SECTION 00 91 13

ADDENDUM NO. 3

DATE: March 11, 2026

PROJECT: HVAC Upgrades at Hoxsie Elementary School
55 Glenwood Drive,
Warwick, RI 02889

- This addendum forms a part of the Contract Documents and modifies the original Bidding Documents dated February 9, 2026 as noted below.
- Please advise all sub-contractors.
- Acknowledge receipt of this Addendum in the space provided on the Bid Form.

SPECIFICATIONS

GENERAL

ITEM NO. 1 – REVISED SPECIFICATION SECTIONS

A. Remove the following specification sections and replace with the revised specification sections attached to the Addendum as an integral part of this bidding document.

Section 23 00 00 - HVAC

ARCHITECTURAL

ITEM NO. 1 – SECTION 07 50 01 – Repairs to Existing Roof

A. Section 1.2: Delete section B, Add section "B. Product Data: For each roofing system product, include product data, manufacturer's specifications of materials and installation instructions..".

ITEM NO. 2 – SECTION 07 92 13 – Joint sealants

B. Section 3.6 – C: Add section "4. Silicone Joint Sealant at Exterior Masonry, Windows, Insulated Metal Glazing Panels Single Component, Neutral-Curing Silicone Joint Sealant, Type S, Grade NS, Class 50, for Use NT, G, A and O, equal to Dowsil-795 by Dow or Spectrem-2 by Tremco.".

ITEM NO. 3 – SECTION 08 88 60 – Insulated Metal Glazing Panels

A. Section 2.04: Add section "B. 1" Aluminum Molding, Two Piece Cap including: MIN-68 receptor and MIN-67 cap, factory finish matching panel, by Mapes Industries.".

B. Section 3.01: Delete section C, Add section: "C. If the panels need to have a cut-out in them, the cut-out is to be performed per the manufactures installation requirements. Cut-out are to be 3 inches or more away from the edges of the panel. ".

MECHANICAL

ITEM NO. 1 – SECTION 230000 – HVAC

A. Removed all language for "Alternate Design".

B. Revised sections "2.19 Dedicated Outdoor Air Units (Packaged)" & "2.20 Packaged Rooftop HVAC Units".

DRAWINGS

GENERAL

ITEM NO. 1 – REVISED DRAWINGS

A. Remove the following drawings and replace with revised drawings attached to this Addendum.

M0.2 – Mechanical Schedules
M0.3 – Mechanical details
M3.1 – Mechanical Roof Plan & Details
E1.0 – Electrical Legend, Lighting Fixture Schedule and Notes
ED1.2 – Electrical Plans – Areas B, C & D – Lighting Demolition
E1.2 – Electrical Plans – Areas B, C & D – Lighting
E2.3 – Electrical Overall Roof Plan
E3.3 – Electrical Schedule, Riser Diagrams and Details

ITEM NO. 2 – DRAWING G1.1 General Notes

A. General Notes: Delete note 58, Add note "Provide 25 PSI insulation at the roof surface, typical.".

ITEM NO. 3 – DRAWING A1.0 Floor Plan

A. General: Provide one hour fire rated construction at new openings in corridor walls and closure of existing openings in corridor walls, throughout school. Construction equal to UL Designs U906 including concrete block classification D-2 and full bed of mortar.

B. General: Provide two hour fire rated construction at new openings and closure of existing openings in walls between additions including: Area-A (Corridor C101) and Area-B (Corridor C102) above double doors, Area-A (Corridor-C103) and Area-D (Corridor C104) above double egress doors. Construction equal to UL Designs U906 including concrete block classification D-2 and full bed of mortar.

C. 1/A1.0 Floor Plan Area-D: Provide opening, 2 hour fire rated construction, in existing CMU wall above double egress doors and above acoustical ceiling for new ductwork, see work keynote M-G, see details 6/S2.1 and 9/A2.1, see engineering documents.

ITEM NO. 4 – DRAWING A1.1 Reflected Ceiling Plan

A. General: Remove & Dispose existing acoustical ceiling and metal grid over whole building, unless noted otherwise. See Ceiling Plan Work Note B.

