and close the outside air damper if air temperature drops below 35 degrees F and open

hot water heating valves. Low limit thermostats shall include hardwire interlock to fans and the building automatic control system. Low limit thermostats shall remain active even when H-O-A switches are in "HAND". Additional requirements are indicated in Sequence of Operation.

C. Room temperature sensors shall be accessible to ADA occupants.

D. All global sensors shall be monitored in accessible locations. Exterior sensors shall be provided with sun shield and be installed to prevent bird nesting.

2.4. DAMPERS

A. Control Dampers

1. The temperature control contractor shall provide all automatic control dampers of the types indicated on the plans and not specified to be integral with other equipment. Frames shall be not less than 16 gauge galvanized steel. Blades shall not be over 6 inches wide airfoil shaped double skin construction of 14 gauge equivalent thickness. Bearings shall be stainless steel sleeves with 2 inch shafts. Blade edge seals shall be vinyl blade with flexible metal compressible jamb seals of the tight-seal spring type. Dampers and seals shall be suitable for temperature ranges of -40 to 250 degrees F.

2. All proportional control dampers shall be opposed blade type and all two-position dampers shall be parallel blade type.

3. Dampers shall be sized to meet flow requirements of the application. The sheet metal contractor shall furnish and install baffles to fit the damper to duct size. Baffles shall not exceed 6 inches.

4. Dampers shall be minimum leakage type to conserve energy and the temperature control manufacturer shall submit leakage and flow characteristic data for all control dampers with the temperature control submittal. Maximum leakage shall be 3 CFM/Sq. Ft. at static pressure of 1 inch W.C. for a damper width of 48 inches.

5. Ultra-low leakage dampers shall have blade edges shall to be fitted with replaceable, snap-on, inflatable seals to limit damper leakage to 2 percent at applied static pressure.

6. Medium and low pressure rectangular control dampers shall be Type CD60 airfoil low leakage damper as manufactured by Ruskin or as approved equal of American Warming and Ventilating, Air Balance and Arrow.

7. Round control dampers shall be Type CERS25 with blade edge seals as manufactured by Ruskin or as approved equal.

8. Fume hood and chemical storage room exhaust fan control damper and dampers mounted in stainless steel ductwork shall be Type 304 stainless steel construction, heavy duty control damper with blade edge seals suitable for fume hood, chemical service Type CDR82 manufactured by Ruskin or as approved equal.

9. Provide damper end switch for all control dampers where indicated. Damper end switch shall be independent of the damper actuator and shall provide "proof of open" prior to allowing fan to energize. Damper end switch shall be Model TS-475 Mechanical Damper Arm Switch (no-mercury) as manufactured by MDI, Inc. or approved equal. Install per manufacturer's recommendations on control damper. End switch shall have the following features:

    a. Housing Material: Glass filled PBT (polybutylene terephthalate).
    b. Bracket Material: Plated steel.
    c. Operation: Steel ball actuated sub-miniature snap action switch.
    d. Operating angle: 15 degrees. (Contact closes at 10 degrees above horizontal and contact opens at 5 degrees below horizontal).

B. Duct Smoke Detectors

1. Duct Smoke detectors shall be provided by the Electrical Contractor and installed by the Mechanical Contractor. All wiring, interlocks, etc., to be provided by Electrical Contractor. Wiring from duct smoke detectors to fans shall be by ATC Contractor. Duct smoke detectors shall be tested by the Test and Balance Engineer as specified in Division 23 Section, Testing Adjusting & Balancing for HVAC and Plumbing.

C. Damper Operators

1. Electric damper actuators shall be properly sized to provide sufficient torque to position the damper throughout its operating range.

2. Use devices which are quiet in operation and which in the event of power failure, will "fail safe" by spring action in either the normally open or normally closed position as required for freeze, moisture, smoke, or fire protection.

3. Electric actuators requiring a 24 VAC power supply will be utilized. Motors shall be specifically designed and sized with proper torque according to requirements of the device it is to be used on (i.e.: valve, damper). Each actuator will accept the proper control input as the system is designed, (i.e.: floating, 0-10VDC, 4-20Ma etc.) without the need for any additional interface devices.

4. For all exterior damper operators provide NEMA 4X stainless steel corrosion resistant enclosure. Damper operator enclosure shall be model ZS-300 as manufactured by Belimo or approved equal.

2.5. PRESSURE INDEPENDENT HYDRONIC CONTROL VALVES

A. All automatic control valves 2 inches and smaller shall be screwed type, and valves 2 ½ inches and larger shall be flanged. Valves shall be factory-rated to withstand the pressures encountered. Valves shall have stainless-steel stems and spring loaded Teflon packing with replaceable seats and discs. All control valves must be capable of withstanding the shut-off head of the pumps, they are connected to without the valve seat lifting. Valves shall have stainless steel stems and spring loaded Teflon packing with replaceable seats and discs.

1. All modulating straight-through water valves shall be provided with equal-percentage contoured throttling plugs and shall be pressure independent type. All three-way valves shall be provided with linear throttling plugs such that the total flow through the valve shall remain constant regardless of the valve's position modulating. Valves shall be sized for a pressure drop equal to the coil they serve but not to exceed 5 psi. Valves shall have replaceable seats and discs. Pressure independent control valves shall be as manufactured by Griswold, Delta P, Warren Controls, Danfos, Bray, or approved equal.

2. Pressure Independent Actuated Ball Valves (PIC-V) for Flows up to 85 GPM

   a. The modulating control valves shall be pressure independent.
   b. Valves shall accurately control flow within +/-5% (including manufacturing tolerance) independent of system pressure fluctuation by maintaining a constant pressure differential across the control valve so that the valve only repositions on a change in load demand.
   c. The pressure independent modulating control valve shall include a Pressure Compensating Cartridge, Actuated Ball Valve, 2 PT's, Manual Air Vent, Union, and Manual Isolation Ball in a single valve housing.
   d. The valve shall have an accuracy of +/- 5% including manufacturing tolerances and pressure variations.
   e. Valve housing shall consist of forged brass, rated at no less than 360 psi at 250°F.
   f. A venturi flow meter fitting shall be field installed so that the flow rate can be read by means of differential pressure. Valve shall include a field installed or factory installed venturi metering station so that the flow rate can be read by means of differential pressure. Venturi metering station shall not require any straight runs of piping before or after meter. Provide separate flow meter fitting if venturi flow meter is not integral to PIC valve assembly.
   g. Both the ATC and shutoff valve shall have stems that are field repairable with the valve in the line. The body design shall allow inspection or repair of the stem without disturbing piping connections or draining water. The repairable stem shall include two Teflon seals and one EPDM O-ring for protection against chemicals and modulating temperature.
   h. Valve shall have a union end connection with factory installed air vent to allow for venting of the coil or heat pump.
   i. The control valve shall accurately control the flow from 0 to 100% full rated flow.
   j. The ATC portion of the valve shall use the full 90 degrees of the stroke for control. Stroke limiting of the valve shall not be acceptable.
   k. A flow tag shall be furnished with each valve.
   l. A universal mounting plate shall allow installation of actuators meeting the system electrical requirements and valve torque requirements as provided by Honeywell, Invensys, Johnson Controls, KMC, Schneider, Neptronic, or Siemens.
   m. The actuator and plate can be rotated after mounting.
   n. The actuator mounting assembly shall accommodate no less than 1 ½" of insulation.
   o. Pressure Compensating Cartridge (PCC)

i. PCC shall automatically compensate for pressure changes in valve and shall maintain a constant pressure drop across the flow limiting actuated ball.
ii. The operating pressure range shall be available with the minimum range requiring 3 PSID to actuate the cartridge and the maximum 8 psid to actuate the cartridge
iii. Valve internal control mechanism includes a diaphragm and full travel linear coil spring.
iv. Valves shall include an accessible/ replaceable cartridge.
v. Dual pressure/temperature test valves for verifying the pressure differential across the cartridge and flow limiting ball shall be standard.

p. Actuated Ball Valve
i. Valve ball shall consist of chemically plated nickel brass or stainless steel.
ii. Actuator stem shall be removable/ replaceable without removing valve from line.
iii. Manufacturer shall be able to provide ball insert to limit flow to maximum flow rate with ±5% accuracy. Insert shall be constructed of a Glass-Filled Polymer. The insert shall be press fit to the inside of the ball. Clipping the insert onto the exiting side of the ball shall not be acceptable.
iv. Each maximum flow rate selected shall use a different characterizing disc so that stroke limiting is not required.
v. Valve shall have a minimum rangeability as follows: ½”-40:1, ¾”-160:1, 1” to 3”-400:1
vi. Valve shall have EPDM O-rings behind Reinforced Teflon (PTFE) ball seals.
vii. The valve shall have a minimum close-off pressure differential rating of 100 psi with 35 in-lbs of torque for 1/2" to 2" sizes.
viii. Actuator shall provide minimum torque required for full valve shutoff position.

q. Isolation Ball Valve
i. Valve shall include a 600 WOG manual isolation ball valve.
ii. Stem shall be removable/replaceable with the valve in the line.

r. The control valve actuator will be furnished by the controls contractor under Section 230900.

s. Pressure independent valves shall come as one complete assembly from Griswold Controls or approved equal and shall include a supply side combination shutoff/ strainer valve.

3. MVP Pressure Independent Control Valves for Flows above 85 GPM.

a. Pressure Independent Flow Control Valve 2.5” and Larger
i. The modulating control valves shall be pressure independent.
ii. Valve shall accurately control flow within +/-5% (including manufacturing tolerance) independent of system pressure fluctuation by maintaining a constant pressure differential across the control valve so that the valve only repositions on a change in load demand.

iii. Contactor shall install pressure independent flow control valves where indicated in drawings.
iv. Valve shall be electronic, pressure independent, modulating 2-way control device.
v. Balancing valves shall not be required where pressure-independent valves are installed.
vi. Install venturi flow meter fitting to measure flow rate in gallons per minute.
vii. Valve shall include a venturi flow meter fitting so that the flow rate can be read by means of differential pressure. Venturi flow meter fitting shall not require any straight runs of piping before or after meter. Provide separate flow meter fitting if not integral to control valve.

b. Valve Actuator
i. Valve actuator housing shall be rated to IP44 insulation.
ii. Actuator shall be driven by a 24Vdc motor, and shall accept 2-10 Vdc, 4-20mA, 3-point floating or pulse width modulation electric signal and shall include resistor to facilitate any of these signals.
iii. Actuator shall be capable of providing 4-20mA or 2-10 Vdc feedback signal to the control system so that the gpm can be determined.
iv. External LED readout of current valve position and maximum valve position setting shall be standard.
v. Maximum flow setting shall be adjustable to 51 different settings within the range of the valve size by changing the settings electronically on the actuator.
vi. Optional fail safe system to power valve to either open or closed position from any position in case of power failure shall be provided per the sequence of operations and the automatic temperature control diagrams.

c. Valve Housing
i. 2.5"–6": Housing shall be constructed of Ductile Iron ASTM A536-65T, Class 60-45-18 rated at no less than 580 psi static pressure and 248°C.

d. Pressure Regulation Unit
i. Pressure regulation unit shall consist of 304 Stainless Steel and hydrogenated acrylonitrile butadiene rubber (1/2"–1-1/2") or 316 Stainless Steel and EPDM (2"–6").
ii. Flow regulation unit shall be accessible for maintenance without disturbing the piping.
iii. Valve shall have a maximum of 8.6 psid to actuate the pressure regulating cartridge.
iv. Dual pressure/temperature test valves for verifying accuracy of flow performance shall be available for all valve sizes.

4. Where applicable, all two (2) position control valves may be furnished with hose kits at Contractor's option. Coordinate actuator and pressure drop requirements with hose kit supplier. Maximum allowable pressure drop for two (2) position modulating control valves shall be 12 feet at scheduled flow rate.

5. Optional accessories shall include a stem packing lubricator for factory or field assembly. Valve stem packing shall be low friction, tight sealing Teflon.

6. Unitary valves shall be straight-through or three way type as specified in the sequence of operation with high-pressure connections suitable for copper pipe and rated for 250 psig. Stems shall be polished stainless-steel and packing shall be ethylene-propylene suitable for both chilled water and 250 degree hot water service. Straight-through valves shall have back-seating feature, to allow packing to be replaced without draining system.

7. All valves shall use guided valve plugs for good seating and reliable operation. Valves ½ inch to 1 inch shall be ANSI Class 125 brass body with screwed ends. Valves 1-1/4 inches to 2 inches shall be ANSI Class 150 brass body with screwed ends. Valves 2-1/2 inches to 4 inches shall be Class 125 cast iron body with bronze trim and flanged ends. Valves 6 inches and larger shall be Class 125 steel body with bronze trim and flanged ends. Butterfly valves shall be DeZurick HIGH performance or Keystone Keylock, Lug style as specified in Division 23 Section, HVAC Piping, Fittings, and Valves.

8. All heating coil valves shall be normally open to the coil.

B. Control Valve Operators

1. Electric valve actuators shall be properly sized to provide sufficient torque to position valves throughout its operating range.

2. Use devices which are quiet in operation and which in the event of power failure, will "fail safe" by spring action in either the normally open or normally closed position as required for freeze, moisture, smoke, or fire protection. Spring return valves are required for all control valves where coils are exposed to outside air conditions.

3. Electric actuators requiring a 24VAC power supply will be utilized. Motors shall be specifically designed and sized with proper torque according to requirements of the device it is to be used on (i.e: valve, damper). Each actuator will accept the proper control input as the system is designed, (i.e.: floating, 0-10VDC, 4-10Ma etc.) without the need for any additional interface devices.

2.6. CONTROL PANELS

A. Furnish and install local panels for ATC devices. Control panels shall be fully enclosed cabinets, all steel construction and shall meet the requirements of NEMA 1 enclosures. Cabinet shall have piano hinged door with a locking latch. All cabinet locks shall use common key. Provide means of storing control system instructions and drawings inside cabinet for future reference. Panel shall be wall mounted or free standing and located where directed by the Contract Drawings or Engineer.

1. Each panel shall have all internal devices factory wired to a numbered terminal strip. Controllers and associated devices shall be mounted within the panel, accessible through a hinged door.

2. All ATC panels shall be provided with integral disconnect, wiring, and control transformers.

3. Any ATC control panel that is serving equipment on the emergency generator must be powered by an emergency generator fed circuit/electrical panel. Refer to electrical contract documents for all emergency powered equipment.

2.7. MISCELLANEOUS ELECTRICAL DEVICES

A. Electric Actuators. All automatically controlled devices, unless specified otherwise elsewhere, shall be provided with electric actuators which shall be sized to operate their appropriate loads with sufficient reserve power to provide smooth modulating action or two-position action and tight close off as specified.

B. Aquastats shall be line voltage strap on type with single pole, single throw switching. Switches shall have an adequate rating for the applied load. All wiring from aquastats to domestic recirculating pumps shall be by ATC contractor.

2.8. UNINTERRUPTIBLE POWER SUPPLY

A. Furnish, size and install uninterruptible power supplies (UPS's) at all ATC panels.

B. Provide all interlock and power wiring from U.P.S. to control panels as required such that all components are powered via the UPS. For hard-wired equipment furnished with pigtails/wire leads, e.g. control power transformers, splice pigtails/wire leads in junction box to a flexible cord with NEMA 5-15P Plug, which shall be plugged into the UPS.

C. UPS's shall be sized for the ATC panel load and shall provide at least 10 minutes of full load power in the event of a power outage.

D. UPS shall be furnished with plug and cord and shall be powered from emergency power receptacle(s) in ATC panels.

E. Refer to electrical Contract Documents for all equipment served by the generator. All ATC panels for such equipment must be provided with a UPS.

2.9. DESKTOP WORKSTATIONS

A. Description: A tower or all-in-one computer designed for normal use at a single, semipermanent location.

B. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.

2. Energy Star compliant.

C. Personal Computer:

1. Minimum Processor Speed: 3 gigahertz (GHz).

2. RAM:

   a. Capacity: 16GB.
   b. Speed and Type: 1333 MHz, SDRAM.

3. Hard Drive:

   a. Media: Solid state.
   b. Number of Hard Drives: One.
   c. Capacity: 250GB.

4. Optical Read and Write Drive:

   a. Include with at least 2 MB of data buffer.
   b. Type: SCS1 CD-ROM Drive with Read/Write Capability.
   c. Average access time of 150 ms or less.

5. At least four expansion slots.

6. Video Card:

   a. Resolution: 1920 by 1200 pixels.
   b. RAM: 4 GB.
   c. Controller Speed: 4GHz.

7. Sound Card:

   a. At least 128 voice wavetable synthesis.
   b. Capable of delivering three-dimensional sound effects.
   c. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.

8. Two (2) Network Interface Cards: Include cards with connection, as applicable.

   a. 10-100-1000 base TX Ethernet with RJ45 connector port.
   b. 100 base FX Ethernet with SC or ST port.

D. Wireless Ethernet, 802.11 a/b/g/n.

1. Optical Modem: Full duplex link for connection to optical fiber cable provided.

2. I/O Ports:

   a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
   b. One serial port.
   c. One parallel port.
   d. Two PS/2 ports.
   e. One RJ-45.
   f. One stereo line-in and headphone/line-out on back panel.
   g. One microphone and headphone connector on front panel.

h. One IEEE 1394 on front and back panel with PCI-e card.
i. One ESATA port on back panel.

3. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

E. Keyboard:

1. 101 enhanced keyboard.

2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.

3. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

F. Pointing Device:

1. Either a two- or three-button mouse.

2. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

G. Flat Panel Display Monitor:

1. Display:

a. Color display with 21 inches diagonal viewable area.
b. Digital input signal.
c. Aspect Ratio: 16 to 9.
d. Antiglare display.
e. Tilt adjustable base.
f. Energy Star compliant.
g. Resolution: 1920 by 1200 pixels at 60 Hz.
h. Number of Displays: One.

H. Speakers:

1. Two, with individual controls for volume, bass and treble.

2. Signal to Noise Ratio: At least 65 dB.

3. Power: At least 4 W per speaker/channel.

4. Magnetic shielding to prevent distortion on the video monitor.

I. I/O Cabling: Include applicable cabling to connect I/O devices.

2.10. CENTRAL CONTROL AND MONITORING SYSTEM (CCMS) (HARDWARE DESCRIPTION)

A. General

1. The Facilities Management Control System (FMCS) shall be comprised of a network of various independent, Stand-alone Digital Controllers (SDC'S), Mechanical System Digital Controllers (MSDC's), Air Handler Digital Controllers (AHDC's), Unitary Digital Controllers (UDC's); together with Centralized Control Stations (CCS), and Centralized Host Stations (CHS) as specified, to provide centralized access and facility wide control functions. The SDC's, MSDC's, AHDC's, and UDC's shall be interconnected in a communicating network to provide facility wide access and sharing of information. A Gateway Digital Controller (GDC's) shall be provided to allow interface with third party microprocessor based control systems that are specified for integration within specification. A Local Area Network (LAN) shall be provided to interconnect SDC's for high-speed data transmission.

2. Specification Nomenclature

a.	FMCS	Facility Management Control System
b.	SDC	Stand-alone Digital Controller
c.	MSDC	Mechanical System Digital Controller
d.	AHDC	Air Handler Digital Controller
e.	UDC	Unitary Digital Controller
f.	GDC	Gateway Digital Controller
g.	GP	Graphical Programmer
h.	CHS	Central Host Station
i.	CCS	Central Control Station
j.	RPTR	Communications Repeater

B. Centralized Host Stations (CHS)

1. The FMCS shall include Centralized Host Stations. CHS's shall, in conjunction with the full compliment of Digital Controllers, provide the performance requirements within this specification. Each CHS shall include all hardware and software components to serve as a centralized facility operator station, providing color graphics, facility wide access, operator initiation of global control strategies, and centralized documentation.

   The CHS shall be capable of simultaneously interfacing with the following:

   a. -mouse pointing device
   b. -two parallel printers
   c. -high resolution VGA color graphics monitor
   d. -seven auto answer/auto dial modems
   e. -color inkjet printer
   f. -two serial printers
   g. -three FMCS LAN interface
   h. -Alarm Graphic and Report FAX dial out service interface
   i. -Mass storage tape system

   As a minimum, the temperature control contractor shall provide the types and quantities of CHS, CCS, SDC, MSDC, AHDC, GDC, and UDC as required.

2. Computer

a. Furnish and install a new workstation computer and locate where indicated on the contract drawings. Provide modem terminal, and wiring as required to interface this school's CCMS system with FMS computer. I/P data drop shall be provided adjacent to the network panels.
b. Coordinate IP address with Owners' I.T. Department for network connection. The CCMS must be fully networkable.
c. Provide fiber optic cable as required.

3. Operator Workstation: One PC-based microcomputer with minimum configuration as follows:

a. Uninterruptible Power Supply: 2 kVa.
b. Operating System: Microsoft Windows – Latest Version.
   i. ASHRAE 135 Compliance: Workstation shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
   ii. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.
c. Printer: Color, ink-jet type as follows:
   i. Print Head: 4800 x 1200 dpi optimized color resolution.
   ii. Paper Handling: Minimum of 100 sheets.
   iii. Print Speed: Minimum of 17 ppm in black and 12 ppm in color.

C. Centralized Control Stations (CCS)

1. The FMCS shall include Centralized Control Stations, as required. CCS's shall, in conjunction with the network of SDC's and additional CCS components as required, provide the performance requirements within this section of the specification. Each CCS shall include all hardware and software components to serve as a centralized facility operator station, providing facility wide access, for review and modification of global control strategies, real time system monitoring, controller database editing or creation, and centralized documentation.

D. Local Area Networks

1. The LAN shall utilize packetized transmissions, CRC 16 error checking, and distributed error recovery. Single or multiple SDC failures shall not cause loss of communication between other LAN-connected SDC's.

2. LAN connected SDC's shall be provided with a communications watchdog to assure that an individual SDC cannot permanently occupy the LAN. If an SDC is determined to be monopolizing communications, it shall be automatically shut down and an exception reported to annunciate this fact.

3. The LAN shall employ a token passing, peer-to-peer convention, same as or similar to the industry standard format IEEE 802.4. The content of messages shall be the manufacturer's standard. The Local Area Network components shall be manufacturer's standard or available from third party vendors which utilize the same chip implementation as used by the manufacturer.

4. Industry standard ANSI, RS-485 Network Communication System, Lon, or Bacnet, or Equivalent shall be utilized.

5. Trunk Wiring Practices - General

   a. The distributed communication network system shall consist of a multi-drop RS-485 bus architecture connecting SDC's, MSDC's, AHDC's, GDC's, and UDC's. The trunk shall consist of:
      i. A twisted pair of wires (24 awg) completely encased in continuous metallic conduit.
      ii. A twisted shielded pair of wires (24awg) with the shield grounded in accordance with the manufacturer's wiring practices.
      iii. Or a dual channel, 62.5 micron fiber cabling system with ST type connectors.

      There shall be no power wiring, in excess of 30 VAC rms voltage, run in conduit with communications trunk wiring. In cases where power or signal wiring is run in conduit with trunk wiring, all communications trunk wiring and power wiring shall be run using separate twisted shielded pairs (24awg) with the shields grounded in accordance with the manufacturer's wiring practices.
   b. Communication Transient Protection
      i. The manufacturer's catalog data sheet shall provide evidence that all FMCS products offered by the manufacturer are tested and comply with the standard for Transient Surge withstand capabilities for electrical devices ANSI C62.41, IEEE-587-1980, Categories A and B. Such testing shall have included power and communication trunk wiring. Compliance with IEEE-587 shall imply conformance with IEEE-472 transient standards based on the stated position of ANSI and IEEE regarding applicability of the rated standards.
      ii. In addition, at each building entry and exit point, the wire communications trunk wiring shall be protected with a transient surge protection device providing the minimal protection specifications of the General semiconductor, Model #422E device. Transient surge protection is not necessary if the communication trunk, external to the building, is fiber optic in nature.
      iii. The communications circuitry and input/output circuitry, of the SDC's, MSDC's, and AHDC's, shall provide protection against a 1000 volt, 3 amp transient signal, directly applied to the communication or input/output terminations. The manufacturer's catalog data sheet shall provide evidence of conformance with this requirement. Systems not complying with this requirement shall provide equivalent protection external to the FMCS controller. Protection shall be provided for the individual communications and input/output terminations for each FMCS controller. Submittal documentation shall clearly define how this requirement will be met and how the external protection will not affect the performance of the controllers.
   c. RS-485 Trunk Distance and Topology

The manufacturer's RS-485 trunk shall provide operation over end to end linear distances of 4000 feet for wire connections and 6,500 feet for fiber optic connections, without repeaters, at communication data rates of up to 64 kbps. The trunk may be extended up to 20,000 feet through the use of wire repeaters or 80,000 feet through the use of fiber optic repeaters.

At data rates of up to 19.2 kbps, the trunk distance shall be extendible to distances of up to 20,000 feet using RS-485 communication wire or fiber optic repeaters. A repeater shall be used each 4,000 feet of linear distance for wire or every 6,500 feet for fiber optics. Repeating devices shall contain separate LED indication for each communication interface trunk to indicate proper operation of the repeater as well as the communications trunks.

Contractors shall provide devices which are of FMCS control system manufacturer's design.

d. It shall be possible for the trunk to be "T" eed or "starred", at any location using a repeater, to facilitate the installation. Systems which do not provide this capability shall provide a trunk riser diagram showing end to end distances and locations of system topology necessary to meet the trunk diagram shown on the plans.

e. Fiber Optic Communication Trunk

The temperature control contractor shall provide a dual channel fiber optic data link, as required, to minimize the effects of transient surges caused by lightning or external EMI generating equipment. The data link shall be comprised of a single duplex cable containing two fibers (transmit and receive), of 62.5 micron construction, to accommodate data rates of up to 64 kbps.