B. General: Provide acoustical ceiling and metal grid over whole building, unless noted otherwise. Provide 2x4 and 2x2 acoustical ceiling system where indicated in Reflected Ceiling Plan 1/A1.1 and 2/A1.1. See Ceiling Plan Work Note E and F. See Ceiling Plan Work Keynote Legend F-C and F-D.

C. General: Existing interior wood soffits to remain, do not paint, typical.

ITEM NO. 5 – DRAWING A1.2 Roof Plan - Patching

A. General: provide positive drainage at areas of roof patching, changes to the roof surface, around roof top equipment, around roof top equipment supports.

B. General: Provide a shop drawing of the roof system Area-A, to scale 1/8" per foot, depict the existing roof slope, changes to the roof slope, new roof top equipment including the roof top ductwork and ductwork supports.

C. 2/A1.2 Roof Plan – Area-A, B, C: Add note pointing to RTU at Roof-C "GC ensure plenum curb height accommodates 8" clear EPDM membrane surface to top of EPDM termination under ducts penetrating curb. Provide roof membrane system detail like Carlisle-Syntec U-9A Mechanical Termination with Counter Flashing including: 3 3/4" high aluminum one piece counter flashing equal to Securedge model CFW-375, continuous universal single-ply sealant over top edge of one piece counter flashing, flashing fastened 12" OC over term bar and term bar fastened 6" OC thru EPDM and continuous water cut-off mastic under EPDM, typical

ITEM NO. 6 – DRAWING A2.1 Details – Wall Repairs

A. General: Existing exterior wall construction Area-A: 1'-1" thick including: 4" thick brick veneer, 8" thick CMU at interior, no insulation; Area-B: 1'-3" thick wall including: 4" thick brick veneer, 8" thick CMU at interior, 2" thick board cavity insulation; Area-C: 1'-5" thick wall including: 4" thick brick veneer, 12" thick CMU at interior, no insulation, Area-D: 1'-0" thick wall including: 4" thick split face CMU veneer, 6" thick CMU at interior, 1 1/2" thick board cavity insulation. Verify in the field.

B. 2/A2.1 Sect: Area-B Exterior Wall Infill Brick & CMU Work Keynote M-A, Typical: Delete note pointing to new interior CMU, Add note "Provide 8" X 8" X 16" CMU infill, seal edges with mortar, provide air sealing, VIF, typ".

C. 3/A2.1 Sect: Area-C Exterior Wall Infill, Brick & CMU, Work Keynote M-A, Typical: Provide interior paint system over wall, color selected by architect, Typ.".

D. 11/A2.1 Sect: Area-C Concrete Floor Infill, Typical: Delete note pointing to floor patch woven wire mesh, Add note "Provide 4" thk 3000 PSI conc slab with 4X4 #10 gauge woven wire mesh 2" below surface.".

E. 11/A2.1 Sect: Area-C Concrete Floor Infill, Typical: Delete note pointing to rebar, Add note "Provide pinning of conc slab with #4 X 6" rebar epoxied into exist, 2'-0" O.C., pre-drill, Typ.".

ITEM NO. 7 – DRAWING A2.2 Details – Roof Patching,

A. 2/A2.2 Sect: Roof Top Unit Curb Flashing, Typical: Add note "See engineering documents for curb type and locations, typical.".

B. 7/A2.2 Sect: Equipment Support Flashing, Typical: Add note "Provide EPDM termination like Carlisle-

Syntec U-9B Mechanical Termination where equipment support sheet metal cap does not cover the termination bar including: continuous universal single-ply sealant over top edge of term bar and term bar fastened 6" on center thru EPDM and over continuous water cut-off mastic, typical".

MECHANICAL

ITEM NO. 1 – DRAWING M0.2 – Mechanical Schedules

A. Updated electrical information for RTU-1, 2, 3, & 4.

B. RTU-1 has been revised to have powered exhaust, and ERV wheel section, & plenum curb. As a result of the added accessory options, the unit weight has increased by 1600 lbs.

ITEM NO. 2 – DRAWING M0.3 – Mechanical Details

A. Updated the "PACKAGED RTU & DOAS SIDE CONNECTION DETAIL" to include plenum curb connections for RTU-1.

ITEM NO. 3 – DRAWING M3.1 – Mechanical Roof Plan & Details

A. Revised RTU-1 footprint and duct connections for the new equipment selection.

ELECTRICAL

ITEM NO. 1 – DRAWING E1.0 – Electrical Legend, Lighting Fixture Schedule and Notes

A. Updated Lighting Fixture Schedule

ITEM NO. 2 – DRAWING ED1.2 – Electrical Plans – Areas B, C & D – Lighting Demolition

A. Updated lighting demolition in Area C.

B. Updated Keyed Notes.

ITEM NO. 3 – DRAWING E1.2 – Electrical Plans – Areas B, C & D – Lighting Demolition

A. Updated new lighting in Area C.

B. Updated Keyed Notes.

ITEM NO. 4 – DRAWING E2.3 – Electrical Overall Roof Plan

A. Revised electrical connection and disconnect switch requirements for Roof Top Units RTU-1 and RTU-4.

ITEM NO. 5 – DRAWING E3.0 – Electrical Schedules, Riser Diagrams and Details

A. Revised circuit breaker sizes for Roof Top Units RTU-1 and RTU-4 on the Main Distribution Panel schedule.

End of Addendum No. 3

SECTION 23 00 00

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SECTION 23 00 00

HVAC

PART 1 – GENERAL

1.1 GENERAL REQUIREMENTS AND REFERENCES

A. Include "General Requirements" and applicable parts of Division 1 as part of this Section.

B. Examine all other sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section. Where paragraphs of this Section conflict with similar paragraphs of Division 1, requirements of this Section shall prevail.

C. Coordinate work with that of all other Trades affecting, or affected by work of this Section. Cooperate with such Trades to assure the steady progress of all work under the Contract.

D. The Subcontractor shall be responsible for filing all documents, payment of all fees, and securing of all inspections and approvals necessary for the work of this Section.

1.2 RELATED DOCUMENTS

A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the Related Documents identified in Division 01 Section "Summary".

1.3 DEFINITIONS

A. As used in this section, "provide" means "furnish and install", "POS" means "Provided Under Other Sections" and "HVAC" means "Heating, Ventilating and Air Conditioning".

B. As used in the Drawings and Specifications for Mechanical Work, certain non-technical words shall be understood to have specific meanings as follows, regardless of indications to the contrary in the General Conditions of other documents governing the HVAC work.

1. "Furnish" means: Purchase and deliver to the project site complete with every necessary appurtenance and support, all as part of the HVAC work. Purchasing shall include payment of all sales taxes and other surcharges as may be required to assure that purchased item(s) are free of all liens, claims, or encumbrances.

2. "Install" means: Unload at the delivery point at the site and perform every operation necessary to establish secure mounting and correct operation at the proper location in the project, all as part of the HVAC work.

3. "Provide" means: "Furnish" and "Install".

4. "New" means: Manufactured within the past two (2) years and never before used.

C. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of any HVAC item in the Drawings or Specifications for HVAC work carries with it the

instruction to furnish, install and connect the item as part of the HVAC work, regardless of whether or not this instruction is explicitly stated.

D. It shall be understood that the Specifications and Drawings for HVAC work are complimentary and are to be taken together for a complete interpretation of the HVAC work except that indications on the Drawings, which refer to an individual element of work, take precedence over the Specifications where they conflict.

1.4 SCOPE

A. Perform work and provide material and equipment as shown on Drawings and as specified or indicated in this Section of the Specifications. Completely coordinate work of this Section with work of other trades and provide a complete and fully functional installation.

B. Drawings and Specifications form complimentary requirements; provide work specified and not shown, and work shown and not specified as though explicitly required by both. Although work is not specifically shown or specified, provide supplementary or miscellaneous items, appurtenances, devices and materials obviously necessary for a sound, secure and complete installation.

1.5 REGULATORY REQUIREMENTS

A. Perform work strictly as required by rules, regulations, standards, codes, ordinances and laws of Local, State and Federal governments, and all other Authorities that have legal jurisdiction over the site. Materials and equipment shall be manufacturer installed and tested as specified in latest editions of applicable publications, standards, rulings and determinations of:

1. Local and State Building, Plumbing, Mechanical, Electrical, Fire and Health Department Codes.

2. American Gas Association (AGA).

3. National Fire Protection Association (NFPA).

4. American Insurance Association (A.I.A.) (formerly National Board of Fire Underwriters).

5. Occupational Safety and Health Act (OSHA).

6. Underwriters' Laboratories (UL).

B. Material and equipment shall be listed by Underwriters' Laboratories (UL), and approved by ASME and AGA for intended service.