The fiber optic trunk shall be connected to SDC devices using manufacturer's standard RS-485 to fiber optic data link modem. Repeating devices shall contain separate LED indication for each communication interface and the fiber modem, to indicate proper operation of all aspects of the device. Fiber modem devices shall be tested and conform with transient surge withstand tests for electrical devices, ANSI C62.41 IEEE-587 Categories A and B. Manufacturer's data sheet shall provide evidence of compliance with this requirement. Manufacturer's products which do not meet this minimum performance requirement shall not be acceptable.

Systems which require a special gateway controller to accommodate the fiber optic trunks, shall provide such a controller per point where the fiber optic cable enters and leaves the building. Gateway controllers shall not inhibit transfer of point data values between SDC controllers throughout the LAN. Such inhibitive systems shall not be acceptable.

In lieu of the above two options, the contractor may provide a fiber optic link to each SDC controller within the LAN. All controllers shall have access to the fiber optic link for LAN.

Fiber optic cable shall be fully tested and terminated by the temperature control contractor.

E. Standalone Digital Controllers (SDC)

1. General

Standalone Digital Controllers (SDC) shall be 16 bit microcomputer based, utilizing a multi-tasking, multi-user operating system.

The SDC controllers shall permit the simultaneous operation of all control, communication facilities management and operator interface software, as programmed by the Contractor or User. Modification of the on-board SDC controller database shall be performed on-line using the built-in or HHOT interface. Systems which require the SDC to be removed from service while DDC control sequences are modified shall not be acceptable.

SDC controllers shall utilize true floating point arithmetic capabilities. To accommodate totalization of large totalized values, SDC's with reporting capability shall support the calculation, accumulation and display of values within the range of +/-10 to the 10th power.

2. Database and Memory Back-up

All programming defining the functions to be performed by the SDC, including but not limited to application programs and point database within each SDC, shall be protected from loss due to power failure for a minimum of six months. Systems providing non-volatile memory for these functions are preferred. Systems not providing non-volatile memory shall provide a system rechargeable battery backup system sufficient to provide protection for the specified 6 month period. Systems not in compliance shall provide for uninterrupted power to each SDC.

3. Service Ports

SDC controllers shall be equipped with a minimum of one operator service port for the connection of a HHOT. The service port shall be either a built-in RS-232 data terminal port or an RJ-11 type jack which connects to the manufacturer's standard HHOT.

Connection of a service device, to a service port, shall not cause the SDC controller to lose communications with its peers or other networked device controllers.

The service port shall allow utilization of the same HHOT from any location. The same HHOT shall be utilized for any SDC, MSDC, AHDC, or UDC Systems which utilize more than one variety of HHOT shall not be acceptable.

4. Display and Readout Capability

The SDC controller shall provide manufacturer’s standard display and readout capability.

5. Manual/Auto Control and Notification

The SDC controller shall provide commanded override capability from the HHOT or the built-in operator interface. Such overrides shall be annunciated to the CHS's. Such overrides shall be valid as long as power is applied to the controller.

Manual service overrides, such as Hand/Off/Auto switches, shall be provided as

indicated on the drawings. Such overrides shall be located at the controlled device location and conform with OSHA Manual lockout regulations, as appropriate, for safety reasons. SDC indication of such manual override actions shall be provided as feedback status indication points shown on the drawings, in conjunction with the application programs within the SDC. Systems which provide built-in H/O/A switching devices with integral feedback shall provide external manual service overrides, as indicated, to comply with OSHA manual lockout regulations. H/O/A switches remotely located at the SDC controller are not acceptable.

6. Adjustments

Every control panel shall provide adjustments for the functions specified. In general, adjustments shall be provided for all set points used by controllers within each control panel. In addition, adjustments shall be provided for throttling ranges, mixed air damper minimum positions, or other items as specified. Adjustments shall be integral to each individual SDC. The built-in operator interfaces shall allow the easy execution of the adjustment through named identifiers within the SDC. From a single SDC user interface, any other SDC shall be accessible and full adjustment capabilities shall be provided.

7. Sensing and Control Outputs Requirements

a. Sensing
   i. All sensing inputs shall be provided via industry standard signals. Temperatures, humidities, differential pressure signals, and other signal inputs shall be one of the following types:
      1) 0-20 mA
      1) 4-20 mA
      1) 0-5 VDC
      1) 0-12 VDC
   ii. 1000 ohm platinum (at O°C, 2.62 ohms/°C)
   iii. 1000 ohm Balco (2.2 ohms/°F)
   iv. 10 k ohm Thermistor (at 25°C/77°F)

   Custom, definable input signals (accept sensor inputs from RTD devices, other than those of the manufacturer).

   All signal inputs shall be compatible with the controllers used, and with the requirements for readout of variables in true scaled engineering units as specified.

b. Control Outputs
   i. On/Off Outputs

   Control panel shall internally provide test points for the circuit driving the equipment contactor, for the purpose of troubleshooting the 120 VAC or 240 VAC circuit to the contactor. All such relays or digital output modules shall provide a pilot light or LED display of the same status. On/Off output modules shall be of the modular construction that can be easily and quickly replaced, on an individual basis, if the module were to be damaged.

   ii. Modulating Outputs

   Modulating outputs shall be industry standard 0-5 VDC, or 0-12 VDC with definable output spans, to adapt to industry available control products. Milliamp outputs of 0-20 mA or 4-20 mA are also acceptable. Drive

open/Drive closed type modulating outputs are acceptable provided that they also comply with the following requirements.

All modulating outputs shall provide within the control panel, a meter gauge, or display indication via on board display or HHOT, the commanded position signal for the actuating device. This meter, gauge, or display must provide either a 0-100 percent position indication, or read out directly in the engineering unit of the signal being used. Drive open/Drive closed type controllers shall include sufficient components and control algorithms to comply with this requirement. In the case of Drive open/closed technology, position feedback shall be provided to insure positive indication that the control device is at the commanded position.

F. Mechanical System Digital Controllers (Msdc's)

1. General

a. Controls shall be microprocessor based, Mechanical System Direct Digital Controllers (MSDC's). MSDC's shall be provided for air handling units, central pump systems and other applications as required. MSDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the MSDC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates sensor signals. All input/output signal conversion shall be performed through a minimum of a 12 Bit A to D converter. All input/output points shall be universal in nature allowing their individual function definition to be assigned through the application software. All unused input/output points must be available as universally definable at the owner discretion. If input/output points are not fully universal in nature, unused points must be equal in quantity between Analog Input, Digital Input, Analog Output, Digital Output.

Contractor shall provide a minimum of one MSDC controller per mechanical system, as shown on the drawings.

The BAS contractor shall provide and field install al MSDC's specified under this section. Mechanical Equipment manufacturers desiring to provide MSDC type controls as factory mounted equipment, shall provide a separate bid for their product less all controls, BAS/Temperature Control Contractor.

b. All input/output signals shall be directly hardwired to the MSDC. Trouble shooting of input/output signals shall be easily executed with a volt-ohm-milli-amp meter (VOMA). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be used.

c. MSDC shall be in continuous direct communication with the network which forms the facility-wide Building Automation System (BAS). The MSDC's shall communicate with the SDC at a baud rate of not less than 19,200 baud.

2. Non-Volatile Memory

a. All control sequences programmed into the MSDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to

be retained. Power failures shall not cause the MSDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The MSDC shall allow for the creation of unique application control strategies. Systems that allow selection of sequences from the library or table are not acceptable.

b. All control sequences shall be fully field programmable at the MSDC controller, allowing for the creation or editing of an application sequence of operations.

c. Each MSDC shall be provided with manufacturer's standard built-in Operator Interface.

d. The MSDC shall allow for internal processing and reporting of user defined Time of Day Schedules, Alarms, Trend Reports, Run Time Totalization, Energy Utilization Reports, Application Program Documentation and interface with a peripheral device such as an autodial/autoanswer modem, a VT-100 Display Terminal, or a serial printer.

i. Systems not providing the above functionality at the MSDC are not acceptable and shall utilize an SDC in place of the MSDC.

e. The MSDC shall provide LED indication of transmit/receive communications performance as well as for the proper/improper operation of the controller itself.

f. The MSDC shall be provided with a battery backed time clock that is capable of maintaining the time of day and calendar for up to thirty days without loss of setting. The battery for the time clock shall be field replaceable by the customer. Integral daily, weekly, holiday and special event scheduling shall be provided, such that all schedules can be custom tailored to the facility. Predefined schedules, with set quantities of on/off cycles are not acceptable.

3. Controller Location

a. To simplify controls, mechanical service and troubleshooting, the MSDC shall be mounted directly in or on the control compartment of the mechanical system. The MSDC shall be provided in a NEMA 1 enclosure to accommodate direct mounting on the equipment to be controlled. The MSDC shall be constructed in a modular orientation such that service of the failed components can be performed quickly and easily. The modular construction should limit the quantities of printed circuit boards to a maximum of three. When required to replace a printed circuit board, it shall not be necessary to disconnect any field wiring. The MSDC shall allow for the creation of, unique, application control strategies. Systems that allow selection of sequences from a library or table are not acceptable. This shall allow all controls maintenance and troubleshooting to be made while at the unit location. MSDC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.

b. For compatibility to the environment of the mechanical systems, MSDC shall have wide ambient ratings. MSDC shall be rated for service from -40 Deg F (Degrees Fahrenheit) to 140 Deg F.

c. Contractor shall submit description of location for the MSDC's on all mechanical equipment.

G. Air Handler Digital Controller (AHDC)

1. General

a. Controls shall be microprocessor based, Air Handler Digital Controllers (AHDC's). AHDC's shall be provided for air handling units, H & V units, kitchen vent units, rooftop units energy recovery ventilators, make-up air units, and single zone VAV unit, and other applications as required. AHDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the AHDC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates the sensor signals. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter. All input points shall be universal in nature allowing their individual function definition to be assigned through the application software. All unused input points must be available as universally definable at the discretion of the owner. If the input points are not fully universal in nature, unused points must be equal in quantity between Analog Inputs and Digital Inputs.
Contractor shall provide a minimum of one AHDC controller per air handling system as shown on the drawings.
The BAS contractor shall provide and field install all AHDC's specified under this section. Mechanical equipment manufacturers desiring to provide AHDC type controls as factory mounted equipment, shall provide a separate bid for their products less all controls, actuators, valve assemblies and sensors, which are specified to be provided by the BAS/Temperature control contractor.

b. All input/output signals shall be directly hardwired to the AHDC. Troubleshooting of input/output signals shall be easily executed with a volt-ohm meter (VOM). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be utilized.

c. AHDC's shall be in continuous direct communication with the network which forms the facility wide Building Automation System. The AHDC's shall communicate with the SDC at a baud rate of not less than 19,200 baud.

2. Non-Volatile Memory

a. All control sequences programmed into the AHDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the AHDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The AHDC shall allow for the creation of unique application control sequences. Systems that only allow selection of sequences from a library or table, are not acceptable.

b. All control sequences shall be fully programmable at the AHDC, allowing for the creation and editing of an application control sequence, while at the unit.

c. The AHDC shall be provided with an interface port for the HHOT. The

interface port shall allow the HHOT to have full functionality as described. From the interface port, the HHOT shall be able to directly access any AHDC or UDC in the network.

d. The AHDC shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples, per Input/Output point. Each sample shall be taken on a user defined interval, ranging from 1 second to 255 hours per sample. The digital readings shall be on a change of state occurrence for the digital points. All samples shall be recorded with the engineering units for the value, along with a time and date identifier for each sample taken. The samples shall be protected against loss due to power interruptions through a battery or capacitor backup method for a minimum of 30 days.
Systems unable to provide the above capability shall provide for the individual Input/Output point trending at the SDC. Specifics as to how each AHDC point will be trended, at the SDC, shall be provided in the submittal documents. Included in the explanation shall be the sample intervals, the memory allocation in the SDC and the number of AHDC's per SDC that can be expected.

e. The AHDC shall provide LED indication of transmit/receive communications performance, as well as for the proper/improper operation of the controller itself.

f. The AHDC shall be provided with a battery backed time clock that is capable of maintaining the time of day and calendar for up to thirty days, upon loss of power to the AHDC, without loss of setting. The battery for the time clock shall be replaceable by the customer. The AHDC shall be provided with integral time schedules; as a minimum, two seven day schedules with eight on/off periods per day shall be provided. Holiday override of weekly schedules shall be provided for pre-scheduling of holidays, for the year in advance.

3. Controller Location

a. To simplify controls and mechanical service troubleshooting, the AHDC shall be mounted directly in or on the controls compartment of the air handling system. The AHDC shall be provided in a NEMA 1 enclosure to accommodate direct mounting on the equipment to be controlled. The AHDC shall be constructed in a modular orientation such that service of the failed components can be done quickly and easily. The modular construction should limit the quantities of printed circuit boards to a maximum of two. All logic, control system, power supply and input/output circuitry shall be contained on a single plug-in circuit board. When required to replace a printed circuit board, it shall not be necessary to disconnect any field wiring. This shall allow all controls maintenance and troubleshooting to be made while at the air handling unit. The AHDC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.

b. For compatibility to the environment of the air handling unit, AHDC's shall have wide ambient ratings. AHDC's shall be rated for service from -40 Deg F (Degrees Fahrenheit) to 140 Deg F.

c. Contractor shall submit description of location of AHDC's on all

mechanical and air handling equipment.

H. Unitary Digital Controller (UDC)

1. General

a. Controls shall be microprocessor based Unitary Digital Controllers (UDC's). UDC's shall be provided for equipment as necessary. UDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the UDC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates the sensor signals. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter.
Contractor shall provide a minimum of one UDC controller per unitary system as required.
The BAS contractor shall provide and install all UDC's specified under this section. Mechanical equipment manufacturers desiring to provide UDC type controls as factory mounted equipment, shall provide a separate bid for their products less all controls, actuators, valve assemblies and sensors, which are specified to be provided by the BAS/Temperature control contractor.

b. All input/output signals shall be directly hardwired to the UDC. Troubleshooting of input/output signals shall be easily executed with a volt-ohm-milli-amp meter (VOMA). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be utilized.

c. UDC's shall be in continuous, direct communication with the network which forms the facility wide building automation system. The UDC's shall communicate with the SDC at a baud rate of not less than 9,600 baud.

2. Non-Volatile Memory

a. All control sequences programmed into the UDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the UDC memory to be lost, nor shall there be any need for batteries to be recharge or replaced to maintain the integrity of the controller database. The UDC shall allow for the creation of unique application control sequences. Systems that allow only selection of sequences from a library or table are not acceptable.

b. All control sequences shall be fully configurable at the AHDC, allowing for the creation and change of a sequence while at the unit.

c. The UDC shall be provided with the ability to interface with the HHOT. The interface port shall be provided at the wall sensor or within the unitary equipment, as specified on the plans. The interface port shall allow the HHOT to have full functionality as described hereinbefore of this specification. From the interface port, the HHOT shall be able to directly access any AHDC, or UDC in the network.

d. The UDC shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples per Input/Output point. Each sample shall be taken on a user

defined interval, ranging from 1 second to 255 hours per sample. The digital readings shall be on a change of state occurrence for the digital points. All samples shall be recorded with the engineering units for the value, along with a time and date identifier for each sample taken.

Systems unable to provide the above capability shall provide for the individual input/output point trending at the SDC. Specifics as to how each UDC point will be trended, at the SDC, shall be provided in the submittal documents. Included in the explanation shall be the sample intervals, the memory allocation in the SDC and the number of UDC's per SDC that can be expected.

e. The UDC shall provide LED indication of transmit/receive communication performance, as well as for the proper/improper operation of the controller itself.

3. Controller Location

a. To simplify controls and mechanical service troubleshooting, the UDC shall be mounted directly in the controls compartment of the unitary system. The UDC shall be provided with a sheet metal or polymeric enclosure that is constructed of material allowing for the direct mounting within the primary air stream, as defined by UL-465. The direct mounting shall allow all controls maintenance and troubleshooting to be made while at the unitary equipment. The UDC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.

b. For compatibility to the environment of the unitary equipment, UDC's shall have wide ambient ratings. UDC's shall be rated for service from 32 Deg F (Degrees Fahrenheit) to 140 Deg F.

c. Contractor shall submit description of location of UDC's on all mechanical and unitary equipment.

I. Gateway Digital Controller (GDC)

1. General

a. Controls shall be microprocessor based, Gateway Digital Controllers (GDC's). GDC's shall be provided for the purpose of integrating microprocessor based, communicating, direct digital control systems from vendors other than the primary, selected controls manufacturer. GDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the GDC. All communications interface control programs shall be resident within the GDC.

The BAS contractor shall provide and field install all GDC's specified under this section. Any interface requirement beyond a two wire communications wire link, shall be provided by the equipment manufacturer supplying the non-primary or third party microprocessor based, communicating, direct digital controllers.

b. All GDC's shall exist at the LAN level with the SDC's. The GDC's shall possess all capabilities described under the SDC section while additionally providing the interface to the third party systems described above. The GDC's shall communicate with the third party controllers at the highest

possible baud rate offered by the third party system. As a minimum, 9,600 baud communications shall be utilized.

c. All control sequences programmed into the GDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the GDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The GDC shall allow the standard database information from the third party system to be integrated in standard FMCS data formats, allowing for the creation of unique application control sequences. Systems that only allow selection of data and sequences from a library or table, are not acceptable.

d. Each GDC shall be provided with manufacturer's standard built-in operator interface.

The GDC shall provide Alarming, point trending and Energy report generation capabilities. Alarming points shall be uniquely definable, with multiple alarms assignable to a single point. Such alarm shall be provided with a unique 80 character message. Systems utilizing an alarm message library, shall describe the size of the library and verify how all alarming within the GDC will be guaranteed unique 80 character messages.

The quantities of trended point values shall be limited only by total controller memory space. If necessary, a GDC may be dedicated fully to a trending task, allowing all controller memory to be available for the trend storage. Each unique trend report shall contain a minimum of 4 different points and a minimum of 128 samples per point. Trending frequency for each report shall be operator definable from a sample once a second to a sample once every 24 hours. Trend reports shall be internally formatted by the GDC and shall be reportable directly to a serial printer, a VT-100 display terminal, a CCS, CHS or any other device capable of receiving a formatted ASCII data file.

e. The energy reports shall not be limited in quantities only by available memory within the GDC. Each Energy Report shall be fully formatted and reportable to a serial printer, a VT-100 display terminal, a CCS, a CHS or any other device capable of receiving a formatted ASCII data file. As a minimum, each Energy Report shall provide a daily report and a monthly report with summary information such as outside air temperature, outside air humidity, total energy consumed and degree day calculations.

f. The GDC shall be provided with a battery backed clock that is capable of maintaining the time of day and calendar for up to thirty days, upon loss of power to the GDC, without loss of setting. The battery for the time clock shall be field replaceable by the customer.

2.11. SYSTEM SOFTWARE DESCRIPTION

A. General

1. Contractor shall provide all software for a complete and operational system as described herein. Software shall include manufacturer's standard multi-tasking, multi-user operating system for operator consoles and controllers, network communication software for dial-up and hard trunk applications, operator man-machine interface software, control application software and all other software

necessary to provide the functions specified herein.

2. System software shall be as manufactured by Siebe Environmental Controls, Johnson Controls, Johnson Controls Facility Explorer, Honeywell, Siemens, Alerton, Reliable Controls, Schneider Electric, Advanced Power, Trane, or approved equal.

2.12. EXCEPTION REPORTING SEQUENCES

A. Alarm/COS Reports

1. For those digital points indicated on the drawings, the Contractor shall provide a unique change-of-state alarm message of up to 70 characters. The message shall report to all devices assigned to the alarm class.

2. For those points indicated on the drawings which are designated as interrupt priority, the Contractor shall provide an interrupting process display at the CHS location which displays the current conditions for the operator.

In addition, the CHS computer shall automatically send a picture of the process graphic display to the remote locations via e-mail.

3. For those points designated in paragraph 3 above, the FMCS shall also send a history log to the system report printer of the immediate prior history of the points causing the interrupt priority. This log shall contain 1 minute samples of the previous 15 minutes of operation.

4. For those points on the drawings designed as Hard Facts points, the Contractor shall provide an alarm message to a remote facsimile location designated by the Owner. The FMCS system shall provide at the remote location, a facsimile print-out showing location, time/date of alarm and alarm message of the point. For interrupt priority fax alarms, the remote facsimile machine shall receive a hard copy of the interrupt process screen showing on-line dynamic data values of the current conditions.

B. Off Hours Exception Reporting

1. The Owner shall specify up to five sites to which off hours exceptions shall be auto-dialed and reported. This shall allow the owner to assign off hours exception responses to various facility personnel as necessary. Selection of the site to be dialed can be programmed by the Owner, and set to change automatically per time of day and day of week.

2.13. MONITORING SYSTEM, SENSORS AND WIRING

A. Sensors and other Devices for Input/Output Summary Schedule:

1. Provide all necessary sensors, relays, panels, conduits and wire for the points indicated in the input/output summary as shown on the contract drawings.

2. Analog sensing elements for remote indication shall be independent of local

sensors used for local control loops.

3. Temperature sensors shall be Resistance Temperature Detector (RTD) type of 1000 ohm balco. Space (60-90 degrees F); Duct/Well (-30-250 degrees F); Averaging Duct (-30-225 degrees F) or as required under Division 26.

    a. Space temperature sensors shall be provided with blank commercial type locking satin chrome covers.
    b. Duct temperature sensors shall be rigid stem or averaging type as specified in the sequence of operation. Water sensors shall be provided with a separable copper, monel or stainless steel well. Outside air wall mounted sensors shall be provided with a sun shield.
    c. The dew point sensor shall employ a non-reactive organic bobbin material to give precise dew point readings with accuracy of not more than + 1.5 degrees F. The dew point sensor shall incorporate an integral draft shield as part of the instrument for air velocities in excess of 50 feet per minute. The dew point sensor shall operate over a minimum dew point temperature range suitable to application.

4. Relative humidity sensors shall be capacitance type with 10 percent to 90 percent range. Duct mounted relative humidity sensors shall be provided with a sampling chamber. Wall mounted sensors shall be provided with covers identical to temperature sensors. Space 10 percent -90 percent RH; Duct 10 percent - 90 percent RH.

5. All wall mounted temperature sensors, relative humidity sensors, and CO2 sensors shall be installed with stainless steel wire guard. Set point adjustment shall be achievable without removing the wire guard.

6. Differential and Static Pressure Sensors and Switches

    a. Fan proof-of-flow switches shall be U.L. listed adjustable set point and differential pressure type. Switches shall be piped to fan discharge except where fans operate at less than one inch WG, they shall be piped across the fan. For fractional horsepower and non-ducted fans, relays or auxiliary contacts may be used. Maximum pressure rating shall be at least 10 inches WG. with .05-12 inch W.C. range.
    b. Pump proof-of-flow switches shall be U.L. listed adjustable differential pressure or flow type as specified in the sequence of operation or data point summary. Devices shall be 150 psi rated except chilled water flow switches shall be provided with totally sealed vapor tight switch enclosure on 300 psi body. Differential pressure switches shall have valved manifold for servicing, and a range of 3 psi-150 psi.
    c. Air flow and static pressure analog sensors shall be high accuracy suitable for the low velocity pressures to be encountered, be selected for approximately 50 percent overrange, and have a 4 to 20 ma output. These differential pressure sensors shall be connected to the air flow measuring station with valved lines for testing and calibration, and shall have adjustments for zero and span. 5 inch W.C. range.
    d. Water flow analog sensors shall be provided complete with flow element and shall be an all solid state precision industrial type with stainless steel

meter body, maximum error of no more than .5 percent or span, and 4 to 20 ma output. Sensor shall be rated for 250 psi minimum and installed in strict accordance to the manufacturer's instructions complete with three-valve manifold for calibration and maintenance.

7. Overall system accuracy, including electronic analog sensing elements, shall be as follows:

   a. Air: Plus or minus 1.0 degrees F temperature, plus or minus 2.5 percent r.h., plus or minus 2.0 percent static pressure.
   b. Water: Plus or minus 0.7 degrees F over full scale range for water points, plus or minus 1.0 degree F for others.
   c. Proof of fan or pumps operating status, or alarm conditions shall be through positive feedback from differential pressure switches across fan or pump. Auxiliary dry contacts may be used for proof of fans or pumps if the motors are fractional H.P., and other non-ducted fans.

8. Digital inputs from devices with isolated, dry type contacts (no grounds, no voltage) of either normally open (N.O.) or normally closed (N.C.) configuration shall be provided. Live contact inputs, those that have voltage present, shall be provided with isolating devices to meet dry contact requirements.

9. Liquid flow data shall be received and transmitted by commercial grade instruments similar in quality to Honeywell 411, Rosemount, Foxboro, MAMAC Systems or approved equal, type differential pressure transmitter. Pulse type data sensors shall not be acceptable. Speed response of differential pressure transmitters shall be at least 500 milliseconds. Maximum error signal shall be +/- 1 foot.

10. Start-stop relay module shall contain relays for start-stop function at the remote point, with relays mounted and factory wired to numbered terminal strips.

11. Outage Devices:

   a. Control Relays: Control relay contacts shall be rated for the application, with a minimum of two sets of Form C contacts, enclosed in a dustproof enclosure. Relays shall have silver-cadmium contacts with a minimum life-span rating of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression limiting transients to nondamaging levels.
   b. Time Delay Relays: Time delay relay contacts shall be rated for the application with a minimum of two sets of Form C contacts enclosed in a dustproof enclosure. Relays shall have silver-cadmium contacts with a minimum life span rating of one million operations. Relays shall be equipped with coil transient suppression devices to limit transients to nondamaging levels. Delays contact opening or closing shall be adjustable from one to 60 seconds with a minimum accuracy of plus or minus 2 percent of setting.
   c. Latching Relays: Latching relay contacts shall be rated for the application with a minimum of two sets of Form C contacts enclosed in a dustproof

enclosure. Relays shall have silver-cadmium contacts with a minimum life-span rating of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to nondamaging levels.

d. Reed Relays: Reed relays shall be encapsulated in a glass-type container housed in a plastic or epoxy case. Contacts shall be rated for the application. Operating and release times shall be one millisecond or less. Reed relays shall have a minimum life span rating of 10 million operations.

e. Contactors: Contactors shall be of the single-coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semi-permanent magnets. Contacts shall be double-break silver-to-silver type protected by arcing contacts. Number of contacts and ratings shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices to limit transients to nondamaging levels.

f. Solid-State Relays: Input-output isolation shall be greater than 1000 megohms with a breakdown voltage of 1500 V rms or greater at 60 Hz. The contact life shall be 10 million operations or greater. The ambient temperature range shall be minus 20 degrees to plus 140 degrees F. Input impedance shall not be less than 500 ohms. Relays shall be rated for the application. Operating and release times shall be one millisecond or less. Transient suppression shall be provided as an integral part of the relay to limit transients to nondamaging levels.