C. When requirements cited in this Specification conflict with each other or with Contract Documents the most stringent shall govern work. The Architect may relax this requirement when such relaxation does not violate the rulings of Authorities that have jurisdiction. Approval for such relaxation shall be obtained in writing.

D. Most recent editions of applicable Specifications and publications of the following organizations shall form part of the Contract Documents.

1. American National Standards Institute (ANSI).

2. American Society of Mechanical Engineers (ASME).
3. National Electric Manufacturers Association (NEMA).
4. American Society for Testing and Materials (ASTM).
5. American Water Works Association (AWWA).
6. American Society for Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
7. Air Moving and Conditioning Association (AMCA).
8. Sheetmetal and Air Conditioning Contractors National Association (SMACNA).
9. Air Conditioning and Refrigeration Institute (ARI).
10. Thermal Insulation Manufacturers Association (TIMA).

1.6 SUBMITTALS

A. This section shall supplement Division 1.

B. Definitions:

1. Shop Drawings: Information prepared by the Contractor to illustrate portions of the work in more detail than shown in the Contract Documents.
2. Coordination Drawings: Detailed, large-scale layout Shop Drawings showing HVAC, Electrical, Plumbing and Fire Protection work superimposed to identify conflicts and ensure inter-coordination of Mechanical, Electrical, Architectural, Structural and other work.
3. Manufacturer's Product Data: Information prepared by the manufacturer which depicts standard equipment.

C. Submittals Procedures and Format:

1. Review submittal packages for compliance with Contract Documents and then submit to Architect for review. All shop drawings shall be submitted electronically (email or web-based construction management portal) in PDF format. After review, comments shall be returned through an online portal on company standard letterhead with formal review stamp and notes..
2. Each Shop Drawing shall indicate in title block, and each Product Data package shall indicate on cover sheet, the following information:
   a. Title.
   b. Name and location of project.
   c. Names of Architect, Engineer, Contractor and Subcontractor(s).
   d. Names of Manufacturer, Supplier, Vendor, etc.
   e. Date of submittal.

f. Whether original submittal or resubmitted.

3. Shop Drawings showing layouts of systems shall contain sufficient plans, elevations, sections, details and schematics to describe work clearly. They shall be ¼" = 1'-0" and shall indicate work of other Sections where physical clearances are critical and where interferences are possible. Provide larger scale details as necessary. Sheetmetal Drawings shall show elements of Architect's reflected ceiling plan, exposed ductwork, walls, partitions, diffusers, registers, grilles, fire dampers, sleeves and other aspects of construction as necessary for coordination.

D. Acceptable Manufacturers:

1. The Architect's Mechanical/Electrical design for each project is based on the single manufacturer listed in the schedule or shown on the Drawings. In these Specifications certain "Alternate Manufacturers" are listed as being acceptable. These are acceptable only if, as a minimum, they:

   a. Meet all performance criteria listed in the schedules and outlined in the Specifications.

   b. Have identical operating characteristics to those called for in the Specifications.

   c. Fit within the available space it was designed for, including space for maintenance and component removal, with no modifications to either the space or the product. Clearances to walls, ceilings and other equipment will be at least equal to those shown on the Contract Documents. The fact that a manufacturer's name appears as acceptable shall not be taken to mean the Architect has determined that the manufacturer's products will fit within the available space. This determination is solely the responsibility of the Contractor.

   d. For equipment mounted in areas where structural matters are a consideration, the products must have a weight no greater than the product listed in the schedules or Specifications.

   e. Products must adhere to all architectural considerations including, but not limited to, being the same size and of the same physical appearance as scheduled or specified products.

E. Substitutions and Deviations:

1. Deviations from the Contract Documents and the substitution of materials or equipment relative to the "Acceptable Manufacturers" referred to above, shall be requested individually in writing whether deviations result from field conditions, standard shop practice, or other cause. Submit letter with transmittal of Shop Drawings which flags the substitution or deviation to the attention of the Architect. The letter shall describe changes in the system shown and physical characteristics (connections to adjacent materials, electrical services, service access requirements, and other characteristics), and differences in operating characteristics or cycles.