12. Audible Alarm:

a. All alarms shall annunciate on the ATC system front end computer and via pagers.

2.14. CARBON MONOXIDE SENSORS

A. Carbon Monoxide (CO) sensors shall be Tox-CO/ANA as manufactured by Tox Alert, Inc., or approved equal. CO sensors shall be low voltage devices (24 VAC supply) with 4 to 20 mA output to be utilized with direct digital controller. Unit shall have 4 to 20 mA signal, which is linear over the sensor 0 to 400 ppm CO range. Locate CO sensors as indicated on Contract Drawings with vandal-proof locking cover.

B. Provide sensors with control system with audible alarm 0-10V DC output for exhaust fan interlock, and output for existing door operator interlock. Provide system in manufacturer standard cabinet with locking door for surface mounting.

2.15. MAKE-UP WATER FLOW METER/ALARM

A. In-line T-mounted Flowmeter: Made for installation between pipe flanges; measures flow directly in gallons per minute. As manufactured by Aaliant, Badger, Hersey, Kele, Data Industrial or approved equal.

1. Construction: Stainless steel body, with integral transmitter and direct - reading scale.

2. Pressure rating: 400 psig maximum.

3. Temperature Rating: 221 F maximum

4. Display: Two lines; alphanumeric characteristic each. Visual instantaneous rate of flow, with register to indicate total volume in gallons.

5. Output: Two simultaneous outputs; 4 to 20 mA, two-wire, pulse.

6. Transmitter: Universal flow transmitter with pulse output (totalization) to convert digital pulses to totalized gallons.

7. Electronic Housing: NEMA4, 3/4 NPT conduit connection, epoxy coated aluminum.

8. Accuracy: Plus or minus 1 percent of reading.

9. Key Pad: Setting of recalibration, engineering units, data logging sample time, alarms, response time.

B. Power and control wiring to be furnished and installed under this Section of Division 23.

2.16. FLOW MEASURING STATIONS

A. Furnish and install an Onicon Model F-1210, Hersey, Kobold or approved equal dual turbine insertion flow sensor complete with hot tap full port ball valve and installation hardware. The dual turbine element shall have counter rotating axial turbine elements, each with its own rotational sensing system, and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Paddle type rotors will not be acceptable. Rotational sensing of each turbine shall be accomplished electronically by sensing impedance change and not with magnetic or photo-electric means. Each sensor shall be individually calibrated and tagged accordingly against the manufacturers primary standards which must be accurate to within 0.1 percent and traceable to the U.S. National Institute of Standards and Technology (NIST).

B. The sensor shall have a maximum operating pressure of 400 PSI, maximum operating temperature of 220 degrees F (optional 300 degrees F) and a pressure drop of less than 1 PSI at 17 feet per second flow rate. Flow sensor shall have 100:1 turndown ratio. Accuracy shall be + 2 percent of actual reading from 0.4 feet per second to 20.0 feet per second.

C. The sensor shall have integral analog outputs of 0-10 VDC and 4-20 mA current output for connection to the Central Control System. The sensor shall also include three integral frequency outputs, (top turbine, bottom turbine, average frequency) for diagnostic purposes and for connection to peripheral equipment (local display, BTU meter, etc.). All outputs shall be linear with flow rate.

D. The turbine elements shall be made of polypropylene with sapphire jewel bearings and tungsten carbide shafts. The flow sensor shall be constructed of 316 stainless steel with an aluminum electronics enclosure and gasketed cover.

E. Install flow measuring stations with minimum straight lengths of pipe upstream and

downstream from sensor as prescribed by manufacturer's written instructions.

F. Make electrical connections to power supply and interlock with ATC system.

G. Calibrate meters per manufacturer’s requirements.

2.17. WATER METER

A. A building consumption water meter shall be provided and installed under Division 23 Section, “Plumbing Equipment”. Refer to plumbing sections and drawing for type and location. The ATC contractor shall provide all necessary wiring, relays, terminations, etc., as required to interlock meter with ATC system. Building water flow shall be reported on ATC central computer. Flow rate and volume should be reported in ATC system.

B. Trend, hourly, daily, monthly, and yearly water use (in gallons) and forward to Engineer for one year. Create graphic on ATC system.

2.18. FIELD INSTALLED CONDENSATE OVERFLOW SWITCHES

A. Condensate overflow switches must be tested to comply with U.L. 508.

B. Interlock condensate overflow switches to shut-down cooling equipment and alarm on ATC system where overflow condition exists.

2.19. CO2 SENSORS/TRANSMITTER

A. Furnish and install wall mount CO2 sensor/transmitters at locations indicated on floor plans. CO2 sensor/transmitter shall be model CD-W00 as manufactured by Johnson Controls or approved equal.

B. Measuring Range: 0 to 2,000 ppm CO2.

C. Response Time: 1 minute

D. Output Signal: As required by ATC system

E. Max power consumption: Less than 2 watts.

F. Listing: U.L. Listed

G. Accessories: Mounting Kit, Transformer required.

H. Where installed in gyms, toilet rooms, tech rooms, shops, locker rooms, cafeteria, and corridors install heavy duty stainless steel guards.

2.20. CHILLER THERMAL DISPERSION FLOW SWITCHES

A. Furnish and install thermal dispersion flow switches in chiller piping as indicated on the Contract Drawings. The thermal dispersion flow switches shall be manufactured by IFM Efector, Inc., or approved equal. Coordinate exact chiller thermal dispersion flow switch requirements with the chiller manufacturer.

B. Units shall be normally open type and shall be interlocked to prevent chiller from operating until the fluid flow is proven. Unit shall be fully adjustable and include function display LED. Units shall be constructed of 316L stainless steel including housing and material surface sensor. All wetted surfaces shall also be constructed of 316L stainless steel.

C. Furnish with M12 connector and wiring for interface to chiller and automatic temperature control system. Coordinate wiring with ATC system and chiller control panel.

D. Install assembly, sensor, and adaptors as required.

2.21. DEW POINT SENSORS

A. Furnish and install dew point sensors where indicated on the Contract Documents.

B. Dew point sensor shall be model DP4AS as manufactured by TelAire or approved equal. Unit shall monitor dew point and dry bulb temperature and report the same on the ATC system.

C. Units shall comply with the following:

Accuracy	
Enthalpy	± 2 BTU/lb
Dew Point	± 1.8°F (± 1°C)
Wet Bulb	± 3°F (± 1.7°C)
Dry Bulb	± 0.5°F (± 0.9°C)
Supply Voltage	18-30 VDCm 100 mA
Signal Output	Field selectable: 4-20 mA (700Ω max load), 0-5 V, or 0-10 V Humidity and dry bulb temperature
Measurement Range	
Dew Point: Space	40° to 90°F (4.4° to 32.2°C)
Enthalpy: Space	0-50 BTU/lb
Wet Bulb Space:	40° to 90°F (4.4° to 32.2°C)
Dry Bulb Space:	40° to 90°F (4.4° to 32.2°C)
Sensing Technology	Capacitive and replaceable
Operating Humidity	0 to 99% RH, non-condensing
Warranty	1 Year

D. Where installed in gyms, auxiliary, tech rooms, shops, gyms, toilet rooms, and corridors install heavy duty stainless steel guards.

2.22. WALL-BOX TIMER SWITCHES

A. Digital Preset Timer

1. Description: Solid state interval time switch with backlit LCD display.

2. Features:
   a. Adjustable Time Delay: 10, 20, 40, 60, 90 minutes/ 2, 4, 6, 8, hours.
   b. Single button timer selection
   c. LED indication
   d. Silent operation

e. Requires neutral conductor
f. UL listed.
g. BAS/ATC system interface.
h. Override on/off.

3. Ratings:
   a. 1 Amp at 30V maximum.

4. Electronic time switch shall be interlocked with ATC system and associated HVAC equipment.

5. Basis of Design: Tork Model SSA200R-24 (finish to match other wiring devices specified herein).

2.23. TOGGLE SWITCHES

A. Toggle switches shall be quiet-type, extra heavy-duty, horsepower-rated, industrial grade, 120/277V, 20A: Comply with NEMA WD 1, UL 20 and Federal Specification W-S-896. Switches shall have the following basic features:

1. Heavy-gauge one-piece copper alloy contact arm.
2. Fast "make" and positive "break" to minimize arcing.
3. Heavy-duty bumper pads for quiet operation.
4. High strength thermoplastic polycarbonate toggle.
5. Oversized silvery alloy contacts for long life and heat dissipation.
6. Nickel-plated steel strap with integral ground.
7. Auto-ground clip to assure positive ground.

B. Hubbell HBL1221 (single-pole), HBL1222 (two-pole), HBL1223 (three-way), HBL1224 (four-way), Pass & Seymour PS20AC1 (single-pole), PS20AC2 (two-pole), PS20AC3 (three-way), PS20AC4 (four-way), or approved equal by acceptable manufacturer.

C. Manual toggle switches shall be interlocked with ATC system and associated HVAC equipment.

2.24. SMOKE REMOVAL ASSIST SYSTEM

A. Under this Division furnish and install a smoke removal assist and smoke hatch system as indicated on the Contract Drawings. Furnish and install fire fighters' smoke removal assist system control panel, fan/damper interlocks, fire/smoke damper interlocks, monitoring, HVAC equipment interlocks, smoke hatch interlock, relays, monitoring modules, wiring, and programming as required for a complete code compliant system. Entire system shall comply with New Castle County Fire Marshal and City of Newark Fire Marshal Requirements.

B. Coordinate the work under this Division, with Division 28, "Digital, Addressable Fire Alarm System" for initiation device interlocks.

C. Monitor all devices and equipment. All fans, dampers, ERV's, and kitchen make-up air unit, shall be provided with keyed H-O-A switches and pilot lights for fire fighter use.

D. Assist with demonstration and training on the entire system. Also assist with demonstration and testing required by the Fire Marshal and the commissioning agent.

E. Locate the fire fighters' smoke removal assist and smoke hatch system control panel where shown on the Contract Drawings.

F. All components shall be listed for smoke control systems.

PART 3. EXECUTION

3.1. GENERAL

A. The Automatic Temperature Control System and Central Control and Management System, shall be designed, installed, and commissioned in a turnkey fully implemented and operational manner.

3.2. BMS SPECIFIC REQUIREMENTS

A. Graphic Displays

1. Provide a color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.

2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.

B. Custom Reports:

1. Provide custom reports as required for this project:

3.3. WORKSTATION INSTALLATION

A. Desktop Workstations Installation:

1. Install workstation(s) at location(s) directed by Owner.

2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single duplex electrical power receptacle.

3. Install software on workstation(s) and verify software functions properly.

4. Develop Project-specific graphics, trends, reports, logs and historical database.

5. Power each workstation through a dedicated UPS unit. Locate UPS adjacent to workstation.

B. Portable Workstations Installation:

1. Turn over portable workstations to Owner at Substantial Completion.

2. Install software on workstation(s) and verify software functions properly.

C. Color Graphics Application:

1. Use system schematics indicated as starting point to create graphics.

2. Develop Project-specific library of symbols for representing system equipment and products.

3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.

4. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Architect's review before creating graphic using graphics software.

5. Seek Owner input in graphics development once using graphics software.

6. Final editing shall be done on-site with Owner's and Architect's review and feedback.

7. Refine graphics as necessary for Owner acceptance.

8. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.4. INSTALLATION & SUPERVISION

A. All wiring and tubing shall be properly supported and run in a neat and workmanlike manner. All wiring and tubing exposed and in equipment rooms shall run parallel to or at right angles to the building structure. All piping and wiring within enclosures shall be neatly bundled and anchored to prevent restriction to devices and terminals.

B. The control contractor shall be responsible for all electrical installation required for a fully functional control and automation system and not shown on the electrical plans or required by the electrical specifications. All wiring shall be in accordance to all local and national codes.

1. All line voltage wiring, all wiring exposed, and all wiring in equipment rooms shall be installed in conduit in accordance to the electrical specifications.

2. All electric and electronic wiring shall be minimum #20 AWG minimum THHN and shielded if required.

3. All wiring in the central control room shall be concealed in an approved manner.

C. Verify locations of temperature sensors, relative humidity sensors, CO2 sensors, and other exposed control sensors with plans and Owner prior to installation.

D. The installation and supervision of this project shall be carried out by factory trained personnel who are employed by the Contractor and licensed for this type of work.

E. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.

F. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation.

G. Install in accordance with manufacturer's instructions.

H. Check and verify location of space temperature sensors, relative humidity sensors, CO2 sensors, and other exposed control sensors with plans and room details before installation. Align with lighting switches and relative humidity sensors, and dewpoint temperature sensors.

I. Mount freeze protection thermostats using flanges and element holders.

J. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.

K. Provide separable sockets for liquids and flanges for air bulb elements.

L. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.

M. Install equipment plumb and level.

N. Install all equipment to be accessible for service and maintenance.

3.5. ACCEPTANCE TESTING

A. Point Verification

To verify end-to-end operation of the system the Contractor shall provide a hard copy of an All Points Summary Listing to the Owner of each part or system to be placed in warranty by the Owner. For CHS systems, the Contractor shall additionally provide a print screen of the process display showing real time dynamic point information for all points on the subsystem(s) to be accepted.

B. Sequence Verification

1. The Contractor shall notify the Owner's representative of systems which perform all specified sequences.

2. The warranty acceptance test shall be of 5 days duration and the system shall perform as follows:

a. During the five days, the FMCS system shall not report any system diagnostics from the subsystem under test.
b. The subsystem shall be performance verified as operational using temporary trends of each control loop located in the SDC or MSDC.

c. During the occupied periods, BAS control loops, under test, shall maintain control of the process variable within the following scales:

i.	Duct Static Pressure	+/-0.3 inch WC
ii.	Pump Head Pressure	+/-10 percent of control range
iii.	Duct Temperature Loops	+/-2 degrees F
iv.	Room Temperature Loops	+/-1degrees F
v.	Pipe Temperature Loops	+/-2 degrees F
vi.	Duct Relative Humidity	+/-2x rated error of Humidity Transmitter

d. The contractor shall provide a hard copy printout of the process variable, process variable set point and control loop output percent for the period of 2 hours prior to occupancy to 2 hours after occupancy with samples taken every 15 minutes.

3.6. COORDINATE WITH TAB AGENCY

A. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water reset, freeze stats and duct smoke detectors.

B. Verify that all controlling instruments are calibrated and set for design operating conditions prior to commencement of TAB work.

C. Calibrate sensors after installation, and before the sensor control verification tests are performed. Prove the accuracy of final settings by taking temperature readings. The readings shall be in a typical conditional space for each separately controlled zone.

D. Allow sufficient time in the project to provide assistance and instruction to the balancing agency in the proper use and setting of control components such as, but not limited to, computers, static pressure controllers, or any other device that may need set points changed so that the testing and balancing work can be performed.

E. All control sequences, software, equipment, and components shall be started-up by a qualified technician. Start-up report shall be submitted to Engineer prior to the commencement of testing and balancing work. Testing and balancing shall not commence until start-up reports are completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.

3.7. EXAMINATION

A. Verify existing conditions before starting work.

B. Verify that systems are ready to receive work.

C. Beginning of installation means installer accepts existing conditions.

D. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.

E. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

F. Verify that conditioned power supply is available to the control units and to the operator work station. Verify that field end devices, wiring, and tubing is installed prior to installation proceeding.

3.8. INTERLOCK REQUIREMENTS

A. The fan and equipment interlock requirements are as scheduled on the contract drawings.

B. Furnish and install all necessary relays, transformer, contactors, wiring, conduit, and accessories to perform fan, equipment, and damper interlocks.

C. Unless otherwise noted, fan interlocks shall be arranged such that dampers associated with fan shall be open when fan starts and close when fan stops.

D. In projects with condensing units/heat pumps, the evaporator fans shall be hard wired interlocked with the condensing unit/heat pumps so that if evaporator fan fails, the condensing unit/heat pump shall de-energize.

E. All boiler primary pumps shall be hardwired interlocked with boilers so that if primary pump fails, boiler shall de-energize.

3.9. SUBMITTALS AT PROJECT CLOSEOUT

A. Project Record Documents: Record actual locations of components and set points of controls, including changes to sequences made after submission of shop drawings.

3.10. CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to machine to allow service and maintenance.

B. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

C. Connect hand-off-auto selection switches to override automatic interlock controls when switch is in hand position.

3.11. FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to

confirm proper unit operation. Remove and replace malfunctioning units and retest.

2. Test and adjust controls and safeties.

3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

4. Test each point through its full operating range to verify that safety and operating control set points are as required.

5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.

6. Test each system for compliance with sequence of operation.

7. Test software and hardware interlocks.

8. Test all end switches and verify status is reported on the ATC system.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.

2. Check instruments for proper location and accessibility.

3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.

4. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.

5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.

6. Check temperature instruments and material and length of sensing elements.

7. Check control valves. Verify that they are in correct direction.

8. Check DDC system as follows:

   a. Verify that DDC controller power supply is from emergency power supply, if applicable.
   b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
   c. Verify that spare I/O capacity has been provided.
   d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

E. All temperature control and interlock wiring shall be installed in conduit unless otherwise noted on the plans. Power or interlock wiring shall be run in separate conduit from sensor and communications wiring.

3.12. ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.

2. Make three-point calibration test for both linearity and accuracy for each analog instrument.

3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.

4. Control System Inputs and Outputs:

a. Check analog inputs at 0, 50, and 100 percent of span.
b. Check analog outputs using volt-ohm-milli-amp meter (VOMA) at 0, 50, and 100 percent output.
c. Check digital inputs using jumper wire.
d. Check digital outputs using ohmmeter to test for contact making or breaking.
e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:

a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 0, 50, 90, and 100 percent of span.
b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers.

9. Provide diagnostic and test instruments for calibration and adjustment of system.

10. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial CO_2 temperature and relative humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.13. ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

3.14. SCHEDULING

A. Submit spreadsheet to Owner indicating occupied/unoccupied times for each item controlled by ATC system. Incorporate all scheduling requirements into sequence of operation.

3.15. STAGING

A. Coordinate staging requirements with equipment being controlled. Where multistage units are scheduled or specified, provide all devices, controllers, wiring to control and sequence all stages.

END OF SECTION

DIVISION 23 SECTION 23 09 23
AIRFLOW MONITORING STATIONS
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SECTION 23 09 23
AIRFLOW MONITORING STATIONS

PART 1. GENERAL

1.1. RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

A. Section Includes:

1. Airflow measurement stations and sensors.

2. Airflow switches.

3. Airflow transmitters.

B. Related Requirements:

1. Section 230900 "Instrumentation and Controls of HVAC and Plumbing Systems" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3. DEFINITIONS

A. Ethernet: Local area network based on IEEE 802.3 standards.

B. FEP: Fluorinated ethylene propylene.

C. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.

D. PEEK: Polyetheretherketone.

E. PTFE: Polytetrafluoroethylene.

F. PPS: Polyphenylene sulfide.

G. RS-485: A TIA standard for multipoint communications using two twisted pairs.

H. RTD: Resistance temperature detector.

I. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

1.4. ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.

2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.

3. Product description with complete technical data, performance curves, and product specification sheets.

4. Installation instructions, including factors affecting performance.

5. Product certificates.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.

2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Include diagrams for power, signal, and control wiring.

4. Include diagrams for air and process signal tubing.

5. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Delegated-Design Submittal:

1. Schedule and design calculations for flow instruments, including the following.

a. Flow at Project design and minimum flow conditions.
b. Pressure drop at Project design and minimum flow conditions.

1.5. INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

B. Product Test Reports: For each product, for tests performed by manufacturer and witnessed by a qualified testing agency.

C. Documentation of NIST traceability.

1.6. CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

1.7. MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Provide parts, as indicated by manufacturer's recommended parts list, for product operation during two-year period following warranty period.

PART 2. PRODUCTS

2.1. PERFORMANCE REQUIREMENTS

A. Delegated Design: Select and size products to achieve specified performance requirements.

B. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2. GENERAL REQUIREMENTS FOR FLOW INSTRUMENTS

A. Air sensors and transmitters shall have an extended range of 10 percent above Project design flow and 10 percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

B. Source Limitations: For flow instruments, obtain products from single source from single manufacturer.

2.3. AIRFLOW MEASUREMENT

A. General Requirements:

1. Adjustable for changes in system operational parameters.

2. Airflow Sensor and Transmitter Range: Extended range of 10 percent above Project design flow and 10 percent below minimum Project flow to signal abnormal flow conditions.

3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.

a. Product certificates are required.

4. System Accuracy: The total system accuracy, including array averaging error, transducer error, etc… when installed in accordance with the manufacturer’s recommendations and without field adjustment shall be as follows throughout the entire operating range.

a. Ducts and plenums: +/- 3% of reading
b. Outside air intakes +/- 5% of reading
c. Fan inlets +/- 10% of reading

5. Recalibration:

a. If the technology provided requires recalibration, the contractor shall be responsible for recalibrating the system on a semi-annual basis during the construction phase through the end of the project warranty period.

6. Product Applications

a. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
i. The contractor will be required as part of the submittal process to provide a working demo that demonstrates that the unit will operate at the lowest air flows possible on the project. If the manufacture is unable to provide a working demo than their submittal will not be reviewed by the design team.
b. Duct-Mounted Airflow Sensors:
i. Measured Velocities 500 fpm and Less:
1) Thermal dispersion airflow station.
ii. Measured Velocities Greater than 500 fpm:
1) Thermal dispersion airflow station
2) Pitot-tube airflow sensor station.

B. Duct Mounted Thermal Dispersion Airflow Measuring Station:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Ebtron: Gold Series. (Basis of Design)
b. Air Monitor Corporation: Electra-Flo

2. Source Limitations: Obtain airflow and temperature measuring sensors and transmitters from single manufacturer.

3. Description: Airflow station shall consist of one or more sensor probes and a remotely mounted microprocessor-based transmitter.

4. Performance:

a. Capable of independently processing up to 16 independently wired sensor assemblies.
b. Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.
c. Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output.
d. Listed and labeled by an NRTL as successfully tested as an assembly according to UL 873, "Temperature-Indicating and Regulating

Equipment."

e. Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-listed cable placed in conduit.
f. Each flow station shall be factory calibrated at a minimum of 16 airflow rates and three temperatures to standards that are traceable to NIST.
g. Airflow Accuracy: Within 2 percent of reading over the entire operating airflow range, with 0.25 percent repeatability.

i. Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets the performance requirements throughout the measurement range.

h. Temperature Accuracy: Within 0.15 deg F over entire operating range of minus 20 to plus 160 deg F.
i. Sensor Ambient Operating Temperature Range: Minus 20 to plus 160 deg F.

j. Transmitter Ambient Operating Temperature Range: Minus 20 to plus 120 deg F.
k. Sensor and Transmitter Ambient Operating Humidity Range: Zero to 99 percent, non-condensing.
l. Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.
m. Pressure Drop: 0.05-inch wg at 2000 fpm across a 24-by-24-inch area.
n. Instruments mounted in throat or face of fan inlet cone shall not negatively influence fan performance by reducing flow more than 1 percent of Project design flow or negatively impact fan-generated sound. Losses in performance shall be documented with submittal data, and adjustments to compensate for performance impact shall be made to fan in order to deliver Project design airflow indicated.

5. Sensor Assemblies:

a. Each sensor probe shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
b. Mount thermistors in sensor using a marine-grade, waterproof epoxy.
c. Thermistor leads shall be protected and not exposed to the environment.
d. Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.
e. Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.
f. Sensor Probe Material: Gold anodized, extruded 6063 aluminum tube or Type 316 polished stainless steel.
g. Probe Assembly Mounting Brackets Material: Type 304 stainless steel.

6. Transmitter:

a. Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.

b. Capable of field configuration and diagnostics using an onboard push-button interface and digital display.

i. Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:

1) Integral protection from transients and power surges.

2) Circuitry to ensure reset after power disruption, transients, and brownouts.

3) Integral transformer to convert field power source to operating voltage required by instrument.

2.4. AIRFLOW TRANSMITTERS

A. Airflow Transmitter with 0.10 Percent Accuracy and Auto-Zero Feature:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Ebtron
b. Air Monitor Corporation: Veltron Mass-tron II

2. Transmitter shall receive total- and static-pressure signals from a primary element, amplify signals, extract the square root, and scale the signals to produce 4- to 20-mA dc output signals linear to airflow.

3. Transmitter shall have built in capability for both process temperature and pressure compensation.

4. NEMA 250, Type 1 enclosure.

5. Construct assembly so that shock, vibration, and pressures surges of up to 1 psig will neither harm transmitter, nor affect its accuracy.

6. Transmitter shall include automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. The automatic zeroing circuit shall re-zero transmitter to within 0.1 percent of true zero.

7. Performance:

a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
b. Calibrated Span: Field adjustable, minus 40 percent of the range.
c. Accuracy: Within 0.10 percent of natural span.
d. Repeatability: Within 0.15 percent of calibrated span.
e. Linearity: Within 0.2 percent of calibrated span.
f. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.

8. Integral multi-line digital LED or digital display for continuous indication of airflow.

PART 3. EXECUTION

3.1. EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Provide the services of an independent inspection agency to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

1. Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on shop drawings.