2. Without letters flagging the substitution or deviation to the Architect, it is possible that the Architect may not notice such substitution or deviation or may not realize its ramifications. Therefore, if such letters are not submitted to the Architect, the Contractor shall hold the Architect and his consultants harmless for any and all adverse consequences resulting from the deviations being implemented. Adverse consequences shall include, but not be limited to, excessive noise, excessive maintenance, shortened longevity, spatial coordination problems, and inadequate performance versus scheduled design. This shall apply regardless of whether the Architect has reviewed or approved Shop Drawings containing the deviation, and will be strictly enforced.

3. Do not request substitute materials or equipment unless identical material or equipment has been operated successfully for at least three (3) consecutive years. Such materials and equipment shall be a

regular cataloged item shown in the current catalog of the manufacturer. When deviation or substitution is permitted, coordinate fully with related changes to Architectural, Structural, Plumbing, Fire Protection, Mechanical, and other work. Ensure that related changes necessary for coordination of substituted items are made within the Contract Price. Assume full responsibility for safety, operation and performance of the altered system.

4. Substitutions of equipment, systems, etc. requiring approval of local Authorities must comply with such regulations and be filed by the Contractor (should filing be necessary).

5. Consideration will not be given to claims that the substituted item meets the performance requirements with lesser construction. Performance, as delineated in schedules and in the Specifications, shall be interpreted as minimum performance.

6. Approval of proposed deviations or substitutions, if any, will be made at discretion of Architect.

7. If equipment is proposed for substitution that is not tested and rated according to industry-wide standards, the Architect shall have the right to have performance tests completed, at the Contractor's expense, to confirm the manufacturer's performance claims.

F. Submittal Notations: will be returned from the Architect marked as illustrated below:

□ NO EXCEPTION TAKEN	□ ACCEPTED AS NOTED
□ NOT ACCEPTED	□ REVISE AND RESUBMIT

1. Checking is only for general conformance with the design concept of the project and general compliance with the information given in the Contract Documents. Any action shown is subject to the requirements of the Drawings and Specifications. Contractor is responsible for dimensions which shall be confirmed and correlated at the job site; fabrication process and techniques of construction; coordination of his work with that of all other trades; and the satisfactory performance of his work.

G. Schedule: Incorporate the Shop Drawing review period into the construction schedule so that work is not delayed. Contractor shall assume full responsibility for delays caused by not incorporating the following Shop Drawing review time requirements into his project schedule. Allow at least ten (10) working days, exclusive of transmittal time, for review each time a Shop Drawing is submitted or resubmitted with the exception that fifteen (15) working days, exclusive of transmittal time, are required for the following:

1. Automatic temperature controls.

2. Coordination Drawings, if required by this Specification.

3. If more than five (5) Shop Drawings of this trade are received in one (1) calendar week.

H. List of Proposed Equipment and Materials: Within four (4) weeks after Award of Contract and before ordering materials or equipment, submit a complete list of proposed materials and equipment and indicate manufacturer's names and addresses. No consideration will be given to partial lists submitted out of sequence.

I. Responsibility:

1. The intent of submittal review is to check for capacity, rating, and certain construction features. Contractor shall ensure that work meets requirements of the Contract Documents regarding information that pertains to fabrication processes or means, methods, techniques, sequences and procedures of construction; and for coordination of work of this and other Sections. Work shall comply with submittals marked "REVIEWED" to extent that they agree with the Contract Documents. Submittal review shall not diminish responsibility under this Contract for dimensional coordination, quantities, installation, wiring, supports and access for service, nor the Shop Drawing errors or deviations from requirements of the Contract Documents. The Architect's noting of some errors while overlooking others will not excuse the Contractor for proceeding in error. Contract Document requirements are not limited, waived, nor superseded in any way by review.

2. Inform Subcontractors, Manufacturers, Suppliers, etc. of scope and limited nature of review process and enforce compliance with the Contract Documents.

J. Material and equipment requiring Shop Drawing and/or Manufacturer's Data Submittals shall include but not be limited to:

1. Diffusers, registers, grilles, splitters, dampers and accessories.

2. Ventilating and exhaust fans.

3. Filters.

4. Automatic controls.

5. Insulation and acoustical lining.

6. Vibration isolation.

7. Equipment bases and supports.

8. Identification for pipe, duct, valves and equipment.

9. Complete ductwork Shop Drawings, construction details and duct construction standards.

10. Access panels.

11. Color selection charts and samples for equipment and systems in finished areas.

12. Variable refrigerant flow system.

13. Electric heaters.

14. Energy recovery unit.

15. Ductless heat pump systems.

16. Condensate pumps.

17. Constant flow regulators.

18. Motorized dampers.

19. Raceways and boxes for controls wiring.

1.7 SURVEYS AND MEASUREMENTS

A. Base all required measurements, both horizontal and vertical, on reference points established by the General Contractor and be responsible for the correct laying out of the Mechanical work. In the event of a discrepancy between actual measurements and those indicated, notify the General Contractor in writing. Do not proceed with the work required until written instructions have been issued by the General Contractor.

1.8 COORDINATION

A. HVAC, Plumbing, Fire Protection, and Electrical Drawings are diagrammatic. They indicate general arrangements of Mechanical systems and other work. They do not show all offsets required for coordination nor do they show the exact routings and locations needed to coordinate with Structural and other trades and to meet Architectural requirements.

B. Work shall be performed in cooperation with other trades on the project and so scheduled as to allow speedy and efficient completion of the work.

C. Furnish to other trades advance information on locations and sizes of all frames, boxes, sleeves and openings needed for their work. Furnish information and Shop Drawings necessary to allow trades affected by the work to install their work properly and without delay.

D. In all spaces, prior to installation of visible material and equipment, including access panels, review Architectural Drawings for exact locations and where not definitely indicated, request information from Architect. Where the HVAC work shall interfere with the work of other trades, assist in coordinating the space conditions to make satisfactory adjustments before installation. Without extra cost to the Owner, make reasonable modifications to the work as required by normal Structural interferences. The Mechanical Contractor shall be liable for any additional openings, or relocating and/or enlarging existing openings through concrete floors, walls, beams and roof required for any work which was not properly coordinated. Maintain maximum headroom at all locations. All piping, duct, conduit, and associated components to be as tight to underside of structure as possible.

E. If any HVAC work has been installed before coordination with other trades so as to cause interference with the work of such trades, all necessary adjustments and corrections shall be made by the trades involved without extra cost to the Owner.

F. Where conflicts or potential conflicts exist and engineering guidance is desired, submit sketch of proposed resolution to Architect for review and approval.

G. Protect all materials and work of other trades from damage which may be caused by the Mechanical work, and repair all damages without extra cost to the Owners.

1.9 MECHANICAL AND ELECTRICAL COORDINATION

A. The HVAC Subcontractor shall furnish and install various electrical items relating to the heating and

ventilating equipment and control apparatus. The Electrical Subcontractor shall be required to connect power wiring to this equipment unless noted otherwise.

B. The HVAC and Electrical Subcontractors shall coordinate their respective portions of the work, as well as the electrical characteristics of the heating, ventilating and air conditioning equipment.

C. All power wiring and local disconnect switches will be provided by the Electrical Subcontractor for the line voltage power. All control and interlocking wiring shall be the responsibility of the HVAC Subcontractor.

D. 120V and above power wiring sources extended and connected to HVAC control panels, transformers and switches shall be the responsibility of the Electrical Subcontractor. All low voltage thermostats and any switch wiring shall be the responsibility of the HVAC Subcontractor.

E. Temperature control and equipment wiring shall be installed by the HVAC Subcontractor.

F. The Electrical Subcontractor will provide all magnetic starters except those furnished as an integral part of packaged equipment.

1.10 MECHANICAL AND ELECTRICAL COORDINATION DRAWINGS

A. Coordination Drawings:

1. The Sheetmetal Subcontractor shall prepare a complete set of electronic Drawings at a scale not less than 3/8" equals 1'-0", showing structure and other information as needed for coordination. He shall show sheetmetal layout thereon. These will be the Coordination Drawings.

2. The main paths of egress and for equipment removal, from main Mechanical and Electrical rooms must be clearly shown on the Coordination Drawings. All fire and smoke partitions must be highlighted on the Coordination Drawings for appropriate coordination.