2. Do not begin installation without submittal approval of mounting location.

E. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

F. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to force.

D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied

condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.

2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:

a. Laboratory exhaust airstreams.
b. Process exhaust airstreams.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings with a corrosive-resistant coating that is suitable for environment.

4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3. ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Refer to Division 26.

C. Furnish and install power wiring. Refer to Division 26.

D. Furnish and install raceways. Refer to Division 26.

3.4. INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.

2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.

3. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

4. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.

2. Unless indicated otherwise, mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches (1050 to1800 mm) above the adjacent floor, grade, or service catwalk or platform.

a. Make every effort to mount at 60 inches (1500 mm).

3. Where indicated for rooftop equipment, mount display within rooftop equipment.

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.5. FLOW INSTRUMENTS INSTALLATION

A. Airflow Sensors:

1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.

2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

B. Transmitters:

1. Install airflow transmitters serving an air system in a single location adjacent to or within system control panel.

3.6. IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Division 26.

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.7. CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.8. CHECKOUT PROCEDURES

A. Description:

1. Check out installed products before continuity tests, leak tests, and calibration.

2. Check instruments for proper location and accessibility.

3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

B. Flow Instrument Checkout:

1. Verify that sensors are installed correctly with respect to flow direction.

2. Verify that sensor attachment is properly secured and sealed.

3. Verify that processing tubing attachment is secure and isolation valves have been provided.

4. Inspect instrument tag against approved submittal.

5. Verify that recommended upstream and downstream distances have been maintained.

3.9. ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

4. Equipment and procedures used for calibration shall meet instrument manufacturer's recommendations.

5. Provide diagnostic and test equipment for calibration and adjustment.

6. Field instruments and equipment used to test and calibrate installed instruments

shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

8. If after-calibration-indicated performance cannot be achieved, replace out-of-tolerance instruments.

9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.

2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.

2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.

2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.10. DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION

DIVISION 23 SECTION 23 30 00
HVAC AIR DISTRIBUTION
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END OF SECTION 39

SECTION 23 30 00
HVAC AIR DISTRIBUTION

PART 1. GENERAL

1.1. SUMMARY

A. For General Mechanical Requirements, see Division 23 Section, “Common Work Results for HVAC” and Division 01, “General Requirements”.

B. The fabrication and installation of all ductwork, together with related equipment, shall comply with the standards of the National Fire Protection Association, as set forth in NFPA Standard No. 90A, as well as with the requirements of the Sheet Metal and Air Conditioning Contractors' National Association, Inc., and the latest edition of the ASHRAE Guide.

C. All duct sizes shown are net inside clear dimensions. Where internal duct lining is used, increase duct sizes accordingly to provide the indicated net free area. Unless otherwise indicated size runouts, drops, and connections to air handling equipment, grilles, registers, diffusers, fans, dampers, fire dampers, smoke dampers, coils, louvers, filters, and other equipment to the full size of the equipment connection.

D. Minor changes may be made in duct sizes where required to fit the available space, provided the indicated net free area and approximate aspect ratio are maintained. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE/SMACNA Table of equivalent rectangular and round ducts.

E. Smoothly transition all ductwork to prevent excessive or unnecessary turbulence or pressure loss.

F. All exposed ductwork in finished areas shall be painted in color as indicated by Architect. All ductwork requiring paint shall be constructed of paint grade galvanized sheet steel with a paintable finish. All ductwork exposed to chemicals or shall include a corrosion resistant finish.

1.2. REFERENCES

A. ASTM A 36 - Structural Steel

B. ASTM A 90 - Weight of coating on Zinc-Coated (Galvanized) Iron or Steel Articles

C. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

D. ASTM C 916 Type II – Standard Specification for Adhesives for Duct Thermal Insulation

E. ASTM A 366 - Steel, Sheet, Carbon, Cold Rolled, Commercial Quality

F. ASTM A 480 - General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

G. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process

H. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality

I. ASTM A 568 - Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled

J. ASTM A 569 - Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip, Commercial Quality

K. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate

L. AWS D9.1 - Welding of Sheet Metal

M. NBS PS 15 - Voluntary Product Standard for Custom Contact-Molded Reinforced-Polyester Chemical Resistant Process Equipment

N. NFPA 90A - Installation of Air Conditioning and Ventilating Systems

O. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems

P. NFPA 91 - Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying.

Q. NFPA 96 - Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment.

R. SMACNA - HVAC Air Duct Leakage Test Manual

S. UL 181 - Factory-Made Air Ducts and Connectors.

T. NFPA 90A - Installation of Air Conditioning and Ventilating Systems

U. NFPA 92A - Smoke Control Systems

V. NFPA 70 - National Electrical Code

W. SMACNA - HVAC Duct Construction Standards - Metal and Flexible

X. UL 33 - Heat Responsive Links for Fire-Protection Service.

Y. UL 555 - Fire Dampers and Ceiling Dampers

Z. UL 555S - Leakage Rated Dampers for Use in Smoke Control Systems.

1.3. QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the projects specified in this section with minimum five (5) years documented experience.

B. Installer: Company specializing in performing the work of this section with minimum five (5) years' experience.

1.4. REGULATORY REQUIREMENTS

A. Construct ductwork to NFPA- 90A, NFPA-90B, and NFPA- 96 Standards.

1.5. ENVIRONMENTAL REQUIREMENTS

A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturer.

B. Maintain temperatures during and after installation of duct sealants.

1.6. ALTERNATES

A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. DUCTWORK

A. Unless otherwise indicated or specified, fabricate ductwork of galvanized sheet steel, stainless steel, or aluminum conforming to Commercial Designation 3003 Temper H14 and Duct Sheet. Duct gages, jointing and reinforcement shall conform to Tables 4, 5, 6 and 7, as applicable, Chapter I of the latest ASHRAE Guide and Data Book. Construction details shall conform to Section I and Section II, as applicable, of Duct Manual and Sheet Metal Construction for Ventilation and Air Conditioning Systems as published by Sheet Metal and Air Conditioning Contractors' Association, Inc.

B. Erect sheet metal ductwork in a first-class, workmanlike manner secured in place rigidly and permanently. Provide suitable hangers, securely attached to building construction with bolts, clips or inserts. Hangers shall be structural shapes, unistrut, kindorf or channel; strap hangers or the use of wire will not be permitted. All thread hangers shall not pass through or be inside duct. Hangers shall not penetrate the duct insulation vapor barrier. Support vertical ducts passing through floors by angles riveted to duct and resting either on floor or on brackets secured to building construction. All space around ducts where they pass through any walls, floors, ceilings, or roofs shall be sealed tight with incombustible inert material. Do not arrange ducts so as to impair the effectiveness of fireproofing around structural members. Provide sheet metal flanged collars around exposed ducts passing through walls, floors, or ceilings to provide finished appearance. Seal all duct joints and seams including supply, return, outside air, combustion air, relief air, ventilation air and exhaust ductwork with Hardcast Sealing System as manufactured by Hardcast, Inc., Foster, Childers, or approved equal.

C. Flexible connections of neoprene, excelon, or other NFPA approved non-inflammable fabric shall be provided in the duct system at all fan inlet and outlet connections. Flexible duct connectors shall be Durodyne or approved equal.

D. Provide cut turning vanes in all duct turns where centerline radius is located. Turning

vanes shall be air-foil type with extended trailing edges. Fabricate to comply with SMACNA Sheet Metal Construction for Ventilation and Air Conditioning Systems Manual.

E. Provide duct collars and angle iron framework for mounting of automatic dampers.

F. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.

G. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide air foil turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.

H. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

I. Fabricate continuously welded round and oval duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Joints shall be minimum 4-inch (100 mm) cemented slip joint, brazed or electric welded. Prime coat welded joints.

J. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.

K. Fasteners: Rivets, bolts, or sheet metal screws.

L. Hanger Rods: ASTM A36 - Galvanized steel; threaded both ends, threaded one end, or continuously threaded.

2.2. DUCT SYSTEMS

A. Unless otherwise noted, all supply, return, exhaust, fresh air intake, relief, ventilation, outside air and combustion air ductwork shall be constructed for low pressure service (2 inch W.G.). All exposed round ductwork in finished areas shall be paintable grade, dual wall, constructed for medium pressure service (6 inch W.G.).

B. Refer to Division 23 Section, "Dust Collection System" for ductwork associated with wood working equipment.

C. Refer to Division 23 Section, "Welding Fume, Exhaust System" for ductwork associated with welding equipment.

D. Refer to Division 23 Section, "Carbon Monoxide Exhaust System" for ductwork associated with Carbon Monoxide Removal Systems.

E. Paint spray booth intake/exhaust ductwork shall be medium pressure (4 inches w.g.) welded stainless steel.

2.3. DUCT CONSTRUCTION

A. Rectangular and/or Round Ductwork (Low Pressure):

1. Galvanized Steel Ducts: ASTM A525 and ASTM A527 galvanized steel sheet, lock-forming quality, having G-90 Zinc coating in conformance with ASTM A90.
2. Make allowance for internal duct lining where required. Sizes shown on the drawings are inside clear dimensions.
3. Determine duct gauges for the longest duct side and use for all four sides. Joints and reinforcing requirements apply to the longest duct side.
4. Reinforce all ducts to prevent buckling, vibration, or noise as recommended in the referenced construction standards, and as required to suit the installed conditions.
5. Do not cross break duct which will receive rigid insulation covering.
6. Where tap sizes of divided-flow fittings are not indicated, make branch and main/connection sizes proportional to their respective air flows and maintain uniform transverse velocities in the fitting.
7. Make radius elbows and radius tee connection with throat radius equal to or greater than the width of the duct. Use vaned elbows where shown and where radius elbows will not fit the space, and in all square bends.
8. Turning vanes shall be the air-foil type with extended trailing edges, 36-inch maximum vane length. Where longer vanes are required, use two or more sets of vanes with intermediate runners securely fastened together.
9. Bolt, screw, rivet, or spot weld reinforcing members securely to the duct on not less than 6-inch centers.
10. Where ducts are open-ended without grilles, registers, or other means of stiffening, reinforce and stiffen the open end with standing seams or an angle frame. Provide rolled edges to prevent any exposed sharp edges.
11. Paint all cut ends on galvanized angles, rods, and other uncoated surfaces with aluminum paint.
12. Where ductwork is not painted or otherwise finished, remove all exposed traces of joint sealers, manufacturer's identification and other markings.
13. Aluminum sheet shall be 3003 H14 alloy or duct sheet, 16,000 psi minimum tensile strength, and capable of being formed to a Pittsburgh lock seam.
14. Reinforcing members for aluminum ductwork shall be galvanized steel or aluminum unless otherwise indicated. Where aluminum reinforcing is used, size the member in accordance with ASHRAE recommendations to have rigidity equivalent to listed mild steel angle sizes.
15. Where aluminum ductwork is used, make allowance for increased thermal expansion. Particularly avoid direct contact between aluminum and concrete or masonry walls subject to dampness.
16. Determine duct gauges per SMACNA based on duct size and pressure indicated.

17. All exterior ductwork shall be single wall type with exterior field applied jacketing insulation. Inner wall shall be galvanized steel metal; outer wall shall be aluminum exterior duct insulation system as specified in Division 23 Section, "HVAC Insulation".

B. Round and/or Rectangular Ductwork (Stainless Steel Type 316):

1. Stainless steel ducts: ASTM A167, Type 316.
2. All stainless steel ducts shall be round longitudinal seam or rectangular stainless steel Type 316. Determine duct gauges suitable for duct diameter and welded joints.
3. All fume hood exhaust ductwork, chemical storage room ductwork, dishwash machine exhaust, and prep room exhaust ductwork/dampers shall be stainless steel.
4. All longitudinal seams shall be installed with seam up.
5. These exhaust systems are low pressure service.
6. All elbows are round. Ninety degree squared elbows are not permitted.
7. All joints are welded by gas fusion using rods of similar materials.
8. All dampers, manual and motorized, shall be stainless steel Type 304.
9. These exhaust systems shall be fabricated and installed in strict accordance with requirements of SMACNA and NFPA.
10. Provide stainless steel guy wires, stabilizers, tensioners and accessories at upblast fan discharge ducts.
11. All exterior exhaust ductwork shall be Type 316 stainless steel. Exterior rectangular exhaust ductwork shall be beveled and crossbroken for proper drainage.

C. Round Ductwork (Dual Wall - Medium Pressure)

1. Medium pressure flat oval and round ductwork shall be spiral lock-seam Type K-27 with Type P liner as manufactured by United Sheet Metal Company, Inc., Semco Manufacturing, Inc., Lindab, Ductmate, MKT Metal Manufacturing, or approved equal, Uniseal duct and Uniform fittings. Construct ductwork of galvanized sheet steel. Elbows 8 inches in diameter and smaller shall be smooth formed. Larger elbows shall be five section type. Tees and crosses and laterals shall be conical. Make joints with sleeve type couplings, short length sheet metal screws and duct sealant. Seal joints with Hardcast, Foster, Childers, or approved equal, as hereinbefore specified. Conform to duct manufacturer's recommendations for jointing and installation. Ductwork and fittings shall be manufactured by a company regularly engaged in the construction of spiral ductwork and fittings. Contractor-fabricated ductwork will not be acceptable for ductwork and fittings. Manufacturers substituted for the above specified manufacturers shall submit for approval independently published laboratory test data on all proposed ductwork and fittings showing materials of construction, air flow, pressure drop and acoustical performance characteristics.

2. Round dual wall ductwork shall be installed to the extent shown on the drawings. All duct lining shall be provided with a perforated galvanized liner on the surface exposed to the air stream. All exposed ductwork in finished areas and where indicated on contract drawings shall be painted in color as selected by Architect. All ductwork requiring paint shall be constructed of paint grade sheet steel with

paintable finish.

3. Round dual wall ductwork shall contain a 2 inch thick fiberglass insulation sandwiched between inner and outer ducts.

D. Round/Flat Oval and/or Rectangular Ductwork (Single Wall Medium Pressure):

1. Galvanized Steel Ducts: ASTM A525 and ASTM A527 galvanized medium pressure sheet steel, lock forming quality, having G90 Zinc coating in conformance with ASTM A90.
2. Determine duct gauges based on duct diameter or duct size and pressures indicated.
3. Round and flat oval duct shall be spiral seam type.
4. All branch ducts shall connect to the main duct with a 45 degree conical lateral, or low loss fittings as shown on the drawings where possible. Where not possible, a 90 degree conical connection shall be used.
5. All elbows shall be long radius.
6. All seams and joints of fittings shall be welded by gas fusion with rod material same as duct material.
7. Connections to equipment shall be flexible material, NEMA approved, having adequate reinforcing to be compatible with internal pressure of system.
8. Paint all cut ends and welded joints with aluminum paint.
9. Make allowance for internal duct lining where required. Sizes shown on the drawings are inside clear dimensions. Rectangular lined ductwork shall have perforated metal liner, similar to that hereinafter specified.
10. Determine duct gauges for the longest duct side and use for all four sides. Joints and reinforcing requirements apply to the longest duct side.
11. Reinforce all ducts to prevent buckling, vibration, or noise as recommended in the referenced construction standards and as required to suit the installed conditions.
12. Do not cross-break duct which will receive rigid insulation covering.
13. Where tap sizes of divided-flow fittings are not indicated, make branch and main connection sizes proportional to their respective air flows and maintain uniform transverse velocities in the fitting.
14. Make radius elbows and radius tee connection with throat radius equal to or greater than the width of the duct. Use vaned elbows where shown and where radius elbows will not fit the space, and in all square bends.
15. Turning vanes shall be the airfoil type with extended trailing edges, 36-inch maximum vane length. Where longer vanes are required, use two or more sets of vanes with intermediate runners securely fastened together.
16. Bolt, screw, rivet, or spotweld reinforcing members securely to the duct on not less than 6-inch centers
17. Where ducts are open-ended without grilles, registers, or other means of

stiffening, reinforce and stiffen, and open end with standing seams or an angle frame.

18. Remove all exposed traces of joint sealers, manufacturer's identification and other markings.

E. Clothes Dryer Round Vent Ductwork

1. Aluminum Ducts: ASTM B209. Aluminum sheet, alloy 3003 - H14. Aluminum connectors and band stock: Alloy 6061 - T6 or of equivalent strength.

2. Dryer vent round ductwork shall be 20 gauge (minimum) aluminum construction with die-stamped or fabricated fittings. Ducts shall be constructed for low pressure operation with longitudinal seam up. Provide cleanouts at all changes in direction exceeding 45 degrees.

3. Fabricated elbows shall be the multi-piece type with each segment not exceeding 22½ degrees. Throat radius of all elbows shall equal to the duct diameter. Tees shall be the conceal type. All elbows must be smooth radius type.

4. Joints shall be the slip or flanged type. Do not use drive slip coupling bands. Make-up slip joints with duct sealer.

5. Ducts for exhausting clothes dryers shall not be assembled with screws or other fastening means that extend into the duct and that would catch lint. Install protective metal plates at wall studs where duct is installed concealed in walls.

6. Provide N.F.P.A.-90A approved and U.L. Listed flexible duct section at connection of dryer to ductwork. Also attach label to dryer vent that indicates the “equivalent length”. This warns the Owner of dryer vent equivalent length in the event they replace the dryer in the future.

7. Where indicated, provide and install extruded aluminum brick vent at termination of each dryer duct. Brick vents shall be extruded aluminum, with aluminum mesh bird screen, straight duct extension, and single blade flap damper. Baked enamel finish in color as selected by Architect. Brick vents shall be Model BVE-808 as manufactured by Greenheck.

8. Where clothes dryer vent ducts pass through walls, floors, or partitions, the space around the duct shall be sealed with non-combustible material and firestopped.

9. For gas-fired clothes dryers, provide dual wall gas fired clothes dryer ductwork/ breeching as hereinafter specified.

F. Kitchen Range Hood Exhaust Ductwork

1. Exposed Stainless Steel Ducts: ASTM A167, Type 316

2. The exhaust ductwork serving the kitchen hoods shall comply with NFPA Standard No. 96, International Mechanical Code, State of Delaware Health Department requirements, and local Health Department requirements.

3. The exposed exhaust ductwork shall be Type 316 stainless steel (minimum 18 gauge) No. 4 finish, with all joints and seams welded, ground and polished. All welds shall be liquid tight, continuous external welds. Comply with N.S.F. requirements.

4. Concealed exhaust ductwork shall be constructed of welded carbon steel

(minimum 16 gauge).

5. Proper clearance to combustibles shall be maintained as required by Code.

6. All exhaust ducts shall be installed without forming dips or traps that might collect residue. All exhaust duct must slop toward hood at .25 inches per foot. For ducts longer than 75 feet the slope shall be at least 1 inch per foot.

7. Cleanouts shall be located on horizontal sections of ducts not spaced more than 12 feet apart. Cleanouts shall also be located at all vertical risers and all changes in direction. In horizontal sections, the lower edge of the opening shall be not less than 1½ inch from the bottom of the duct. Access panels shall be of the same material and thickness as the duct. Access panels shall have a gasket or sealant that is rated for 1500 degrees F and shall be grease tight. Fasteners used to secure the access panels shall be stainless steel and shall not penetrate duct walls. A sign shall be placed on all access panels stating: ACCESS PANEL - DO NOT OBSTRUCT.

8. Dampers, either manual or automatic, shall not be installed in kitchen hood exhaust ducts or kitchen hood exhaust duct systems.

9. Ducts that terminate above the roof shall have the discharge located a minimum of 40 inches above the roof surface.

10. Utilize light to verify that all joints are sealed. Submit results of light testing.

2.4. SHOWER ROOM EXHAUST DUCTWORK

A. Aluminum Ducts: ASTM B209, aluminum sheet, alloy 3003-H14. Aluminum connectors and bar stock: Alloy 6061-T6, or of equivalent strength stainless steel ducts: ASTM A167, Type 316.

B. Ductwork shall be 20 gauge aluminum construction where concealed and 18 gauge Type 316 stainless steel where exposed.

C. Ducts shall be constructed for low pressure operation with all seams liquid tight.

D. Ductwork shall be pitched ¼ inch per foot back to hood or equipment for drainage.

E. Provide a cleanout door of the same material as the ductwork for inspection and cleaning of interior duct surface. Cleanout shall be located in the vertical riser. Label all duct cleanout doors.

2.5. WATER HEATER/CONDENSING BOILER INTAKE AND WATER HEATER EXHAUST DUCTWORK (PIPING) MATERIAL

A. Water Heater Exhaust Piping CPVC Pressure Pipe: ASTM F 441/F441M, solid-wall pipe.

1. CPVC Socket Fittings: ASTM F 441/F441M pipe, socket type, and ASTM F438 socket type fitting.

2. Joints: Solvent weld with solvent cement.

3. Furnish and install roof curbs and roof terminations.

4. Use CPVC solvent cement that has a VOC content of 490 g/l or less when calculated to 40 CFR 59, subpart D (EPA method 24).

5. Use CPVC primer that has a VOC content of 550 g/l or less when calculated to 40 CFR 59, subpart D (EPA method 24).

6. Install lime chip neutralizer kit at all flue (exhaust) drain lines prior to discharge into floor drain. Condensate neutralizer shall be as manufactured by JJM Boiler Works or approved equal.

B. Water Heater/Boiler Intake Piping – PVC Pressure Pipe: ASTM D2665, solid wall drain, waste and vent (schedule 40).

1. PVC Socket Fittings: Schedule 40 PVC, ASTM F89 socket fittings.

2. Joints: Solvent weld with solvent cement.

3. Use PVC solvent cement that has a VOC content of 510 g/L of less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

4. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

5. Boiler and water heater intake ductwork shall be PVC.

C. For Boiler Exhaust/Flue Ductwork refer to “Stacks and Breeching” in Part 2 of this specification section.

2.6. AIR TRANSFER OPENINGS

A. Furnish and install metal sleeves or frames, of the same material as the duct or air terminals attached thereto, in all air transfer openings through walls, partitions, floors and other building construction, extending completely through the opening. Securely fasten the sleeves or frames in place and provide face flanges on both sides. Where grilles or registers are required, attach them to the sleeve or frame, or extend ductwork where shown on the drawings. If no grilles, registers or duct connections are required, furnish and install ½ inch x ½ inch removable galvanized wire mesh on one face.

2.7. AIR VOLUME CONTROLS

A. Furnish and install air volume control devices where indicated and where required to adjust and balance air flow in the systems, whether indicated or not. Volume dampers shall be provided in all branch ducts serving air outlets and inlets. For existing air devices install a new volume damper and where required for access, a new access door to allow access and adjustment.

B. Air extraction for air outlets and branch ducts shall be the gang-operated vane type, Tuttle & Bailey - Vectrol, Type VLC or VLK as appropriate, or approved equal, with suitable adjusting device and means of access.

C. Manual volume dampers in ductwork shall be factory-assembled units with rigid frame, opposed-blade action, and locking quadrant operator. Mark the extended damper shaft and align the operating handle to indicate the blade position. Dampers shall be as manufactured by Ruskin, American Warming and Ventilating, Inc., Arrow, Vent Products Company, or approved equal. Rectangular dampers shall be Type MD35, with

steel channel frame, 16 gauge steel blades, 9 inch maximum blade spacing, low pressure, nylon bearings, galvanized finish with aluminum paint touch up. Round manual balancing dampers shall be Type MDRS25 manufactured by Ruskin, Arrow, American Warming and Ventilating, Inc., or as approved equal. When external insulation is to be applied, provide sheet metal standoffs on all manual volume dampers. Provide blade stops to minimize air gaps around damper blades when closed.

D. Motor-operated dampers shall be as hereinafter specified under Division 23 Section, "Instrumentation and Controls of HVAC & Plumbing System".

E. Duct turning vanes shall be Tuttle & Bailey Ducturns, or approved equal.

F. Furnish and install duct collars and angle iron frames for the installation of ATC dampers.

G. Provide Type 316 stainless steel motor-operated dampers for installation in stainless steel ductwork.

H. Where volume dampers are installed in exposed finished spaces locate damper handle on top of duct.

I. Where volume dampers are installed above ceilings attach a colored piece of tape so that Test and Balance Engineer can easily locate for air flow adjustment.

J. When existing air devices do not contain manual volume dampers in the run-out ductwork, install manual volume damper at each existing air device duct runout.

2.8. INSTRUMENT TEST PORTS

A. Furnish and install instrument test ports in the ductwork to allow use of pitot tube length. Equip holes with Ventlok #699 instrument ports. Fittings shall extend beyond duct covering and insulation.

B. Kitchen hood grease ducts shall be fitted with metal to metal seals for pitot tube access port. Assembly shall consist of stainless steel bolt, toothed lock washer, and nut. Nut shall be welded to grease duct as indicated on contract drawings. Locations of pitot tube access ports shall be coordinated with Test and Balance Engineer prior to installation of the ports.

2.9. DUCT THERMOMETERS

A. Duct thermometers shall be Dresser Industries, Trerice, Weiss, Weksler, Miljoco, or approved equal direct-mounting filled system dial thermometers. Duct thermometers shall be vapor-actuated, universal-angle dial type, cast aluminum case with 4 ½ inch diameter, glass lens. Duct thermometers shall include adjustable joint with finish to match case, 180 degree adjustment in vertical plane, 360 degree adjustment in horizontal place, with locking device. Thermal bulbs shall be copper with phosphor-bronze bourden pressure tube. Movement shall be brass, precision geared. Duct thermometer scales shall be Progressive, satin-faced non-reflective aluminum with permanently etched markings. Each stem shall be copper-plated aluminum or brass for separable socket of length to suit installation.

B. Where ductwork is installed at a height that would require duct thermometers to be installed 10 feet above finished floor or greater then remote-ready filled - system dial thermometers shall be installed. Connecting tubing shall be bronze, double-braided, armor-over-copper capillary; of length to suite installation.