3. Each of the below specialty trades shall add its work to these background Drawings with appropriate elevations and grid dimensions. Specialty trade information is required for fan rooms and mechanical rooms, horizontal exits from duct shafts, crossovers, and for spaces in and above ceilings where congestion of work may occur such as corridors, and even entire floors. Drawings shall indicate horizontal and vertical dimensions, to avoid interference with structural framing, ceilings, partitions, and other services.
   a. Specialty Trades:
      1) Plumbing System.
      2) HVAC Piping and Associated Control System.
      3) Electrical.
      4) Sheet Metal Work.

4. Each specialty trade shall sign and date each electronic Coordination Drawing. Return Drawings to the Sheetmetal Subcontractor, who shall route them sequentially to all specialty trades.

5. Where conflicts occur with placement of materials of various trades, the Sheetmetal Subcontractor will be responsible to coordinate the available space to accommodate all trades. Any resulting adjustments

shall be initialed and dated by the specialty trade. The Sheetmetal Subcontractor shall then final date and sign each Coordination Drawing. If he cannot resolve conflicts, the decision of the General Contractor shall be final, subject to the approval of the Architect.

6. A Subcontractor who fails to promptly review and incorporate his work on the Coordination Drawings shall assume full responsibility of any installation conflicts affecting his work and of any schedule ramifications.

7. The Sheetmetal Subcontractor shall make electronic copies of all Coordination Drawings. Fabrication shall not start until such electronic Drawings are received by the Architect/Engineer and have been reviewed.

8. Review of Coordination Drawings shall not diminish responsibility under this Contract for final coordination of installation and maintenance clearances of all systems and equipment with Architectural, Structural, Mechanical, and Electrical Contractors.

1.11 INSTALLATION REQUIREMENTS

A. The arrangement of all HVAC work shown on the Drawings is diagrammatic only and indicates the minimum requirements of the work. Conditions at the building including actual measurements shall determine the details of the installation. All work shall be laid out and installed so as to require the least amount of cutting and patching.

B. Review the Architectural Drawings and Specifications before ordering any material and equipment. Any discrepancies shall be brought to the attention of the Architect for his determination prior to proceeding with the work.

1.12 TYPICAL DETAILS

A. Typical details where shown on the Drawings shall apply to each and every item of the project where such items are applicable. They are not repeated in full on the Drawings, which in many cases are diagrammatic only, but with the intention that such details shall be incorporated in full. Any alternate method proposed for use by the Contractor shall have the prior approval of the Architect.

1.13 SLEEVES, INSERTS

A. Furnish and install all sleeves, inserts, anchor bolts and similar items to be set into masonry or concrete, as required for HVAC work as indicated in Division 01.

1.14 CORING, DRILLING

A. Furnish and install all sleeves, inserts, anchor bolts and similar items to be set into masonry or concrete, as required for HVAC work as indicated in Division 01.

1.15 ACCESSIBILITY

A. Install all work such that parts requiring periodic inspection, operation, maintenance and repair are readily accessible.

B. Furnish all access panels appropriate to particular conditions, to be installed by trades having responsibility for the construction of actual walls, floors or ceilings at required locations.

1.16 SUPPLEMENTARY SUPPORTING STEEL

A. Provide all supplementary (non-structural) steelwork required for mounting or supporting equipment and materials.

B. Steelwork shall be firmly connected to building construction as required. Locations and methods of attachment shall be approved by the Architect.

C. Steelwork shall be of sufficient strength to allow only minimum deflection in conformity with manufacturer's published requirements.

D. All supplementary steelwork shall be installed in a neat and workmanlike manner parallel to floor, wall and ceiling construction: all turns shall be made at forty-five and ninety degrees, and/or as dictated by construction and installation conditions.

E. All manufactured steel parts and fittings shall be galvanized.

1.17 TOOLS AND EQUIPMENT

A. Provide all tools and equipment required for the fabrication and installation of the mechanical equipment at the site.

1.18 PORTABLE AND DETACHABLE PARTS

A. Contractors shall retain in their possession all portable and/or detachable parts and portions of materials, devices, equipment, etc. necessary for the proper operation and maintenance of the Mechanical and Electrical systems until final completion of the work, at which time they shall be handed over to the Owners.