C. Duct thermometers shall be furnished and installed at air handling units, energy recovery ventilators, 100% outside air units, make-up air units, makeup air units, H&V units, single zone VAV units, packaged rooftop units, and kitchen make-up air units as follows:

LOCATION	RANGE
Outdoor Air Duct	-40 degrees Fahrenheit to 120 degrees Fahrenheit
Return Air Duct	40 degrees Fahrenheit to 180 degrees Fahrenheit
Mixed Air Plenum	30 degrees Fahrenheit to 180 degrees Fahrenheit
Supply Air Duct	30 degrees Fahrenheit to 180 degrees Fahrenheit
Exhaust Air Duct	30 degrees Fahrenheit to 180 degrees Fahrenheit

D. Description: Flanged fitting bracket for mounting in hole of duct, with threaded end for attaching thermometer.

1. Extension Neck Length: Nominal thickness of 2 inches, but not less than thickness of exterior insulation.

2. Insertion Neck Length: Nominal thickness of 2 inches, but not less than thickness of insulation lining.

2.10. FLEXIBLE DUCT

A. Where indicated, flexible ductwork shall be Type SLR-25C as manufactured by General Flex Corporation, or as approved equal, insulated fully, UL listed as Class 1 Air Ducts, Standard 181, NFPA 90A and NFPA 90B with scuff-resistant polyethylene connector jacket and suitable for use in return air plenums. Flex duct tape shall be UL-181 listed and marked “181B-FX”.

B. Limit flexible duct runs to 5 feet maximum. Install flexible ducts, using all recommended fittings, couplings, and accessories. Support ducts with wide straps spaced so that horizontal runs do not sag more than 2-1/2 inches in 5 feet. Internally seal all joints and connections, cover with duct tape, and fasten with metal duct strap clamps. Bends of 180 degrees in flexible duct are prohibited.

2.11. FIRE DAMPERS

A. Furnish and install automatic fire dampers where indicated, in all 2-hour fire-rated partitions, shafts, slabs, etc., and where required by NFPA Standard No. 90A and by the Fire Marshal. Refer to the architectural drawings for location of all fire-rated walls, shafts and slabs. Fire Dampers shall also be provided at all transfer air devices installed

in rated walls at all floor penetrations, and as shown on the contract drawings.

B. Construction of fire dampers shall conform to requirements of NFPA No. 90A, UL Standard 555 and shall bear UL label. Fire dampers shall be set in frames adequately secured to fire partitions, floors, etc., and installed in strict accordance with UL listing and manufacturer's instructions.

C. Fire damper shall be Dynamic Type for rectangular ductwork and round ductwork as manufactured by Ruskin, Air Balance, Inc., Arrow, Greenheck, Lloyd Industries, Nailor, Vent Products Company, or approved equal, multi-leaf accordion type, held open by adequate heavy gauge wires and suitably calibrated fusible links. Vertical dampers (horizontal air flow) shall close by gravity. Horizontal dampers (vertical air flow) shall be closed by suitable and positive spring closing devices.

D. Damper frames shall provide pocket which shall store the damper leaves in open position outside of the air stream and shall provide for 100 percent opening connecting to ductwork or grille face. Damper material shall match connecting ductwork.

E. Provide adequately sized hinged access doors with cam locks for access to all fusible links and for resetting fire dampers. Where applicable, access to fire dampers shall be through registers or grilles. Provide identification on access door indicating fire damper within. Letters shall be not less than ½-inch in height.

F. Submit complete information to the Engineer including installation details. Furnish and install sleeves, angles, break-away duct connections, per UL listing.

G. Furnish to the Owner in a suitable storage container not less than six (6) fusible links of each type, size, and rating used on the project. Where required, furnish Greenheck Type CR, CO, or Type C transition sleeves.

H. For chemical storage rooms and science prep rooms and similar corrosive environments fire dampers shall be Type 304 stainless steel including sleeves and angles.

2.12. COMBINATION FIRE/SMOKE DAMPERS WITH INTEGRAL SMOKE DETECTOR

A. Furnish and install automatic combination fire/smoke dampers with actuators and smoke detectors where shown on plans and as required by NFPA-90A, 92A, 93B, 101 and by the State Regulations. Combination fire/smoke dampers shall be tested, rated, and labeled in accordance with the latest edition of UL Standard 555S. Combination fire/smoke dampers shall be of the low leaking design qualified to UL 555S Leakage Class I. Fire dampers shall have a UL 555 fire rating of 1½ hours and be of low leakage design qualified to UL 555S Leakage Class I. Furnish to the Owner in a suitable storage container not less than six (6) fusible links of each type, size, and rating. Smoke detectors shall be tested, rated and labeled in accordance with the latest edition of UL Standard 268A.

B. Each damper/actuator combination shall have a UL 555S elevated temperature rating of 350 degrees F minimum and shall be rated to operate at maximum design air flow at its installation location.

C. Each damper shall be supplied with an appropriate smoke detector installed by the

damper manufacturer. Smoke detectors shall be "no flow" type and rated for air duct velocities between 0-3,000 fpm and operating temperature range of 23 degrees Fahrenheit to 131 degrees Fahrenheit. Electrical characteristics shall be as scheduled on the contract drawings. Detector shall be factory wired to damper actuator so as to provide single point wiring of the damper. Provide detectors with dry contacts for monitoring on the fire alarm system. Coordinate with Division 26. Provide end switches on damper to allow remote monitoring on fire alarm system, coordinate with Division 26. Furnish end switches to allow monitoring of damper position from a remote test station. Remote test station shall be furnished and installed. Remote test switch shall include controlling switch (double throw switch) and indicator lights.

D. Each combination fire/damper shall be supplied with an appropriate actuator installed by the damper manufacturer at the time of damper fabrication. Damper actuators shall be electric type and shall be factory wired to smoke detector so as to provide single point wiring of damper. Electrical characteristics shall be as scheduled on the contract drawings.

E. Combination fire/damper blades shall be of the double skin airfoil type and shall have an equivalent metal thickness of 14 gauge. Combination fire/damper frame shall be galvanized steel furnished into a structural hat channel shape with reinforced covers. Bearings shall be sintered bronze sleeve type, rotating in extended holes in the damper frame.

F. Blade edge seals shall be silicone rubber designed to inflate and provide a tighter seal against leakage as pressure on either side of the damper increases. Jamb seals shall be stainless steel compression type with silicone rubber backing. Blades shall be completely symmetrical relative to their axle pivot point, presenting identical resistance to air flow in either direction or pressure on either side of the damper.

G. Combination fire/smoke dampers must be rated for mounting vertically (with blades running horizontally) or horizontally and be UL 555S rated for leakage and air flow in either direction through the damper. Combination fire/damper shall confirm to the following ratings:

1.	Leakage:	UL 555S Leakage Class I - Leakage rated in both directions.
2.	Pressure:	8 inches w.g. - Differential
3.	Velocity:	Operational rated to 4000 FPM with airflow in either direction
4.	Temperature:	350 degrees F with standard actuator

H. Furnish combination fire/dampers with appropriate galvanized steel sleeves. Where applicable, provide Type R, Type O, or Type C transition sleeve as manufactured by Greenheck or approved equal. Dampers shall be sized to provide 100 percent of the areas of the ductwork in which the damper is installed. Provide stainless steel or aluminum smoke combination fire/dampers when installed in duct systems constructed of these materials, respectively.

I. Provide adequate sized, hinged, insulated access doors with cam locks for access, inspection of all combination fire/smoke dampers. Where applicable, access to combination fire/smoke dampers shall be through registers, on grilles. Provide identification on access doors indicating combination fire/smoke damper within. Letters shall not be less than ½- inch in height.

J. Wiring to fire alarm system shall be provided under Division 26. Installation of combination fire/smoke dampers, duct detectors, and smoke actuators shall be provided under Division 23.

K. Submit complete information to the Engineer, including installation details. Furnish and install sleeves, angles, actuator, etc., per UL listing. Combination fire/smoke dampers shall be Model FSD-33 as manufactured by Greenheck, Air Balance, Ruskin, Lloyd Industries, Nailor, or approved equal.

2.13. DUCT ACCESS DOORS

A. Furnish and install adequately sized duct access doors at fire dampers, smoke dampers, air measuring devices, motor-operated dampers, duct smoke detectors, duct coils and other locations where indicated and required for duct access. Doors shall be the continuous piano-hinged type with approved latches and neoprene compression-type gaskets with 1 inch thick fiberglass double skin and shall be Ruskin Model ADH22, Air Balance, Inc., FSA-100 or as approved equal. Stiffen ductwork at door openings. Where doors are installed in insulated ductwork, provide equivalent insulation in the door assembly. Where access doors are installed in the fire-rated partitions, provide Fire Seal access doors as manufactured by Air Balance, Inc., or approved equal, UL approved, meeting the rating of the enclosure in which the access door is installed.

B. Where duct access doors are installed in medium pressure ductwork, they shall be as manufactured by Ruskin, Type ADHP-3, or approved equal, with six latches continuous gasket and insulated core.

C. For walk-in plenums, provide insulated walk-through access doors, Ruskin Type ADW2, American Air Balance Type WA-100, or as approved equal.

D. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

2.14. SPIN-IN FITTINGS

A. Furnish and install spin-in fittings where indicated on the contract drawings, Model SM-20G, as manufactured by General Environment Corporation, or an approved equal.

2.15. DUCT LINING (LOW PRESSURE DUCTWORK)

A. All low pressure supply and return ductwork within 20 feet of air handling units, rooftop units, makeup air units, heating and ventilation units, kitchen make-up air units, energy recovery ventilation units, single zone VAV units, and as additionally shown on Contract Drawings, shall be lined on the interior for sound attenuation and thermal insulation.

B. All low pressure ductwork within 20 feet of return or exhaust air fans and as additionally shown on Contract Drawings shall be lined on the interior for sound attenuation and thermal insulation. (Does not apply to Kitchen Hood Exhaust Fans)

C. All internal duct lining for low pressure duct systems shall be provided with an interior galvanized perforated liner.

D. Provide additional exterior insulation where required and as indicated in Division 23

Section, “HVAC Insulation”.

E. The lining insulation shall be 1 inch thick, 3.0 pcf density, Aeroflex plus Duct Liner Type 300, Owens Corning Quiet R Rotary Duct Liner, Manville, Knauf, or approved equal. The material shall be specifically designed for this application, shall have a black, fire-resistant coating, shall meet NFPA Standards 90A and 90B and shall have a UL Fire Hazard Classification of Flame Spread 25 or less and smoke developed of 10 or less. The black-coated surface shall face the air stream.

F. All exposed edges and the leading edge of all cross joints of the liner shall be coated with the same adhesive used to secure the duct liner to metal surface. All air stream surfaces shall be treated with EPA registered fungicide Foster 40-20. Coating shall meet ASTM D 5590 with 0 growth rating.

G. The duct liner shall be adhered to the metal with 100 percent coverage of adhesive. Adhesive shall conform to Adhesive and Sealant Council Standards for adhesives for duct liner; ASTM C916, Type II (ASC-A-7001-A-1971). Adhesive shall be Foster 85-60, Childers CP-127 or approved equal.

H. The duct liner shall be additionally secured with mechanical fasteners, which shall compress the duct liner sufficiently to hold it firmly in place. Mechanical fasteners shall conform to Mechanical Fastener Standard MF-1-1971, available from Sheet Metal and Air Conditioning Contractors National Association.

I. All duct lining shall be installed in complete accordance with the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Duct Liner Application Standard, First Edition and Green Guard Indoor Air Quality certification program requirements.

J. Dimensions on drawings indicate inside clear opening of rectangular ductwork. Increase duct dimensions 2 inches each way for accommodating insulation on all shop or field-fabricated rectangular ductwork where lining is specified.

2.16. DUCT LINING (MEDIUM PRESSURE DUCTWORK)

A. All medium pressure supply and return ductwork within 20 feet of air handling units, rooftop units, makeup air units, heating and ventilating units, kitchen make-up air units, energy recovery ventilators, single zone VAV units, ERV units, and as additional shown on contract drawings shall be lined on the interior for sound attenuation and thermal insulation.

B. All medium pressure ductwork within 20 feet of return air fans or exhaust air fans and as shown on Contract Drawings shall be lined on the interior for sound attenuation and thermal insulation.

C. Provide additional exterior insulation where required and as indicated in Division 23 Section, “HVAC Insulation”.

D. All internal duct lining for medium pressure duct systems shall be provided with interior galvanized perforated liner.

E. The insulation shall be 1 inch thick, 3.0 pcf density, Aeroflex plus Duct Liner Type 300, Owens Corning Quiet R Rotary Duct Lines, Manville, Knauf, or approved equal. The material shall be specifically designed for this application, shall have a black, fire-resistant coating, shall meet NFPA Standards 90A and 90B and shall have a UL Fire Hazard Classification of Flame Spread 25 or less and smoke developed of 10 or less. The black-coated surface shall face the air stream.

F. All exposed edges and the leading edge of all cross joints of the liner shall be coated with the same adhesive used to secure the duct liner to metal surface. All air stream surfaces shall be treated with EPA registered fungicide Foster 40-20. Coating shall meet ASTM D5590 with 0 growth rating.

G. The duct liner shall be adhered to the metal with 100 percent coverage of adhesive. Adhesive shall conform to Adhesive and Sealant Council Standards for adhesives for duct liner; ASTM C 916 (ASC-A-7001-A-1971). Adhesive shall be Foster 85-60, Childers CP-127 or approved equal.

H. The duct liner shall be additionally secured with mechanical fasteners which shall compress the duct lines sufficiently to hold it firmly in place. Mechanical fasteners shall conform to Mechanical Fastener Standard MF-1-1971, available from Sheet Metal and Air Conditioning Contractors National Association.

I. All duct lining shall be installed in complete accordance with the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Duct Liner Application Standard, First Edition and Green Guard Indoor Air Quality certification program requirements.

J. Dimensions on drawings indicate inside clear opening of rectangular ductwork. Increase duct dimensions 2 inches each way for accommodating insulation on all shop or field-fabricated rectangular ductwork where lining is specified.

2.17. STACKS AND BREECHING CONDENSING BOILERS

A. The factory-built modular connector, manifold and breeching system shall be laboratory-tested and listed by Underwriters Laboratories, for use with building heating equipment which produces exhausted flue gases at a temperature not exceeding 550 degrees Fahrenheit (F) under continuous operating conditions and shall comply with UL-1738, ULC 5636, NFPA-54, and NFPA-211 when burning gaseous, solid or liquid fuels as described in NFPA 211. The breeching system shall be designed and installed to be gas and water tight and thus prevent leakage of combustion products into a building. The system shall be designed to compensate for all flue gas induced thermal expansions.

B. Vent shall be factory-built special gas type, double wall, engineered and designed for use on Category I, II, III, and IV appliances, or as specified by the equipment manufacturer.

C. The double wall breeching shall have an inner gas carrying pipe of Type AL29-4C stainless steel for natural gas. Vent shall be listed for an internal static pressure of 15” w.g. and tested to 37”w.g. There shall be a nominal 1-inch fiber insulation between the walls. The outer jacket shall be Type 430 stainless steel. The materials and construction of the modular sections and accessories shall be as specified by the terms of the product's UL listing.

D. The stack system shall be installed according to the manufacturer's installation instructions and shall comply with the codes and standards of the State of Delaware, International Mechanical Code, and applicable N.F.P.A. pamphlets. Stack termination height shall be sufficient to prevent re-entrainment into other building openings. Stack termination shall be minimum of 15 feet away from all building openings, intakes. All breeching stack terminations with a 15 foot radius of any building opening intake, or louver shall be extended 3 feet above the opening, intake or louver.

E. Inner wall joints shall be designed with a male and female overlapping metal-metal connection to maintain condensate in the AL29-4C stainless steel. Proper ¼" per foot pitch must be maintained at all times and condensate should flow back toward the appliance to the required number of drains. All inner wall conduit components shall be manufactured from AL-29-4C stainless steel. The joint closure system shall be an inner wall mechanical locking strap design. Joints shall not use screws or fasteners that penetrate inner conduit.

F. When installed according to the manufacturer's installation instructions, the piping and its supporting system shall resist side loads (whether system is horizontal or vertical) at least 1.5 times the weight per foot of the piping. Wall supports shall support 40 feet of pipe with a factor of safety of at least four (4). Plate supports shall support (as verified by manufacturer testing) 200 feet of pipe in 6-inch through 20-inch ID sizes and 100 feet of pipe in 24-inch ID and larger sizes with a factor of safety of at least four (4).

G. The entire breeching system from the equipment to termination, including all required accessories (ventilated roof thimbles, guy wires, storm collar, guy tensioners, expansion joints, discharge cone, supports, etc.), shall be from one manufacturer.

H. The breeching shall be warranted against functional failure due to defects in material and manufacturer's workmanship for a period of fifteen years from date of installation. Drawings showing the actual layout and drawn to scale shall be provided by the manufacturer. The system shall be installed as designed by the manufacturer and in accordance with the terms of the manufacturer's 15-year warranty and in conjunction with sound engineering practice. The inner diameter for breeching and stacks shall be verified by the manufacturer's computations. The computations shall be technically sound, shall follow ASHRAE calculation methods, and incorporate the specific flow characteristics of the inner pipe. The Contractor shall furnish the exact boiler model and operating characteristics to the factory representative. Operating characteristics shall include flue gas flow rate, BTU input, outlet temperature, local altitude, stack layout, and available external pressure at boiler or equipment outlet, etc., necessary to determine system operation at maximum and minimum levels of burner turndown range.

I. Boiler or equipment breeching, as hereinbefore specified, shall be provided for all new fuel-fired equipment, including but not limited to boilers.

J. General Electric RTV106 (aka Momentive) or Dow Corning 736 High Temperature Sealant shall be used to seal all joints on systems where the maximum flue gas temperature will not exceed 550°F.

K. Boiler breeching shall be Type Saf-T Vent CI Plus as manufactured by Selkirk Metalbestos, Type CS Plus by Van Packer, Type SD by Schebler, or Type CG by Metal-FAB.

2.18. AIR DEVICE REQUIREMENTS

A. Furnish and install air supply, return, exhaust devices of sizes and capacities as scheduled on the drawings. Catalog numbers shown are Titus, Inc., products for equipment which have been found suitable for the application. Other manufacturers listed below or approved equal will be considered only if performance characteristics including throw, drop, pressure loss, sound pressure level, etc., are equal to or better than the performance characteristics of the specified products. All air devices shall be ADC certified. Ductwork behind registers, grilles, open ended ducts, and diffusers shall be given two coats of flat black paint. Perimeter of all ceiling diffusers shall be caulked to provide a neat, aesthetic appearance.

B. Where air terminal devices are installed in duct collars or branches, furnish and install air extractors. Furnish and install control grids, volume dampers, and/or other accessories necessary to ensure uniform air flow across the terminal devices. Accessories shall be of the same material as the terminal device. Install fixed blade terminals so that blades block the normal line of vision. Furnish three (3) of each type of removable key operators.

C. Contractor shall determine frame and mounting type as per type of ceiling as shown on Architectural drawings.

D. Air devices and accessories that are installed in a finished, non-white ceiling shall be of a color as selected by the Architect.

E. Noise Criteria: All air devices shall be sized and selected to limit maximum NC (Noise Criteria) levels to 30.

2.19. SUPPLY AIR DEVICES

A. LSD1 Diffuser, Linear Slot, Supply

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Titus Model ML
    b. Metal-Aire
    c. Price
    d. Tuttle & Bailey
    e. Anemostat
    f. Carnes
    g. Nailor
    h. Krueger
    i. Greenheck

2. Construction:

    a. Material: Aluminum
    b. Finish: Baked Enamel, White
    c. Face Style: Linear Slots
    d. Mounting: Surface

e. Pattern: Fully adjustable 180-degree pattern controllers
f. Damper: Integral, Opposed Blade type

3. Accessories:

a. Plenum; Insulated

4. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

B. RD1 Diffuser, Round

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Titus Model TMRA
b. Metal-Aire
c. Price
d. Tuttle & Bailey
e. Anemostat
f. Carnes
g. Nailor
h. Krueger
i. Greenheck

2. Construction:

a. Material: Steel
b. Finish: Baked Enamel, White
c. Face Style: Four Cone
d. Mounting: Duct Connection
e. Pattern: Fully Adjustable
f. Damper: Integral, Opposed Blade type

3. Accessories:

a. Equalizing grid
b. Safety Chain

4. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

C. SD1 Diffuser, Square/Rectangular

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Titus Model TDCA-AA
b. Metal-Aire
c. Price
d. Tuttle & Bailey

e. Anemostat
f. Carnes
g. Nailor
h. Krueger
i. Greenheck

2. Construction:

a. Material: Aluminum
b. Finish: Baked Enamel, White
c. Face Style: Louvered
d. Mounting: Lay-in or Gypboard
e. Pattern: Adjustable core style
f. Damper: Integral, Opposed Blade type

3. Accessories:

a. Square to round neck adaptor
b. Adjustable pattern vanes

4. Provide auxiliary panel for lay-in tile installation.

5. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

D. SD2 Diffuser, Perforated

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Titus Model PAR-AA
b. Metal-Aire
c. Price
d. Tuttle & Bailey
e. Anemostat
f. Carnes
g. Nailor
h. Krueger
i. Greenheck

2. Construction:

a. Material: Aluminum
b. Finish: Baked Enamel, White
c. Face Style: Perforated
d. Mounting: Lay-in or Gypboard
e. Pattern: Straight Down
f. Damper: Opposed Blade type

3. Accessories:

a. Square to round neck adaptor

4. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

E. SG1 Grille, Square/Rectangular

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Titus Model 300FS
b. Metal-Aire
c. Price
d. Tuttle & Bailey
e. Anemostat
f. Carnes
g. Nailor
h. Krueger
i. Greenheck

2. Construction:

a.	Material:	Aluminum
b.	Finish:	Baked Enamel, White
c.	Face Style:	Grille
d.	Mounting:	Surface
e.	Pattern:	Double Deflection; spaced 3/4 inch apart.
f.	Damper:	Integral, Opposed Blade type

3. Accessories:

a. Drop control

4. The grille shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

F. SLB1 Diffuser, Linear Bar

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Titus Model CT-PP
b. Metal-Aire
c. Price
d. Tuttle & Bailey
e. Anemostat
f. Carnes
g. Nailor
h. Krueger
i. Greenheck

2. Construction:

a. Material: Aluminum
b. Finish: Baked Enamel, White
c. Face Style: Linear Bar
d. Mounting: Surface
e. Pattern: 0° Deflection
f. Damper: Integral, Opposed Blade type

3. Accessories:

a. Pencil Proof

4. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

2.20. RETURN/EXHAUST/TRANSFER GRILLES

A. LSD2 Diffuser, Linear Slot, Return

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Titus Model MLR
b. Metal-Aire
c. Price
d. Tuttle & Bailey
e. Anemostat
f. Carnes
g. Nailor
h. Krueger
i. Greenheck

2. Construction:

a. Material: Aluminum
b. Finish: Baked Enamel, White
c. Face Style: Linear Slots
d. Mounting: Surface
e. Pattern: Fully adjustable 180-degree pattern controllers
f. Damper: Integral, Opposed Blade type

3. Accessories:

a. Plenum; Insulated

4. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

B. RG1 Return/Exhaust/Transfer Grille, Square/Rectangular

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Titus Model 350FS
b. Metal-Aire
c. Price
d. Tuttle & Bailey
e. Anemostat
f. Carnes
g. Nailor
h. Krueger
i. Greenheck

2. Construction:

a.	Material:	Aluminum
b.	Finish:	White Baked Enamel
c.	Ceiling Type:	Lay-in, Gypboard, Sidewall
d.	Blades:	Fixed, 35° Angle, 3/4” Spacing

3. Accessories:

a.	Face:	Grille
b.	Damper:	Integral, Opposed Blade type

4. Provide auxiliary panel for lay-in tile installation.

5. The register shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

C. RG2 Return/Exhaust/Transfer Grille, Square/Rectangular with Filter, Aluminum

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Titus Model 350FSF
b. Metal-Aire
c. Price
d. Tuttle & Bailey
e. Anemostat
f. Carnes
g. Nailor
h. Krueger
i. Greenheck

2. Construction:

a.	Material:	Aluminum
b.	Finish:	White Baked Enamel
c.	Ceiling Type:	Lay-in, Gypboard, Sidewall
d.	Blades:	Fixed, 35° Angle, 3/4” Spacing

3. Accessories:

a. Face: Grille
b. Damper: Integral, Opposed Blade type

4. Provide auxiliary panel for lay-in tile installation.

5. Provide return air filter racks and 1" thick filters.

6. The register shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

D. RG3 Return/Exhaust/Transfer Grille, Square/Rectangular with Filter, Steel

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Titus Model 350RSF
b. Metal-Aire
c. Price
d. Tuttle & Bailey
e. Anemostat
f. Carnes
g. Nailor
h. Krueger
i. Greenheck

2. Construction:

a. Material: Heavy Duty Steel, 16 gauge
b. Finish: White Baked Enamel
c. Ceiling Type: Sidewall
d. Blades: Fixed, 35° Angle, 3/4" Spacing

3. Accessories:

a. Face: Grille
b. Damper: Integral, Opposed Blade type
c. Core: Hinged

4. Provide return air filter racks and 1" thick filters.

5. The register shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

E. RLB1 Diffuser, Linear Bar

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Titus Model CT-PP
b. Metal-Aire
c. Price

d. Tuttle & Bailey
e. Anemostat
f. Carnes
g. Nailor
h. Krueger
i. Greenheck

2. Construction:

a.	Material:	Aluminum
b.	Finish:	Baked Enamel, White
c.	Face Style:	Linear Bar
d.	Mounting:	Surface
e.	Pattern:	0° Deflection
f.	Damper:	Integral, Opposed Blade type

3. Accessories:

a. Pencil Proof

4. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

F. Noise Criteria: All air devices shall be sized and selected to limit maximum NC (noise criteria) levels to 30.

2.21. INTAKE/RELIEF HOODS

A. Furnish and install heavy gauge aluminum intake/relief hoods of size, capacity, and arrangement as shown on Contract Drawings. Intake/relief hoods shall be Greenheck Model FHI for intake or Model FHR for relief as manufactured by Greenheck, ACME Engineering, Cook, Twin City, Vent Products Company, or approved equal.

B. Gravity roof ventilators shall be constructed of heavy gauge aluminum or galvanized steel. Hoods shall be constructed of precision formed, arched panels with interlocking seams. Bases shall be constructed so that the curb cap is 8 inches larger than the throat size. Insulated roof curbs shall be furnished as specified and shall be of same manufacturer as roof hood.

C. Hood support members shall be constructed of galvanized steel and fastened so that the hood can be either removed completely from the base or hinged open. Birdscreens constructed of ½ inch galvanized steel mesh shall be mounted horizontally across the intake/discharge area of the hood. Intake units with throat widths through 42 inches shall ship assembled when throat lengths do not exceed 84 inches. Relief units with throat widths through 48 inches shall ship assembled when throat lengths do not exceed 96 inches.

D. Motor-operated dampers shall be provided by the ATC Subcontractor and installed by Mechanical Contractor.

E. Provide 12-inch high, fully insulated, aluminum hinged roof curbs with each hood.

Furnish roof curbs with damper trays for field mounting of motor operated damper by the ATC subcontractor. Hood and roof curb shall be provided by the same manufacturer.

F. Motor operated dampers shall be provided by ATC subcontractor and installed by mechanical contractor. Coordinate damper tray with roof curbs per detail on the drawings.

2.22. OPEN END DUCTS (OED)

A. Whether indicated on plans or not, all open-ended ducts shall be provided with a protective screen.

B. All open-ended ducts shall be furnished with a 12 gauge ½ inch x ½ inch aluminum mesh screen. Screens shall be permanently installed in a removable frame, and the frame shall be attached to the open-ended duct in a neat, workmanship-like manner without any exposed edges or sharp surfaces.

C. Screen shall be attached to a ¾ inch x 1/8 inch continuous galvanized perimeter frame. Install duct stiffeners greater than 16 inches in any direction at open-ended ducts.

D. Behind all open end ducts, paint ductwork and dampers with two (2) coats of flat black paint.

2.23. DRIP PANS

A. Furnish and install suitable watertight, aluminum drip pans where water or drain piping is routed over electrical switchgear, transformers, computers, elevator machine equipment, dry storage rooms, etc. Each drip pan shall have a 1 inch copper type M drain piped to discharge where shown on drawings; or, if not shown, to discharge over nearest available open drain. Size and arrangement shall be as approved by Engineer. Sides shall be minimum 1.5 inches deep.

B. Drain pans shall be of 16 gauge welded construction. Provide drawings of typical drain pan construction for approval before construction. See Submittals in Division 01 Section, “Product Requirements”.

2.24. DUCT SEALANTS AND ADHESIVES

A. All ductwork shall be sealed, including low pressure exhaust systems. Transverse joints and longitudinal seams in duct systems shall be sealed with a duct sealant of the type specified hereinafter in Section 1, 2, or 3, or with a tape sealing system as specified in Section 4. Spiral lockseams are not longitudinal seams and do not require duct sealant. All seams and joints shall require duct sealant suitable for the pressure rating and installation application. All sealants shall exceed 500 hours without becoming brittle under ASTM-D572 test conditions (oxygen bomb), unless specified otherwise. No surface preparation or solvent cleaning shall be necessary to remove light coatings of oil and dust before applying sealant unless specified otherwise. Flanged joints shall be sealed according to Section 5. Construction joints that are not fully welded shall be sealed according to Section 6. Adhesive to secure insulation to metal surfaces shall be that specified in Section 7.

1. Assembly joints to be installed indoors or outdoors shall be sealed with Foster 32-19, Childers CP-146, United Duct Sealer WB, or equivalent, which is a water-based sealant formulated to withstand service temperatures from 20 degrees F to +200 degrees F. Sealant shall have a UL Classification marking with a flame spread of 15 and smoke developed of 0 when applied to inorganic reinforced cement board, both at a coverage of 31 square feet per gallon. Store and apply between 40°F (4°C) and 100°F (38°C); protect from freezing.

2. Assembly joints to be installed indoors shall be sealed with Foster 32-19, childers CP-146, UNI-GRIP™ duct sealer or equivalent, which is a water-based (vinyl-acrylic polymer) sealant formulated to withstand temperatures from –20 degrees to +200 degrees Fahrenheit. Surfaces to be sealed should be clean, dry, and free from oil, grease, and dirt. Sealant shall be nonflammable (wet) and fire retardant. Sealant shall have a UL Classification marking with a flame spread of 5 and smoke developed of 5 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 0 when applied to inorganic reinforced cement board, both at a coverage of 40 square feet per gallon.

3. Assembly joints shall be sealed with UNI-CAST® tape sealing system or equivalent, which is a combination of an adhesive activator and woven-fiber tape impregnated with a gypsum mineral compound. Modified acrylic/silicone activator (MTA-20 for indoor use) reacts exothermically with the tape to form a hard, airtight seal. Sealant shall be formulated to withstand temperatures from –40 degrees F to +200 degrees Fahrenheit. Combination of tape and MTA-20 adhesive shall have a flame spread and smoke developed of 0. Do not use for outdoors.

4. Flanged joints to be installed indoors shall be sealed with UNI-GASKET™ flange sealer or equivalent, which has a synthetic elastomer base and is formulated to withstand temperatures from –20 degrees F to +150 degrees F. Sealant shall have a UL Classification marking with a flame spread of 5 and smoke developed of 5 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 5 when applied to inorganic reinforced cement board, both at a coverage of 80 square feet per gallon.

5. Where duct fittings are constructed with standing seam or spot-welded techniques, all construction joints shall be sealed with UNI-WELD™ metal cement or equivalent, which is composed of neoprene rubber, resins, and inert reinforcing material dispersed in a petroleum distillate. Sealant shall be formulated to withstand temperatures from –20 degrees F to +225 degrees F. Sealant shall have a UL Classification marking with a flame spread of 0 and smoke developed of 0 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 0 when applied to inorganic reinforced cement board, tested as applied in two 1/8 inch beads 8 inches on center.

6. Where insulation is to be secured to metal surfaces, the adhesive used shall be Foster 85-60, Childers CP-127, UNI-TACK™ duct liner adhesive or equivalent, which are water-based, vinyl-acrylic copolymer adhesives formulated to withstand temperatures from –20 degrees Fahrenheit to +200 degrees Fahrenheit. Adhesive shall have a UL Classification marking with a flame spread of 0 and smoke developed of 0 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 0 when applied to inorganic reinforced cement board, both at a coverage of 267 square feet per gallon. Adhesive shall

conform to ASTM C916, Type II.

B. Manufacturers: Duct Mate, United McGill, MKT Metal Manufacturers, Semco, Elgen, Childers, Foster, or as approved equal.

2.25. AUXILIARY DRIP PANS

A. Furnish and install suitable watertight, aluminum drip pans for all suspended air handling units, installed on upper floor and/or attic. Each drip pan shall have a 1" copper type "M" drain piped to discharge where shown on drawings. Drain pan shall extend 3" beyond sides of air handling unit/heat pump. Sides shall be minimum 1.5" deep.

B. Drain pans shall be of 16 gauge welded construction. Provide drawings of typical drain pan construction for approval before construction. See Submittals, Division 23 Section, "Common Work Results for HVAC" and Division 01, Section, "General Requirements".

C. Install U.L. 580 listed condensate float switch in auxiliary drain pan and wire to shut-down unit upon sensing water. All control and interlock wiring to be furnished and installed under Division 23 Section, "Instrumentation & Controls of HVAC & Plumbing Systems"

2.26. FILTER MEDIA DURING CONSTRUCTION

A. Filter media installed during construction: Minimum MERV 8.

PART 3. EXECUTION

3.1. DUCT INSTALLATION REQUIREMENTS

A. Coordinate ductwork with other work and install ducts at proper elevations and locations to maintain indicated ceiling heights and clearances. Provide all elbows, transitions, offsets, connections, and other fittings necessary to fit the work into place or to connect to equipment or diffusers. Method of duct support connection to structure and slabs shall be approved by Structural Engineer, and Shop Drawings shall be submitted.

B. Substantially support ductwork with structural shapes, flat bars, or formed strap hangers securely attached to the building structure by means of bolts, clamps, or inserts. Support vertical ducts by angles attached to the duct and resting on the floor or supported by brackets or hangers attached to the building structure. Strap hangers shall be 16-gauge minimum galvanized steel formed under the bottom edge of duct. Use square ¼ inch thick washers tight against the bend on upper strap attachments to horizontal surfaces. Place all supports external to the ductwork and out of the air stream. Provide additional supports at coils and other concentrated loads. Arrange supports so that duct weight is not transmitted to ceilings, fans or other equipment.

C. Prevent direct contact between ductwork and building surfaces or other equipment. Where ducts pass through walls, partitions, floors, ceilings, or roofs, pack and seal the space around the duct with an approved fire-safe inert material. Provide flanged duct escutcheons at all exposed ducts that pass through walls, partitions, floors, and ceilings.

D. Use galvanized (compatible) corrosion-resistant hangers, supports, brackets, and

hardware. All duct supports in chemical storage rooms or science prep room areas shall be provided with noncorrosive metal finish such as Galv-Krom or equal.

E. Furnish and install NFPA-approved duct connections where shown and at all connections to fans, air handling units, and similar rotating equipment. Use glass-reinforced neoprene fabric, roll-formed to sheet metal strips or flanges. Support adjacent ductwork to provide sufficient slack in the connection. For corrosive or chemical fume duct systems utilize chemical resistant flexible connections.

F. See NFPA 90A, and latest publication of SMACNA. Prevent direct contact between ductwork and building surfaces or other equipment. The opening in the construction around the duct shall not exceed one-inch average clearance on all sides. Where ducts pass through walls, partitions, floors, ceilings, or roofs, pack and seal the space around the duct with an approved fire-safe inert material capable of preventing the passage of flame and hot gases sufficiently to ignite cotton waste when subjected to the same NFPA 251 Time-Temperature Conditions required for fire barrier penetration. All exposed duct penetrations shall be finished with a sheet metal field erected flange escutcheon to form a neat appearance.

G. Coordinate duct installation with the requirements of Division 23 Section, “Vibration Controls for HVAC, Plumbing & Fire Protection Equipment”.

H. Install in accordance with manufacturer’s instructions.

I. Install and seal ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

J. Duct Sizes are inside clear dimensions. For lined ducts, maintain sizes inside lining.

K. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

L. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

M. Use crimp joints, with or without bead, for joining round duct sizes eight (8) inches and smaller with crimp in direction of air flow.

N. Use double nuts and lock washers on threaded rod supports.

O. Set plenum doors 6 to 12 inches (150 to 300 mm) above floor. Arrange door swings so that fan static pressure holds door in closed position.

P. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for clean out. Use welded stainless steel for ductwork exposed to view and welded carbon steel for ducts where concealed. Submit to local Health Department calculations, duct layout, hood layout, sizes for all kitchen hood exhaust, make-up air systems prior to fabrication.

Q. During construction, provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork systems. Also provide temporary closures of metal or taped polyethylene at all air handling equipment openings to prevent dust from entering equipment openings.

R. Paint behind all air devices, louvers, and open end ducts with 2 coats of flat black paint.

3.2. ACCESSORY INSTALLATION REQUIREMENTS

A. Install accessories in accordance with manufacturer's instruction, NFPA 90A, and SMACNA HVAC Duct Construction Standards - Metal and Flexible. Also provide temporary closures of metal or taped polyethylene at all air handling equipment openings to prevent dust from entering equipment openings.

B. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, duct detectors, air flow monitoring stations, duct-mounted equipment, duct coils] and elsewhere as indicated. [Provide for cleaning kitchen exhaust ductwork in accordance with NFPA 96. Provide minimum 10 x 10 inch size for hand access, 18 x 18 inch size for shoulder access 20 x 20 inch for kitchen exhaust systems. Review locations prior to fabrication.

C. Provide duct test holes where required for testing and balancing purposes. Review locations with Test and Balance Engineer prior to installation.

D. For all motor operated dampers, mark the shaft so operators know the position of the damper.

E. Provide fire dampers, combination fire and smoke dampers and smoke dampers at locations indicated, where ducts and outlets pass through fire-rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion-resistant springs, bearings, bushings and hinges.

F. Install smoke dampers and combination fire and smoke dampers in accordance with NFPA 92A. Furnish and install a remote test station and connect to damper end switches.

G. Demonstrate re-setting of fire dampers to Owner's representative.

H. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment and supported by vibration isolators. Refer to Division 23 Section, "Vibration Control for HVAC and Plumbing Systems".

I. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum duct widths from duct take-off.

J. Use splitter dampers only where indicated.

K. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

L. Install diffusers, registers, and grilles to ductwork with airtight construction.

M. Check location of all air outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangements.

N. Install duct thermometer support flanges in wall of duct. Attach to duct with screws. Locate duct mounted thermometers, minimum 10 feet downstream of mixing dampers, coils or other devices causing air turbulence.

O. Install remote - reading duct dial thermometers in control panels with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length. Mount control panel 60 inches above finished floor and label each dial thermometer.

P. Install duct accessories according to applicable details shown in SMACNA's HVAC Duct Construction Standards Metal and Flexible for metal ducts.

Q. Install volume dampers in lined duct; avoid damage to and erosion of duct liner.

R. Provide test holes at fan inlet and outlet and elsewhere as indicated.

S. Install fire, smoke, and combination fire and smoke dampers according to manufacturer's UL approved written instructions.

1. Install fusible links in fire dampers. Label access doors according to equipment served.

T. Adjust duct accessories for proper settings.

U. Adjust fire and smoke dampers for proper action.

3.3. DUCT LINING INSTALLATION REQUIREMENTS

A. All portions of duct designated to receive duct liner shall be completely covered with duct liner. Transverse joints shall be neatly butted and there shall be no interruptions or gaps. The black pigmented or mat faced surface of the duct liner shall face the airstream.

B. Duct liner shall be adhered to the sheet metal. with 90 percent coverage of adhesive complying with requirements of ASTM C916. All exposed leading edges and transverse joints shall be factory coated or coated with adhesive during fabrication. Install perforated galvanized inner liner where indicated

C. Duct liner shall be additionally secured with mechanical fasteners, either weld-secured or impact-driven, which shall compress the duct liner sufficiently to hold it firmly in place. Adhesive bonded pins are not permitted due to long term adhesive aging characteristics. Spacing of mechanical fasteners with respect to duct liner interior width shall be in accordance with SMACNA HVAC DGS. Maximum spacing for mechanical fasteners shall be as follows:

Velocity = 0 to 2,500 feet per minute (0 to 12.8m/s):	
From transverse end of liner	3: (75mm)
Across width of duct	12 inches (300 mm) O.C.

From corners of duct	4 inches (100mm)
Along length of duct	18 inches (450mm) O.C.

Velocity = 2,501 to 5,000 feet per minute (12.8 to 25.4 m/s):

From transverse end of liner	3 inches (75m)
Across width of duct	6 inches (150mm) O.C.
From corners of duct	4 inches (100mm)
Along length of duct	16 inches (400mm) O.C.

D. When air velocities exceed 4,000 fpm (20.3m/s), galvanized sheet metal nosing shall be applied to all leading edges of duct liner.

E. Acoustical Duct Liner shall be cut to assure overlapping and compressed longitudinal corner joints.

F. Upon completion of installation of duct liner and before operation is to commence, visually inspect the system and verify that the duct liner insulation has been correctly installed.

G. Open all system dampers and turn on fans to blow all scraps and other loose pieces of material out of the duct system. Allow for a means of removal of such material.

H. Check the duct system to ensure that there are no air leaks through joints.

3.4. STACKS AND BREECHING INSTALLATION REQUIREMENTS

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NFPA 54 (ANSI Z223.1) and NFPA 31.

C. Install breechings with minimum of joints. Align accurately at connections, with internal surfaces smooth.

D. Support breechings from building structure, rigidly with suitable ties, braces, hangers, and anchors to hold to shape and prevent buckling. Support vertical breechings, chimneys, and stacks at 12 foot (4 m) spacing, to adjacent structural surfaces, or at floor penetrations. Refer to SMACNA HVAC Duct Construction Standards - Metal and Flexible for equivalent duct support configuration and size.

E. Install concrete inserts for support of breechings, and stacks in coordination with formwork.

F. Pitch breechings with positive slope up from fuel-fired equipment to chimney or stack.

G. For double wall gas vents, maintain UL listed minimum clearances from combustibles Assemble pipe and accessories as required for complete installation.

H. Install vent dampers, locating close to draft hood collar, and secure to breeching.

I. Assemble and install stack sections in accordance with NFPA 82, Industry practices, and

in compliance with UL listing. Join sections with acid-resistant joint cement to ASTM C105. Connect base section to foundation using anchor lugs.

J. Level and plumb chimney and stacks

K. Clean breechings, chimneys, and stacks during installation, removing dust and debris.

L. At appliances, provide slip joints permitting removal of appliances without removal or dismantling of breechings, breeching insulation, chimneys, or stacks.

M. Provide maximum 2 feet of breeching to connect appliance to chimney.

N. Do not install bull head tee at connections to equipment.

3.5. WATER HEATER AND CONDENSING BOILER INTAKE AND WATER HEATER EXHAUST DUCT INSTALLATION REQUIREMENTS

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NFPA 54 (ANSI Z223.1).

C. Install flue pipes with minimum of joints. Align accurately at connections, with internal surfaces smooth.

D. Support flue pipes from building structure, rigidly with suitable ties, braces, hangers, and anchors to hold to shape and prevent buckling. Support vertical flue pipes, and stacks at 6 foot spacing, to adjacent structural surfaces, or at floor penetrations. Refer to SMACNA HVAC Duct Construction Standards - Metal and Flexible for equivalent duct support configuration and size.

E. Install concrete inserts for support of flue pipes and stacks in coordination with formwork.

F. Pitch flue pipes with positive slope up from fuel-fired equipment to stack.

G. Install vent dampers, locating close to draft hood collar, and secure to flue pipes.

H. Assemble and install stack sections in accordance with NFPA 82, Industry practices, and in compliance with UL listing. Join sections with acid-resistant joint cement to ASTM C105. Connect base section to foundation using anchor lugs.

I. Level and plumb flue pipes and stacks

J. Clean flue pipes and stacks during installation, removing dust and debris.

K. At appliances, provide slip joints permitting removal of appliances without removal or dismantling of flue pipes or stacks.

L. Do not install bull head tee at connections to equipment.

M. Provide and install condensate removal pipes and neutralizers per manufacturer's

requirements.

N. For condensing boilers provide and install flue pipe thermometers.

3.6. CLEANING

A. Clean duct system and force air at high velocity through ducts to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.

B. Clean duct systems with high power vacuum machines. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes.

C. Ductwork shall be cleaned in accordance with "Duct Cleanliness for New Construction (SMACNA 2000)", and shall achieve a "Basic" cleanliness level.

3.7. LEAKAGE TESTS

A. All low pressure sheet metal ductwork shall undergo leakage tests at 2 inch W.G. Tests shall be accomplished under this section and witnessed as specified under Division 23 Section, "Testing, Adjusting, and Balancing for HVAC and Plumbing".

B. All medium pressure sheet metal ductwork shall undergo leakage tests at 5 inch W.G. Tests shall be accomplished under this section and witnessed as specified under Division 23 Section, "Testing, Adjusting, and Balancing for HVAC and Plumbing".

C. Leakage from each duct system shall not exceed 5 percent for low pressure systems and 1 percent for medium pressure systems of the normal air handling capacity of the system. If the system ductwork is tested in sections, the leakage shall not exceed ½ of 1 percent of the CFM to be handled by that section, and the total leakage of the system shall not exceed 1 percent of the total system CFM. Test pressure shall not exceed the pressure limits of the duct construction as defined in SMACNA High Pressure Duct Construction Standards. Repair all leaks which are audible, regardless of the leakage rate of the duct system as a whole, by remaking the entire defective joint or seam. Spot sealing of ducts in place will not be acceptable.

D. All duct accessories, including but not limited to volume dampers, ATC sensors, motor operated dampers, duct access doors, duct detectors, and duct coils shall be installed prior to duct leakage testing.

E. Submit a complete report of the ductwork leakage tests to the Architect and include final approved copies in test and balance reports.

F. Refer to Division 23 Section, "Dust Collection System" for leakage testing associated with Dust Collection Ductwork.

G. Refer to Division 23 Section, "Welding Fume Exhaust System". For "leakage testing" associated with welding fume exhaust system welding hood exhaust ductwork.

H. Refer to Division 23 Section, "Carbon Monoxide Exhaust System". For "leakage

testing" Division 23 Section, "Carbon Monoxide Exhaust System" for leakage testing associated with Carbon Monoxide exhaust ductwork.

I. All paint spray booth intake and exhaust ductwork shall be leakage tested.

3.8. DUCTWORK IDENTIFICATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

B. All ductwork shall be identified with painted background marked with the name of the service with arrows to indicate flow direction. Color Code and System Identification shall comply with ANSI Standards.

C. Marking shall be plain block letters, stenciled on ductwork (above and below ceilings) and shall be located near each branch connection and at least every ten feet on straight runs of ductwork. Where ductwork is aligned adjacent to each other, markings shall be neatly lined up. All markings shall be located in such a manner as to be easily legible from the floor.

D. Identify ductwork with plastic nameplates or stenciled painting. Identify with air handling unit/fan identification and area served.

E. Length of fan color field for ductwork shall be 32 inches. Lettering shall be minimum 3-1/2 inches high.

3.9. CLOTHESDRYER DUCTWORK INSTALLATION REQUIREMENTS

A. Install in accordance with manufacturer's instructions.

B. Install clothes dryer ducts with minimum of joints. Align accurately at connections, with internal surfaces smooth.

C. Support clothes dryer ducts from building structure, rigidly with suitable ties, braces, hangers, and anchors to hold to shape and prevent buckling. Support vertical clothes dryer ducts, and stacks at 12 foot (4 m) spacing, to adjacent structural surfaces, or at floor penetrations. Refer to SMACNA HVAC Duct Construction Standards - Metal and Flexible for equivalent duct support configuration and size.

D. Coordinate installation of dryer booster fan.

E. Level and plumb stacks.

F. Clean clothes dryer ductwork during installation, removing dust and debris.

G. At appliances, provide slip joints permitting removal of appliances without removal or dismantling of clothes dryer ductwork, clothes dryer ductwork insulation, or stacks.

H. Do not install bull head tee at connections to equipment.

I. Transition to dryer booster fan

J. Provide and install fitting for installation of dryer booster fan probe as required by dryer booster fan system manufacturer.

K. Install cleanouts at all changes in direction.

3.10. PAINT SPRAY BOOTH DUCTWORK INSTALLATION REQUIREMENTS

A. Paint spray booth intake and exhaust ductwork and accessories shall be installed under this Division and per the manufacturer's requirements.

B. Ductwork shall be minimum of 18 gauge or as required by the paint spray booth manufacturer or pressure requirements, whichever is higher.

C. All ductwork shall be sealed and shall be waterproof. Leakage test all ductwork.

D. Intake and exhaust ductwork shall be installed as straight as possible with no offsets exceeding 45 degrees. Intake ductwork shall be insulated. Refer to specification Section 230701 "HVAC Insulation" for duct insulation requirements.

E. Duct access door shall be installed above the dampers in the exhaust stack.

F. All roof penetrations shall be through roof curbs.

G. The intake cap and exhaust caps shall be as required by the paint spray booth manufacturer. The intake and exhaust caps shall be installed a minimum of 10 feet from each other and any other intakes. Do not install bird screen on the exhaust cap.

H. Install guy-wires on stacks with stainless steel cables, turnbuckles, and hardware.

END OF SECTION

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SECTION 23 82 20
CARBON MONOXIDE EXHAUST SYSTEMS

PART 1. GENERAL

1.1. GENERAL

A. For general mechanical requirements, see Division 23 Section, Common Work Results for HVAC and Division 01, General Requirements.

B. Industrial exhaust system for carbon monoxide removal shall be constructed with materials recommended herewith and shall be installed in a permanent and workmanlike manner.

C. Interior of all ducts shall be smooth and free from obstructions with all joints, fittings, and connections welded air tight. Duct construction shall be Class II. All duct construction shall be in accordance with the references hereinafter specified.

D. All duct sizes shown are net inside clear dimensions. Unless otherwise indicated size runouts, drops, and connections to fan, disappearing exhaust units and other equipment to the full size of the equipment connection.

E. Minor changes may be made in duct sizes where required to fit the available space, provided the indicated net free area and approximate aspect ratio are maintained.

F. Smoothly transition all ductwork to prevent excessive or unnecessary turbulence or pressure loss.

G. All exposed ductwork in finished areas shall be painted in color as selected by Architect/Engineer. All ductwork requiring paint shall be constructed of paint grade material with a paintable surface.

1.2. REFERENCES

A. ACGIH - Industrial Ventilation, A Manual of Recommended Practice.

B. AMCA 99 - Standards Handbook.

C. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

D. AMCA 300 - Test Code for Sound Rating Air Moving Devices.

E. AMCA 301 - Method of Calculating Fan Sound Ratings from Laboratory Test Data.

F. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Sheet Articles.

G. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.

H. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.

I. AASTM A 527 - Steel Sheet, Zinc Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.

J. ASTM A 569 - Steel, Carbon (0.15 maximum percent), Hot-Rolled Sheet and Strip, Commercial Quality.

K. AWS D9.1 - Welding of Sheet Metal.

L. MNB PS 15 - Voluntary Product Standard for Custom Contact-Molded Reinforced-Polyester Chemical-Resistant Process Equipment.

M. NFPA 91 - Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal or Conveying.

N. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

O. SMACNA - Round Industrial Duct Construction Standard.

P. SMACNA - Rectangular Industrial Duct Construction Standard.

Q. UL 181 - Factory-Made Air Ducts and Air Connectors.

R. UL 214 - Test for Flame Propagation of Fabrics and Films.

1.3. QUALITY ASSURANCE

A. Fans

1. Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.

2. Sound Ratings: AMCA 301, tested to AMCA 300 and bear AMCA Certified Sound Rating Seal.

3. Fabrication: Confirm to AMCA 99.

1.4. REGULATORY REQUIREMENTS

A. Products requiring electrical connection: Listed and classified by Underwriters' Laboratories, Inc., suitable for the purpose specified and indicated.

1.5. ALTERNATES

A. Refer to Division 01 Section, Alternates - Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. CARBON MONOXIDE REMOVAL SYSTEMS AND ACCESSORIES

A. Flexible Tubing for Gasoline Engines

1. Shall be Car-Mon type NU, AQC Dust Collection Systems, or approved equal, fabricated entirely of neoprene material and shall contain no fabric or wire supports. Complete assembly shall be crush-proof neoprene tubing. It shall be fabricated using a vacuum mandrel forming process with a precision-patterned spiral convolution.

2. Tubing wall thickness shall be uniform throughout. The tubing shall resist kinking and collapsing and shall return to its original shape after being crushed or compressed. Exhaust adapters, flanges or other fittings shall be attached to the tubing at the factory. Field assembly is not acceptable. Tubing diameter and length shall be as scheduled on Contract Drawings.

B. Flexible Tubing for Diesel/Truck Engine

1. Shall be High Temperature exhaust hose and be Car-Mon type HTC, Dust Collection Systems, or approved equal of an abrasion-resistant fire retardant fabric, utilizing a silicone coated glass fabric inner layer and silicone coated nomex outer layer, clinched within an external galvanized steel helix to withstand continuous exposure to exhaust air temperatures within the tubing up to 1,000 degrees F interior and exterior.

2. The tubing shall have an interior spring steel wire reinforcing spiral encased within the fabric lamination. Exhaust adapters, flanges or other fittings shall be attached to the tubing at the factory. Field assembly is not acceptable. Tubing diameter shall be as scheduled on the Contract Drawings.

C. Overhead Tubing Storage Reels: Provide and install overhead electric tubing storage reels of the size, outlet fitting diameter, tubing lengths, tubing diameter and electrical characteristics as shown on the contract drawings. Tubing storage reel shall be designed for use with Car-mon type NE, AQC Dust Collection Systems, tubing for gasoline engines and Car-Mon HTC tubing, AQC Dust Collection Systems, for diesel engines, or approved equal. The frame shall be welded construction using 2 x 2 x 1/8 square tubular steel with 12 gauge end plates, and airtight rotating cylinder with a recessed inlet fitting to which the flange mounted flexible tubing will be bolted. The assembly shall be driven by a 1/6 H.P. motor (115 volt) 1 phase/60 HZ with a sprocket and chain drive. A remote mounted push button station shall be provided with each unit and wired by the electrical subcontractor. Units shall be Car-mon series TSR-P, AQC Dust Collection Systems, or approved equal. Each unit shall be finished in a baked enamel finish.

D. Contractor shall provide to Owner one additional 4-inch diameter flexible hose for extending length for all gasoline exhaust units. Extension tubing shall be identical to that specified for gasoline engines, shall be 10 feet in length and shall be provided with all necessary adapters.

E. Provide to Owner additional flexible hoses for diesel/truck engine exhaust units as scheduled. Extension tubing shall be identical to that specified for diesel engines, shall be in length as scheduled on Contract Drawigns and shall be provided with all adapters necessary to attach to exhaust hoses.

F. Diesel Exhaust Package: Provide diesel exhaust package as scheduled/detailed on Contract Drawings. Diesel exhaust package shall include all hoses, flange set, Series

LFT retractor, hose sling, positioning pole, series RDS EPDM diesel stack adapters and manual hand dampers. Provide additional flexible extension hoses as specified.

G. Dual Exhaust Adapter: Contractor shall provide a Car-Mon T series, AQC Dust Collection Systems, or approved equal dual exhaust adapter for use with all gasoline engine exhaust units. Unit shall consist of slotted collar to fit tail pipe adapter. Two 5 feet long, 3-inch diameter flexible tubes shall be provided of the same material as that specified for gasoline engines. Two stainless steel tapered cone adapters shall be provided with unit.

2.2. CARBON MONOXIDE EXHAUST FANS (INDUSTRIAL UTILITY SET EXHAUST FANS)

A. Carbon Monoxide Exhaust Fans shall be Arrangement 10, single width, single inlet, belt driven centrifugal backward inclined fans. Fans shall be Car-Mon centrifugal backward inclined fans with rotation and discharge as indicated on contract drawings. All fans shall be rated in accordance with AMCA standard 210 and shall carry the AMCA certified ratings seal.

B. Fans shall be AMCA Class I or Class II construction, with heavy gauge housings. The entire fan shall be completely coated inside and out with red heresite phenolic resin corrosion protective coating. Every fan shall be individually tested prior to shipment.

C. Housing shall be minimum 14 gauge and shall contain formed and welded corners fully caulked between housing and frame with non-hardening caulk. Housing shall be assembled with self-locking flange nuts and stud mounted with no bolts in the airstream. Inlet side of the housing shall be supported on the fan base in addition to motor compartment section Bearing supports shall be minimum 3/16 inch structural angles and motor base shall be adjustable from exterior of the fan. OSHA belt guard shall be provided and shall have provisions for tachometer measurement.

D. Wheel shall have welded blades with welds on the stress side of the blades. Any balancing weights shall be outside of the airstream part of the wheel, not on the blades. No nuts or bolts shall protrude into the airstream part of the wheel. Wheel shall be removable and shall have no greater than 3/32 inch running clearance between the wheel shroud and the inlet cone. Shaft shall be turned type and completely coated with asphaltic coating for corrosion protection and easy wheel removal. Shaft shall have a maximum of 0.001 inches per foot of run-out tolerance.

E. Bearings shall be self-lubricating cast frame steel ball type. Stamped frame bearings will not be acceptable.

F. Drives shall be variable pitch double groove type with matched belts and rated at 150 percent of motor load capacity. Provide belt and drive guard. Additional set of belts to be turned over to the owner upon final acceptance.

G. Motor shall be ODP continuous duty industrial grade with accessible wiring boxes and shall be manufactured by a major domestic motor manufacturer. All motors shall be premium efficiency motor as indicated in Division 23 Section, Common Work Results for HVAC of these specifications.

H. All fans shall be provided with belt guards per OSHA requirements, flanged outlets,

scroll access door and drain fitting in scroll fans. shall be provided with aluminum mesh inlet screen, vibration isolators, and weather cover. Provide NFPA-90 approved flexible connections on inlet and outlet of fans. Fans shall be installed with proper inlet and outlet conditions to minimize system effect as shown on contract drawings.

2.3. CARBON MONOXIDE EXHAUST FANS (VERTICAL IN-LINE WITH INTEGRAL DISCHARGE NOZZLE)

A. Carbon Monoxide Fume Hood Exhaust Fans (Vertical In-Line Carbon Monoxide Fan With Integral Discharge Nozzle)

1. General

a. Base fan performance at standard conditions (density 0.075 Lb/ft^3).
b. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.
c. Each fan shall be belt driven.
d. Fans to be equipped with 316 stainless steel lifting lugs for corrosion resistance.
e. Fasteners exposed to corrosive exhaust shall be stainless steel.
f. Fan assembly shall be designed for a minimum of 125 MPH wind loading, without the use of guy wires.
g. Carbon Monoxide exhaust fans shall be Greenheck Fan Corp Model Vektor – H, High plume carbon monoxide exhaust system or approved equal.

2. Corrosion Resistant Coating

a. All fan and system components (fan, nozzle, wind band, plenum) shall be corrosion resistant coated with LabCoat^{TM}, a two part electrostatically applied and baked, sustainable, corrosion resistant coating system; or Heresite P-413C. Color to be selected by Architect.

3. Fan Housing and Outlet

a. Fan housing to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
b. Fan housing shall be welded steel with corrosion resistant coating. No uncoated metal fan parts shall be acceptable.
c. A high velocity conical discharge nozzle shall be supplied by the fan manufacturer and be designed to efficiently handle an outlet velocity of up to 6000 FPM.
d. Provide housing drain for removal of rain and condensation.
e. A bolted and gasketed access door shall be supplied in the fan housing allowing for impeller inspection or removal of impeller, shaft and bearings without removal of the fan housing.
f. Color selection by Architect.

4. Fan Impeller

a. Fan impeller shall be centrifugal, backward inclined, with non-stall characteristics. The impeller shall be electronically balanced both statically and dynamically per AMCA Standard 204.
b. Fan impeller shall be manufactured of aluminum (AMCA type B spark resistant), fully welded, and be provided with corrosion resistant coating.

2.4. DUCTWORK AND DUCT ACCESSORIES

A. Material

1. Above-grade carbon monoxide ductwork shall be stainless steel ducts, ASTM A 167, Type 316 suitable for 6 inch medium pressure class.

B. Ductwork

1. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible 6-inch Pressure Class Round Industrial Duct Construction Standard and Rectangular Industrial Duct Construction Standard and ACGIH Industrial Ventilation Manual except as indicated.

2. Construct T's, bends, and elbows with radius of not less than 1½ times width of duct on centerline.

3. Increase duct sizes gradually, not exceeding 25 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

4. Fabricate continuously welded round and oval duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Prime coat welded joints.

5. Joints: Minimum 4-inch (100mm) brazed, or electric welded to AWS 9.1. Prime coat welded joints.

6. Provide standard 45 degree lateral wye branch fittings unless otherwise indicated.

7. Use double nuts and lock washers on threaded rod supports.

8. All exterior industrial exhaust ducts shall be constructed of Type 316 stainless steel.

9. The following metal thickness shall be supplied:

	DIAMETER OF STRAIGHT DUCTS	US STANDARD GAUGE FOR 316 STAINLESS STEEL DUCTS
a.	To 8 inches	20
b.	Over 8 inches to 18 inches	18
c.	Over 18 inches to 30 inches	16
d.	Over 30 inches	14

10. All motor-operated dampers located in stainless steel ductwork shall be constructed of Type 316 stainless steel. All motor-operated dampers shall be provided by the ATC subcontractor and installed by the Mechanical Contractor.

11. Longitudinal joints of ducts shall be continuously welded with seams up.

12. Girth joints of duct shall be made with inner lap in direction of air flow, with 1 inch lap, diameters to 19 inches, and 1-1/4 inch laps for diameters over 19 inches. All joints shall be continuously welded.

13. Elbows and angles shall have a centerline radius of 2.5 pipe diameters. Construct elbows 6 inches or less in diameter of at least five sections, over 6 inches in diameter of seven sections. Prefabricated elbows of smooth construction may be used. Angles shall be pieced proportionately. Prefabricated elbows shall be industrial duct fittings manufactured by United McGill or as approved equal.

14. Hoods must be free of sharp edges or burrs and reinforced to provide necessary stiffness.

15. All welds shall be by gas fusion using rods of similar material.

16. Hangers shall be Type 316 stainless steel hangers and support spacing shall be in accordance with SMACNA's standards for round industrial ducts.

17. Connect duct to fan inlet with split sleeve drawband at least one pipe diameter long, but not less than 12 inches.

18. Transitions in mains and sub-mains to be tapered; taper 5 inches long for each 1 inch change in diameter. Transitions shall be eccentric: Flat on bottom.

19. All branches shall enter main at the large end of the transition at an angle not to exceed 30 degrees. Connect branches only to the top or sides of the main with no two branches entering diametrically opposite.

20. Provide dead-end caps within 6 inches from last branch of all mains and sub-mains.

21. Provide access openings or cleanouts every 10 feet and near each elbow, angle or duct junction in horizontal sections, except for non-corrosive gases and vapors containing no particulate matter.

22. Support ducts sufficiently to place no load on connecting equipment and to carry weight of system if plugged with material. Maximum supporting interval 12 feet for 8-inch or smaller ducts, 20 foot intervals for larger ducts.

23. Provide 6-inch minimum clearance between ducts and ceiling, wall or floors.

24. Where blast gates are used for adjustment of system, place near connection of branch to main. Provide means of locking after adjustments have been made. Butterfly-type dampers shall not be permitted.

25. Fire dampers, explosion vents, etc., should be installed in accordance with National Fire Protection Association Codes or local fire ordinances.

26. Where state or local laws conflict with above specifications, the more stringent regulation shall be followed. Any other deviation must be approved before installation.

C. Flexible Connections: UL 214 listed, fire-retardant chloroprene or chlorsulfonated polyethylene impregnated fabric, minimum density 36 ounces per square yard, approximately 6 inches wide, crimped into metal edging strip.

D. Blast Gates: Full collar of steel with galvanized steel side.

2.5. CARBON MONOXIDE SENSORS

A. Carbon Monoxide (CO) sensors shall be Tox-CO/ANA as manufactured by Tox Alert, Inc., or approved equal. CO sensors shall be low voltage devices (24 VAC supply) with 4 to 20 mA output to be utilized with direct digital controller. Unit shall have 4 to 20 mA signal, which is linear over the sensor 0 to 400 ppm CO range. Locate CO sensors as indicated on Contract Drawings with vandal-proof locking cover.

PART 3. EXECUTION

3.1. INSTALLATION

A. Install equipment in accordance with manufacturer's instructions.

B. Do not operate fans for any purpose until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

C. Install fans with resilient mountings and flexible electrical leads.

D. Install flexible connections at fan inlet and discharge. Ensure metal bands of connectors are parallel with minimum one-inch (25mm) flex between ductwork and fan while running.

E. Provide pitot tube openings where required for testing of systems, complete with metal cap with spring device or screw or ensure against air leakage.

F. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

G. Slope underground ducts to plenums or low pump out points at 1:500. Provide access doors for inspection.

3.2. TESTING

A. TESTING: Measure the air flow in the system with a standard pitot tube to determine whether it is functioning in accordance with design specification. All branch ducts shall be tested to assure design air flow rates as scheduled on Contract Documents. Static pressure profiles shall be conducted at all fan systems as indicated in Division 23 Section,

Testing Adjusting & Balancing for HVAC & Plumbing.

3.3. LEAKAGE TESTS

A. All sheet metal ductwork shall undergo leakage test at 4 inches WG. Test shall be accomplished under this section and witnessed as specified under Division 23 Section, Testing Adjusting & Balancing for HVAC & Plumbing.

B. Leakage from each duct system shall not exceed 1 percent of the nominal fan capacity of the system. If the system ductwork is tested in sections, the leakage shall not exceed ½ of 1 percent of the CFM to be handled by that section and the total leakage of the system shall not exceed 1% of the total system CFM Test pressure shall not exceed the pressure limits of the duct construction as defined in SMACNA High Pressure Duct Construction Standards. Repair all leaks which are audible, regardless of the leakage rate of the duct system as a whole, by remaking the entire defective joint or seam. Spot sealing of ducts in place will be unacceptable.

C. Submit a complete report of ductwork leakage test to the Architect/Engineer and include final approved copies in Test and Balance Reports.

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SECTION 23 82 21
WELDING FUME EXHAUST SYSTEM

PART 1. GENERAL

1.1. GENERAL

A. For general mechanical requirements, see Division 23 Section, Common Work Results for HVAC and Division 01, General Requirements.

B. Industrial exhaust system for welding fume exhaust collection shall be constructed with materials recommended herewith and shall be installed in a permanent and workmanlike manner.

C. Interior of all ducts shall be smooth and free from obstructions with all joints, fittings, and connections welded air tight. Duct construction shall be Class II. All duct construction shall be in accordance with the references hereinafter specified.

D. All duct sizes shown are net inside clear dimensions. Unless otherwise indicated, size runouts, drops, and connections to welding arms, hoods, fans and other equipment to the full size of the equipment connection.

E. Minor changes may be made in duct sizes where required to fit the available space, provided the indicated net free area and approximate aspect ratio are maintained.

F. Smoothly transition all ductwork to prevent excessive or unnecessary turbulence or pressure loss.

G. All exposed ductwork in finished areas shall be painted in color as selected by Architect/Engineer. All ductwork requiring paint shall be constructed of paint grade material with a paintable surface.

1.2. REFERENCES

A. ACGIH - Industrial Ventilation, A Manual of Recommended Practice.

B. AMCA 99 - Standards Handbook.

C. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

D. AMCA 300 - Test Code for Sound Rating Air Moving Devices.

E. AMCA 301 - Method of Calculating Fan Sound Ratings from laboratory Test Data.

F. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Sheet Articles.

G. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.

H. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.

I. AASTM A 527 - Steel Sheet, Zinc Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.

J. ASTM A 569 - Steel, Carbon (0.15 maximum percent), Hot-Rolled Sheet and Strip, Commercial Quality.

K. AWS D9.1 - Welding of Sheet Metal.

L. MNB PS 15 - Voluntary Product Standard for Custom Contact-Molded Reinforced-Polyester Chemical-Resistant Process Equipment.

M. NFPA 91 - Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal or Conveying.

N. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

O. SMACNA - Round Industrial Duct Construction Standard.

P. SMACNA - Rectangular Industrial Duct Construction Standard.

Q. UL 181 - Factory-Made Air Ducts and Air Connectors.

R. UL 214 - Test for Flame Propagation of Fabrics and Films.

1.3. QUALITY ASSURANCE

A. Fans

1. Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.

2. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA-Certified Sound Rating Seal.

3. Fabrication: Confirm to AMCA 99.

1.4. REGULATORY REQUIREMENTS

A. Products requiring electrical connection: Listed and classified by Underwriters' Laboratories Inc., suitable for the purpose specified and indicated.

1.5. ALTERNATES

A. Refer to Division 01, Section, Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. WELDING HOOD EXHAUST FANS (UTILITY SET)

A. Welding booth exhaust fans shall be Arrangement 10, single width, single inlet, belt-

driven, centrifugal backward-inclined fans. Fans shall be Car-Mon, Greenheck, Penn Ventilator or approved equal centrifugal, backward-inclined fans with rotation and discharge as indicated on contract drawings. All fans shall be rated in accordance with AMCA Standard 210 and shall carry the AMCA certified ratings seal.

B. Fans shall be AMCA Class I or Class II construction, with heavy gauge housings. The entire fan shall be completely coated inside and out with red heresite phenolic resin corrosion protective coating. Every fan shall be individually tested prior to shipment.

C. Housing shall be minimum 14 gauge and shall contain formed and welded corners fully caulked between housing and frame with non-hardening caulk. Housing shall be assembled with self-locking flange nuts and stud-mounted with no bolts in the airstream. Inlet side of the housing shall be supported on the fan base in addition to motor compartment section. Bearing supports shall be minimum 3/16 inch structural angles and motor base shall be adjustable from exterior of the fan. OSHA belt guard shall be provided and shall have provisions for tachometer measurement.

D. Wheel shall have welded blades with welds on the stress side of the blades. Any balancing weights shall be outside of the airstream part of the wheel, not on the blades. No nuts or bolts shall protrude into the airstream part of the wheel. Wheel shall be removable and shall have no greater than 3/32 inch running clearance between the wheel shroud and the inlet cone. Shaft shall be turned type and completely coated with asphaltic coating for corrosion protection and easy wheel removal. Shaft shall have a maximum of 0.001 inches per foot of run out tolerance.

E. Bearings shall be self-lubricating cast frame steel ball type. Stamped frame bearings will not be acceptable.

F. Drives shall be variable pitch, double groove type with matched belts and rated at 150 percent of motor load capacity. Provide belt and drive guard. Additional set of belts to be turned over to the Owner upon final acceptance.

G. Motor shall be ODP continuous duty industrial grade with accessible wiring boxes and shall be manufactured by a major domestic motor manufacturer. All motors shall be premium efficiency motor as indicated in Division 23 Section, Common Work Results for HVAC of these specifications.

H. All fans shall be provided with belt guards per OSHA requirements, flanged outlets, scroll access door and drain fitting in scroll. Fans shall be provided with aluminum mesh inlet screen, vibration isolators, and weather cover. Provide NFPA-90 approved flexible connections on inlet and outlet of fans. Fans shall be installed with proper inlet and outlet conditions to minimize system effect as shown on contract drawings.

I. See Division 23 Section, Heating, Ventilating, & Air-Conditioning Equipment for make-up air units.

2.2. DUCTWORK AND DUCT ACCESSORIES

A. Material: Stainless steel ducts-- ASTM A167, Type 316, suitable for 6-inch pressure service.

B. Ductwork

1. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible 6-inch Pressure Class Round Industrial Duct Construction Standard and Rectangular Industrial Duct Construction Standard and ACGIH Industrial Ventilation Manual, except as indicated.

2. Construct T's, bends, and elbows with radius of not less than 1½ times width of duct on centerline.

3. Increase duct sizes gradually, not exceeding 25 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

4. Fabricate continuously welded round and oval duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Prime coat welded joints.

5. Use crimp joints with or without bead for joining round duct sizes 8 inches and smaller with crimp in direction of air flow, with liquid adhesive plus sheet metal screws.

6. Joints: Minimum 4-inch (100mm) cemented slip type, brazed, or electric welded to AWX D9.1.

7. Provide standard 45-degree lateral wye branch fittings unless otherwise indicated.

8. Use double nuts and lock washers on threaded rod supports.

9. All exterior industrial exhaust ducts shall be constructed of Type 316 stainless steel.

10. The following metal thickness shall be supplied:

	DIAMETER OF STRAIGHT DUCTS	US STANDARD GAUGE FOR 316 STAINLESS STEEL DUCTS
a.	To 8 inches	20
b.	Over 8 inches to 18 inches	18
c.	Over 18 inches to 30 inches	16
d.	Over 30 inches	14

11. All motor-operated dampers located in stainless steel ductwork shall be constructed of Type 316 stainless steel. All motor-operated dampers shall be provided by the ATC subcontractor and installed by the Mechanical Contractor.

12. Longitudinal joints of ducts shall be continuously welded with seams up.

13. Girth joints of duct shall be made with inner lap in direction of air flow, with 1inch lap, diameters to 19 inches, and 1-1/4 inch laps for diameters over 19 inches. All joints shall be continuously welded.

14. Elbows and angles shall have a centerline radius of 2.5 pipe diameters. Construct elbows 6 inches or less in diameter of at least five sections, over 6 inch diameter of seven sections. Prefabricated elbows of smooth construction may be used. Angles pieced proportionately. Prefabricated elbows shall be industrial duct fittings manufactured by United McGill or as approved equal.

15. Hoods must be free of sharp edges or burrs and reinforced to provide necessary stiffness.

16. All welds shall be by gas fusion using rods of similar material.

17. Hangers shall be Type 316 stainless steel hanger and support spacing shall be in accordance with SMACNA's standards for round industrial ducts.

18. Connect duct to fan inlet with split sleeve drawband at least one pipe diameter long, but not less than 12 inches.

19. Transitions in mains and sub-mains to be tapered; taper 5inches long for each 1inch change in diameter. Transitions shall be eccentric: Flat on bottom.

20. All branches shall enter main at the large end of transition at an angle not to exceed 30 degrees. Connect branches only to top or sides of main with no two branches entering diametrically opposite.

21. Provide dead-end caps within 6 inches from last branch of all mains and sub-mains.

22. Provide access openings or cleanouts every 10 feet and near each elbow, angle or duct junction in horizontal sections, except for non-corrosive gases and vapors containing no particulate matter.

23. Support ducts sufficiently to place no load on connecting equipment and to carry weight of system if plugged with material. Maximum supporting interval 12 feet for 8 inch or smaller ducts, 20 feet intervals for larger ducts.

24. Provide 6inch minimum clearance between ducts and ceiling, wall or floors.

25. Where blast gates are used for adjustment of system, place near connection of branch to main. Provide means of locking after adjustments have been made. Butterfly-type dampers shall not be permitted.

26. Fire dampers, explosion vents, etc., should be installed in accordance with National Fire Protection Association Codes or local fire ordinances.

27. Where state or local laws conflict with above specifications, the more stringent regulation shall be followed. Any other deviation must be approved before installation.

C. Flexible Connections: UL 214 listed, fire-retardant chloroprene or chlorsulfonated polyethylene impregnated fabric, minimum density 36 oz per sq yd, approximately 6 inches wide, crimped into metal edging strip.

D. Angle Rings: Carbon Steel, unpainted, leg out, drilled with bolt holes.

E. Flat Back Elbows: Long radius rectangular elbow at duct material with heavy gauge, removable, stainless steel back strip.

2.3. WELDING ARM HOODS AND ACCESSORIES

A. Counterbalanced Welding Exhaust Arm - Shall be Monoxivent (Series 15000-TT), Car-Mon, Air Flow System Inc., AQC Dust Collection Systems, or approved equal, consisting of a double ball bearing swivel, support arm, Type PT flexible tubing, and Model M fume receptor. External support arm to be constructed in three sections with gas cylinder counterbalances and tensioning controls at each pivot point; arm to be assembled and pretuned at the factory for ease of installation and use. Due to the corrosive nature of the fumes being handled by the unit, the added turbulence created, and the restrictions in adjusting tension, arm assemblies with arm sections, pivots, and tensioning devices inside of the tubing are NOT acceptable. Unit shall have 6 inch diameter by 7 foot long weldproof flexible tubing with swivel and receptor as described below. Provide and install quantity, size, and arrangement as shown on contact drawings.

B. Weldproof Tubing - Shall be Monoxivent, Air Flow System Inc., Car-Mon Ammerman, Nederman, AQC Dust Collection Systems, or approved equal, manufactured using a flame-retardant, oil-resistant red polymer coated polyester fabric with spatter-repellent characteristics. It shall be single ply, double overlap construction having a totally enclosed nylon helix and shall have a textured wear strip for abrasion resistance. The tubing shall be electrically nonconductive to eliminate any chance of conveying electrical current to the duct system and to avoid accidental arcing. Tubing shall have a smooth interior surface to minimize friction loss. Exhaust receptors, flanges or other fittings shall be attached to the tubing at the factory. Field assembly is not acceptable. Tubing shall be 6 inches in diameter by 7 feet long. Provide and install quantity, size and arrangement as shown on the contract drawings.

C. Welding Receptor - Shall be Monoxivent, Air Flow System Inc., Car-Mon, receptor, Ammerman, Nederman, AQC Dust Collection Systems, or approved equal, formed from high impact rated ABS thermoset polymer compound with high heat resistance capabilities in a low resistance elliptical air entry design with flanged perimeter. It shall be complete with integral swivel collar, convenience handle, and collector screen of corrosion resistant metal. The receptor shall be electrically nonconductive to eliminate any change of conveying current to the duct system and to avoid accidental arcing. Provide and install quantity, size, and arrangement as shown on the contract drawings.

D. Wall Mounting Platform for Arms - Shall be Monoxivent, Air Flow System Inc., Car-Mon, Ammerman, Nederman, AQC Dust Collection Systems, or approved equal, constructed of welded heavy gauge steel angles and channels permitting 180-degree rotation of the arm. Platform shall be suspended and secured from the wall and shall support the entire weight of the counterbalanced arm, tubing and receptor. Contractor shall prime and finish with two coats of corrosion-resistant paint in color as selected by Architect. Method of attachment to building structure shall be approved by the Structural Engineer. Provide additional support framing where required to mount arm over table without wall.

E. Blast Gate Dampers - Provide and install where indicated on contract drawings

Monoxivent, Air Flow System Inc., Car-Mon Series BG blast gate dampers, AQC Dust Collection Systems, or approved equal. Dampers shall be two (2) piece stainless steel construction with fully adjustable sliding gate and set screw for permanent damper settings. Select blast gate size to match duct system where damper is installed.

PART 3. EXECUTION

3.1. FIELD MEASUREMENTS

A. Verify that field measurements are as indicted on shop drawings.

3.2. INSTALLATION

A. Install equipment in accordance with manufacturers' instructions.

B. Install in accordance with NFPA 91, SMACNA, HVAC Duct Construction Standards - Metal and Flexible 6-Inch Pressure Class Round Industrial Duct Construction Standard and Rectangular Industrial Duct Construction Standard and ACGIH Industrial Ventilation Manual, except as indicated.

C. Do not operate fans for any purpose until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

D. Install fans with resilient mountings and flexible electrical leads.

E. Install flexible connections at fan inlet and discharge. Ensure metal bands of connectors are parallel with minimum one inch (25mm) flex between ductwork and fan while running.

F. Provide pitot tube openings where required for testing of systems, complete with metal cap with spring device or screw to ensure against air leakage.

G. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

3.3. TESTING AND BALANCING

A. Testing: Measure the air flow in the system with a standard pitot tube to determine whether it is functioning in accordance with design specification. All branch ducts shall be tested to assure design air flow rates as scheduled on contract documents. Static pressure profiles shall be conducted at all fan systems as indicated in Division 23 Section, Testing Adjusting & Balancing for HVAC & Plumbing.

3.4. LEAKAGE TESTS

A. All sheet metal ductwork shall undergo leakage test at 4 inch W.G. Test shall be accomplished under this section and witnessed as specified under Division 23 Section, Testing Adjusting & Balancing for HVAC & Plumbing.

B. Leakage from each duct system shall not exceed 1 percent of the nominal fan capacity of the system. If the system ductwork is tested in sections, the leakage shall not exceed ½ of

1 percent of the CFM to be handled by that section, and the total leakage of the system shall not exceed 1percent of the total system CFM. Test pressure shall not exceed the pressure limits of the duct construction as defined in SMACNA High Pressure Duct Construction Standards. Repair all leaks which are audible, regardless of the leakage rate of the duct system as a whole, by remaking the entire defective joint or seam. Spot sealing of ducts in place will not be acceptable.

C. Submit a complete report of the ductwork leakage tests to the Architect/Engineer and include final approved copies in Test and Balance Reports.

END OF SECTION

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PACKAGED KITCHEN HOOD VENTILATION CONTROL SYSTEM
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SECTION 23 82 22
PACKAGED KITCHEN HOOD VENTILATION CONTROL SYSTEMS

PART 1. GENERAL

1.1. RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

A. This Section includes the following:

1. Packaged Kitchen Hood Ventilation Control Systems.

B. Related Sections include the following:

1. Division 11 Section, Food Service Equipment for kitchen hoods.

2. Division 23 Section, Heating, Ventilating, and Air Conditioning for hood make-up units.

3. Division 23 Section, Heating, Ventilating, and Air Conditioning for hood exhaust fans.

4. Division 23 Section, Instrumentation & Controls of HVAC & Plumbing Systems for temperature control and sequences of operation.

C. The kitchen hood demand control ventilation (DCV) control system shall include controls that sense temperature and smoke under the hood and vary the fan speed to maintain safe and effective kitchen exhaust per ASHRAE/ANSI/IES Standard 90.1 2010. Melink Intelli-Hood Demand Control Ventilation (DCV) control system shall monitor cooking activity under the kitchen hood via auto-calibrated infrared Optic Sensors consisting of an Emitter and Receiver mounted on either side of the hood canopy as well as duct or canopy mounted three-wire Temperature Sensor. System shall be capable of operating exhaust fan motors at minimum speeds of 30%-50%. Optic Sensors, with dedicated Air Purge Units, shall immediately increase fan speeds to 100% upon detection of smoke or effluent in the hood canopy with a response time of 0.2 seconds. Upon evacuation of smoke or effluent the fans will modulate according to exhaust temperature for optimal energy savings. System will actively modulate make-up airflow according to exhaust load to maintain correct space airflow balance.

D. Demand Control Ventilation (DCV) system that only includes a temperature sensor to detecting cooking activity shall not be permitted. Additionally a DCV system that includes infrared heat sensors without a dedicated air purge unit and auto-recalibration of sensors shall not be permitted. Modulating dampers or other devices that may impede exhaust airflow and grease extraction shall not be permitted.

E. Modulating dampers or other devices that may impede exhaust airflow and grease extraction shall not be permitted.

1.3. SUBMITTALS

A. Comply with the requirements of Division 01 Section Submittal Procedures.

B. For Approval:

1. Product Data: Include rated capacities, furnished specialties, and accessories.

2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Prepare the following:

a. Mounting Details: For securing variable speed drives, temperature sensors, optical sensors, and key pads to kitchen hoods. Indicate coordinating requirements with kitchen hood.
b. Wiring Diagrams: Power, signal, and control wiring.

3. Coordination Drawings: Equipment mounting details drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

a. Size and location of variable speed drives, temperature sensors, optical sensors and key pads and methods for anchoring units to kitchen hoods.

C. For Information:

1. Startup service reports.

2. Operation and Maintenance Data: For packaged kitchen hood ventilation control systems to include in emergency, operation, and maintenance manuals.

1.4. QUALITY ASSURANCE

A. Product Options: Drawings performance requirements of packaged kitchen hood ventilation systems are based on the specific system indicated. Refer to Division 01 Section Product Requirements.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Control System shall be tested and certified to conform to the following standards.

1. UL 2017 – Standard for General-Purpose Signaling Devices and Systems.

2. UL 710 – Standard for Exhaust Hoods for Commercial Cooking Equipment.

3. FCC Class B Standard CFR47 Part 15.109 on Radiated Emissions.

4. FCC Class B Standard CFR47 Park 15.109 on Conducted Emissions.

5. CSA C22.2 No. 205-M1983 – Signal Equipment.

6. CE Class B Directive 98/34/EEC: Technical Standards & Regulations Directive.

7. CE Class B Directive 2004/108/EC: Electromagnetic Compatibility with Amending Directives 92/31/EEC, 93/68/EEC and 91/263/EEC

8. CE Standard EN 61000-6-3: 2007 Emissions

9. CE Standard EN 61000-3-2: 2006 Harmonic Current Emissions

10. CE Standard EN 61000-3-3: 1995 +A1:2001, +A2:2005 – Voltage Fluctuations and Flicker

11. CE Standard EN 61000-6-1: 2007 Electrostatic Discharge

12. CE Standard EN 61000-6-1: 2007 Radiated Immunity

13. CE Standard EN 61000-6-1: 2007 Electrical Fast Transients

14. CE Standard EN 61000-6-1: 2007 Surge

15. CE Standard EN 61000-6-1: 2007 Conducted Immunity

16. CE Standard EN 61000-6-1: 2007 Voltage Dips and Short Interruptions.

1.5. COORDINATION

A. Coordinate supply fan speed control of Make-up air units are specified in Division 23.

B. Coordinate installation of equipment and devices with kitchen hoods. Kitchen hoods are specified in Division 11 Section Food Service Equipment. Coordinate exhaust fan and make-up air unit speed control of hood exhaust fans and make-up air units. Hood exhaust fans are specified in Division 23. Hood exhaust fans and make-up air units are specified in Division 23 Section, “Heating, Ventilating, and Air Conditioning Equipment”.

C. Coordinate with Division 23 “Common Work Results for HVAC”. Furnish and install motor bearing protective rings at all variable frequency drive motors.

D. Coordinate installation of hood sensors in kitchen hoods listed in Division 11 Food Service Equipment.

E. Coordinate installation of the System Controller(s), Touchpad(s), and Aux Touchpad(s).

F. Coordinate installation of Variable Frequency Drives.

G. Coordinate installation of hood sensor wiring.

H. Coordinate power wiring of System Controller, Auxiliary Power Supplies, and Auxiliary Light Controllers.

I. Coordinate VFD and motor power wiring.

J. Coordinate installation of VFD control wiring and auxiliary contacts on equipment disconnects.

K. Coordinate installation and connections of control wiring for make-up air unit(s), air handling unit(s), pollution control exhaust fan, and any other HVAC equipment related to the kitchen ventilation system.

L. Coordinate supply fan speed and/or damper control of make-up air units or other air handlers to maintain building balance as exhaust fans modulate in speed.

M. Coordinate installation and control wiring of special hood systems.

N. Coordinate fire mode interlock and Sequence of Operation.

O. Coordinate interface of IntelliHood Control system to building automation network via BACnet protocol over TCP/IP.

P. Coordinate connection of IntelliHood Control System to an internet gateway such that IntelliHood System Controller can connect to the Melink IntelliHood Server.

1.6. EXTRA MATERIAL

A. If the manufacturer is not capable of providing variable frequency drives with integral across the line starter bypass, then spare variable frequency drives shall be provided for each exhaust air fan and makeup air unit.

PART 2. PRODUCTS

2.1. MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Melink Corporation.

2. Greenheck

3. CaptiveAire

4. Or approved Equal

2.2. PACKAGED UNITS

A. Factory assembled, pre-wired, self-contained units consist of processors key pads, temperature sensors, optic sensors, air purge units, and variable frequency drives.

B. The kitchen ventilation control system shall automatically control the speed of the exhaust and make-up air fan(s) to ensure optimal hood performance. The system includes the

following: I/O Processor, Keypad, Temperature Sensors, Optic Sensors, Electronic Motor Starters (VFD's which replace magnetic starters for 3-phase motors), and cables.

C. Factory assembled, modular, control system, consisting of the following components:

D. System Controller

1. Communicates to Hood Controller, Touchpad(s), Temperature and Optic Sensors via proprietary RS-485 Protocol.

2. Controller capable of communicating with up to (39) Hood Controllers, (10) Touchpads, (10) Auxiliary Touchpads, (10) Auxiliary Power Supplies, and (10) Auxiliary Light Controllers.

3. Communicates with up to (64) Variable Frequency Drives via Modbus Protocol.

4. Programmable I/O containing (3) Digital Inputs, (4) Digital Outputs, (1) Analog Input and (1) Ana-log Output.

5. Adjustable Temperature range vs. Fan Speed Curve.

6. Automatic On/Off based on hood temperature or programmable clock for individual fan schedules.

7. Removable USB memory storage for setup files and operational performance history data.

8. Calculates appropriate speeds for exhaust and supply fans based on cooking temperature demand and optical infrared monitoring.

9. Internet-based Service Application for monitoring, programming and troubleshooting.

10. BACnet over TCP/IP Interface for communication to Building Automation System.

11. Internet-based Service Application for programming and monitoring

a. Monitoring can be done using hard-wired Ethernet plug-in or 4G wireless modem.

2.3. I/O PROCESSOR

A. Processor shall be housed in painted enclosure for durable construction and a smooth finish. The processor shall have the capability of interfacing with up to four (4) pairs of optic sensors, four (4) temperature sensors, four (4) electronic motor starter interfaces plus supply fan command and eight (8) Air purge units. When required provide multiple processors should the quantity of hoods/fans exceed four (4) per processor. The processor shall include the following:

1. Auto Start/Stop Command and Timer function.

2. Winter Setback Mode.

3. Comfort Mode: Utilizes cool outside air to keep kitchen comfortable.

4. Smoke Detection Relay.

5. Two (2) alarm relays for controlling external devices based on exhaust temperature.

6. Plug-n-play cables provided for quick and easy installation.

7. 4-20 milliamp signal output.

B. Hood Controller

1. Monitors Temperature and Optic Sensors on each kitchen hood and sends the sensor data to the System Controller via RS-485 Protocol communications.

2. Steel beam clamps for installation on hoods or other mechanical structures above kitchen hood.

3. Hood Controller Temperature Rating: 0° to 50°C, 32° to 120°F

2.4. KEYPAD

A. Touchpad

1. Full color screen, 2.8” diagonal, QVGA resolution screen to display operating status and programmable menus.

2. Integrated membrane FANS switch for turning fans from Active Mode (On) and Standby Mode (off).

3. Integrated membrane LIGHTS switch for turning hood lights On / Off via line voltage relays to change state of line voltage.

4. Soft keys and Directional integrated membrane switches for user to boost fans to full speed, access programming menus, access diagnostic and help screens.

5. Fully programmable graphical interface to conform to operators’ hood and fan nomenclature.

6. Provide keypad for each hood.

B. Aux Touchpad

1. Aux Touchpad shall be used as an additional user interface, if applicable, for the control of the FANS, LIGHTS and 100% switches.

2. Integrated membrane FANS switch shall change associated hoods between Active Mode (fans running) to Standby Mode (fans off).

3. Integrated membrane LIGHTS switch shall change the state of associated line voltage relays which may be used to control Hood Lights circuits.

4. Integrated membrane 100% Switch shall allow users to temporarily boost fan speeds to full speed on associated hoods.

5. Stainless steel cover plate (304L) for durable construction and smooth finish.

6. Synthetic overlay for water protection.

C. Aux Power Supply

1. Aux Power Supply shall be used for large installations when additional power is needed to power Hood Controllers, Optic Sensors and Touchpads.

2. Aux Power Supply Temperature Rating: 5° to 40°C, 41° to 104°F

D. Aux Lighting Controller

1. Aux Lighting Controller shall be used for large installations where there is a need to control multiple hood light circuits.

2. Aux Lighting Controller Temperature Rating: 5° to 40°C, 41° to 104°F

2.5. TEMPERATURE SENSOR(S)

A. Platinum three-wire resistive temperature device (RTD) encased in stainless steel tube.

B. Threaded housing shall be assembled in UL-Listed grease-tight fittings for installation in exhaust duct or kitchen hood canopy.

C. Temperature sensors shall be wired to Hood Controller via 8-pin, RJ-45 connectors to the RS-485 Protocol Hood Network Cables.

D. Temperature Rating: 0° to 535°C, 32° to 1000°F

2.6. OPTIC SENSOR(S)

A. Optic Sensors shall consist of conformal coated Emitter and Receiver boards housed in stainless steel enclosures on opposite ends of the kitchen hood interior.

B. Infrared sensors capable of detecting effluent in the air at any point along the length of the beam with a response time of 0.2 seconds.

C. Sensors shall be capable of spanning 3 to 40 feet of kitchen hood interior with automatic gain adjustment.

D. Optic sensors shall auto-calibrate every day at start up and/or every 24 hours.

E. Sensors shall be wired to Hood Controller with liquid-tight connectors at sensor board via the Air Purge Unit.

F. Optic Sensor Temperature Rating: 0° to 85°C, 32° to 185°F

2.7. AIR PURGE UNIT(S)

A. Air Purge Unit (APU) consisting of a 12VDC blower and interface PCB inside an 18 gauge galvanized steel enclosure shall be installed to reduce the accumulation of contamination on the Optic Sensor lenses and reduces heat buildup inside the Optic Sensor enclosure.

B. APU shall physically connect to the Optic Sensor enclosure via stainless steel conduit pipe.

C. Blower fan bearings shall be permanently lubricated.

D. APU Temperature Rating: 0° to 50°C, 0° to 125°F

2.8. ELECTRONIC MOTOR STARTERS

A. Variable frequency drives (VFD) shall be used to control the exhaust and supply fan motors. The VFD modulates the speed of the fan motors by varying the output voltage and frequency based on a signal received from the controller. The VFD will send a feedback signal to the controller in or-der for the keypad to display the actual speed of the motor. The variable frequency drives shall have the following characteristics:

1. NEMA 1 Enclosure or NEMA 3R when installed on roof.

2. Full across the line bypass/starter or spare exhaust air fan and makeup air unit drives.

3. Soft-Start Capability.

4. Digital keypad displays output frequency, current, voltage, and allows programming for field modifications.

5. Protective functions: motor overload, overheating, overcurrent, overvoltage, output shorts, etc.

6. High and low frequency limiters.

7. Adjustable torque boost.

8. Plug-n-play cables provided for quick and easy installation.

9. Single point power connection.

10. Coordinate exact size of VFDs based on approved submittals for make-up air units and exhaust fans.

11. VFDs shall be provided under this Division and shall be remote mounted where shown on the Contract Drawings.

12. Building Automation System shall acquire VFD control data (stop, start, speed, fault status) from IntelliHood System Controller via BACnet Protocol over TCP/IP

Communication.

13. Phase loss protection.

2.9. MOTORS

A. General requirements for motors are specified in Division 23 Section "Common Work Results for HVAC".

B. Motors controlled by Variable Frequency Drives should be designed and tested to meet recommendations of NEMA MG1, Part 31.

1. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Di-vision 26 Sections.

C. Furnish and install shaft grounding rings on all motor shafts.

PART 3. EXECUTION

3.1. EXAMINATION

A. Examine substrates areas and conditions with Installer present for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Delete first subparagraph below if not required.

C. Examine roughing-in for hood suppression piping, hood exhaust ductwork systems to verify actual locations of piping connections before equipment installation.

D. Examine kitchen hoods and ceilings for suitable conditions where variable frequency drives will be installed.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. INSTALLATION

A. Install packaged kitchen hood ventilation control systems per manufacturer's requirements.

B. Install interlock wiring between motors and variable frequency drives.

C. Install processors and variable frequency drives in the utility cabinet.

D. Install wiring to shunt trip breakers and gas solenoid valves. Interlock with fire alarm system.

E. Install temperature sensors in exhaust duct collars.

F. Install optic sensors in the inside ends of each hood with air purge units mounted on top.

G. Wire system components with plug-in-play cables.

H. Install controls and equipment shipped by manufacturers for field installation with packaged kitchen hood ventilation control system.

I. Mount key pads at all kitchen hoods. Coordinate with Owner to ensure accessibility of location.

J. Install and interlock air flow monitoring station. Interlock with ATC system.

K. Program VFD parameters in the kitchen make-up unit and kitchen hood exhaust fan drives. Parameters shall be determined by Test/Balance Engineer and the same should be noted on the inside door of the make-up air unit and adjacent to the exhaust fans and drives.

L. Assist the Automatic Temperature Control Contractor with mapping over points to the BMS.

3.3. CONNECTIONS

A. Install sensors, cabinet, variable speed drives and key pads adjacent to kitchen hoods to allow service and maintenance.

B. Ground equipment according to Division 26 Section Grounding and Bonding.

C. Connect wiring according to Division 26 Section Conductors and Cables.

D. Interlock packaged kitchen control system with ATC system.

E. Where a local motor disconnect is indicated downstream of the electronic motor starter (VFD), provide interlock wiring from auxiliary contacts on the disconnect to the electronic motor starter to de-energize the VFD when the local disconnect is turned “off”.

3.4. FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

3.5. STARTUP SERVICE

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

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Programming of system parameters for proper detection of cooking conditions.

3. Programming of system parameters for proper operation of control input/output points.

4. Programming of VFD parameters for proper control communication with control system.

5. Programming of VFD motor operational set points (maximum speed and allowable motor current).

6. Verification of IntelliHood system functionality.

7. Results shall be captured in a written report.

3.6. ADJUSTING

A. Adjust initial temperature and optic sensor set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Adjust variable frequency drives and fan speed set points. Coordinate with Test and Balance Engineer.

D. Adjust pre-set minimum supply fan and exhaust fan(s) air flow rates.

3.7. DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain Packaged Kitchen Hood Ventilation Control Systems. Refer to Division 01 Section Closeout Procedures and Demonstration and Training.

END OF SECTION

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SECTION 23 83 12
ELECTRIC HEATING CABLES

PART 1. GENERAL

1.1. RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

A. This Section includes heating cables for the following applications:

1. Heat tracing.

1.3. SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Diagram power, signal, and control wiring and differentiate between manufacturer installed and field installed wiring.

C. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling mounted items; and floor plans and sections showing heating cable layout and relationships between components and adjacent structural and mechanical elements. Show the following:

1. Ceiling suspension assembly members.

2. Method of attaching hangers to building structure.

3. Ceiling mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Maintenance Data: For electric heating cables to include in maintenance manuals specified in Division 01.

F. Warranties: Special warranties specified in this Section.

1.4. QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5. COORDINATION

A. Coordinate layout and installation of electric heating cables and system components with other construction.

1. Coordinate concrete, reinforcement, and formwork requirements specified in Division 03 Section, Cast in Place Concrete.

2. Coordinate with ceiling installation requirements.

3. Coordinate with roofing installer, for installation and roof penetrations specified in Division 07 Sections.

1.6. WARRANTY

A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of electric heating cables that fail in materials or workmanship within specified warranty period.

C. Warranty Period: Two years from date of Substantial Completion.

1.7. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Accutron Heat Tracing Systems.

2. Ari Industries.

3. BICC Pyrotenax USA Inc.

4. Caloric, Inc.

5. Chromalox; Wiegard Industrial Division; Emerson Electric Company.

6. Copperheat Inc.

7. Delta Therm Corp.

8. Easy Heat, Inc.

9. INDEECO.

10. Maxxon Corp.; Infloor Heating Systems Div.

11. Nelson Heat Tracing Systems.

12. Omega Engineering Inc.

13. Raychem Corporation.

14. Thermon Manufacturing Co.

2.2. ELECTRICAL HEAT TRACING FOR PIPELINES

A. The self-regulating heater shall consist of two (2) 16 AWG nickel coated-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature all along its length, allowing the heater to be crossed over itself without overheating, to be used directly on plastic pipe, and to be cut to length in the field. The heater shall be covered by a radiation cross-linked modified polyolefin dielectric jacket.

B. In order to provide energy conservation and to prevent overheating, the heater shall have a self-regulating factor of at least 90 percent. The self-regulation factor is defined as the percentage reduction, without thermostatic control, of the heater output going from 40 degrees F pipe temperature operation to 150 degrees F pipe temperature operation.

C. The heater shall operate on line voltages of 120 volts without the use of transformers.

D. The heater shall be sized according to this table. The required heater output rating is in watts per foot at 50 degrees F

Pipe Size	**= - 10 degrees F**
3 inch or less	5 watt
4 inch	5 watt
6 inch	8 watt
8 inch	2 strips - 5 watt
12 inch to 14 inch	2 strips - 8 watt

E. The heater shall be XL-Trace as manufactured by Raychem Corporation or as approved

equal.

F. Power connection, end seal, splice and tee kit components shall be applied in the field.

G. The system shall be controlled by a bulb-sensing thermostat AMC-1B set at 40 degrees F either directly or through an appropriate contractor.

2.3. CONTROLS

A. Wall Thermostat: Temperature range from 35 to 95 degrees F (2 to 35 degrees C), with manually operated off position switch, as recommended by cable manufacturer.

B. Pipe Thermostat: Unit with adjustable temperature range from 35 to 50 degrees F (2 to 10 degrees C) snap action; open on rise, single pole switch with 25 A rating; and remote bulb for directly sensing pipe wall temperature.

2.4. ACCESSORIES

A. Cable Installation Accessories: Tapes, cable ties, warning labels, end seals and splices, and installation clips.

PART 3. EXECUTION

3.1. EXAMINATION

A. Examine surfaces and substrates to receive heating cables for compliance with requirements for installation, tolerances, and other conditions affecting performance.

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.

2. Ensure pipe testing is complete.

3. Ensure surfaces and substrates are level and plumb.

B. Test cables for electrical continuity before installing.

C. Test cables for insulation resistance before installing.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2. INSTALLATION

A. Cut cable to length required.

B. Install heater to cold lead connections in accessible locations. Do not embed in concrete or plaster.

C. Avoid crossing expansion, construction, or control joints with heating cables. Provide sufficient slack conductor in expansion loop.

D. Do not install heating cable mats across expansion, construction, or control joints.

E. Install cables and mats after applying bituminous binder course to lower base; ensure that second bituminous binder course is applied to cables before pouring finish topping.

F. Do not energize cables embedded in concrete, asphalt, or plaster until those assemblies are cured, except for brief testing.

3.3. CONNECTIONS

A. Electrical installation requirements are specified in Division 26 Sections. Drawings indicate general arrangement of wiring, conduit, and specialties.

B. Connect heating cables and other components to wiring systems.

C. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4. FIELD QUALITY CONTROL

A. Testing: Perform tests after installation but before application of coverings, such as insulation, plaster, or concrete.

1. Test cables for electrical continuity before energizing.

2. Test cables for insulation resistance before energizing. Remove cables if measured resistance is less than 10 megohms to ground.

3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation.

C. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.5. ADJUSTING

A. Set field adjustable switches and circuit breaker trip ranges as indicated.

3.6. PROTECTION

A. Protect installed heating cables, including leads, from damage before Substantial Completion.

END OF SECTION