1.19 RECORD DRAWINGS, PROJECT CLOSEOUT

A. As work progresses and for the duration of Contract, maintain a complete and separate set of prints of Contract Drawings at job site at all times. Record work completed and all changes from original Contract Drawings clearly and accurately including work installed as a modification or addition to the original design. Work shall be updated on a weekly basis and shall be made available for review by Architect. Failure to perform this work shall be reason for withholding requisition payments. In addition, take photographs of all concealed equipment in gypsum board ceilings, shafts, and other concealed, inaccessible work. At completion of work, make copies of photographs with written explanation on back. These shall become part of Record Documents.

B. At the completion of work, prepare a complete set of Record Drawings showing all systems as actually installed. The copies will be made available for the HVAC Contractor's copying, at his expense, to serve as backgrounds for the Record Drawings. The quantity of copies which are made available shall in no way be interpreted as setting a limit to the number of Drawings necessary to show the required information. The HVAC Contractor's professional Draft Person shall transfer changes to electronic CAD files. Submit

three (3) sets of electronic copies to Architect for comments as to compliance with this section.

C. The Architect will not certify the accuracy of the Record Drawings. This is the sole responsibility of the Mechanical Contractor.

D. This trade shall submit the Record Drawings for approval by the Fire and Building Departments in a form acceptable to the departments, when required by the jurisdiction.

E. Record Drawings shall show record condition of details, sections, riser diagrams, control changes and corrections to schedules. Schedules shall show actual manufacturer, make and model numbers of final equipment installation.

1.20 GUARANTEE/WARRANTY

A. Guarantee and 24 hour service.

1. Guarantee Work of this Section in writing for not less than one (1) year following the date of acceptance by the Owner. If the equipment is used for temporary heat, cooling, etc, prior to acceptance by the Owner, the bid price shall include an extended period of warranty covering the one (1) year of occupancy, starting from the date of acceptance by the Owner. The

2. guarantee shall repair or replace defective materials, equipment, workmanship and installation that develop within this period, promptly and to the Architect's satisfaction and correct damage caused in making necessary repairs and replacements under guarantee within Contract Price.

3. In addition to guarantee requirements of Division 1 and of Subparagraph A above, obtain written equipment and material warranties offered in manufacturer's published data without exclusion or limitation, in Owner's name.

4. Upon receipt of notice from the Owner of failure of any part of the systems or equipment during the warranty period, the affected part or parts shall be replaced by this Contractor without any reimbursement.

5. Replace material and equipment that require excessive service during guarantee period as defined and as directed by Architect.

6. Provide 24 hour service beginning on the date the project is accepted by the Owner, whether or not fully occupied, and lasting until the termination of the guarantee period. Service shall be at no cost to the Owner. Service can be provided by this Contractor or a separate service organization. Choice of service organization shall be subject to Architect and Owner approval. Submit name and a phone number that will be answered on a 24 hour basis each day of the week, for the duration of the service.

7. Submit copies of equipment and material warranties to Architect before final payment.

8. At end of guarantee period, transfer manufacturer's equipment and material warranties still in force to Owner.

9. This paragraph shall not be interpreted to limit Owner's rights under applicable codes and laws and under this Contract.

10. PART 2 paragraphs of this Specification may specify warranty requirements that exceed those of this paragraph. Those paragraphs shall govern.

11. Use of systems provided under this Section for temporary services and facilities shall not constitute Final Acceptance of Work by Owner, and shall not initiate the guarantee period.

12. Provide manufacturer's engineering and technical staff at site to analyze and rectify problems that develop during guarantee period immediately. If problems cannot be rectified immediately to Owner's satisfaction, advise the Architect in writing, describe efforts to rectify situation, and provide analysis of cause of problem. The Architect and/or Engineer will direct course of action.

1.21 OPERATING, INSTRUCTION AND MAINTENANCE MANUALS

A. Obtain at time of purchase of equipment, three copies of operation, lubrication and maintenance manuals for all items. Assemble literature in coordinated manuals with additional information describing combined operation of field-assembled units, including as-built wiring diagrams. The manual shall contain the names and addresses of manufacturers and local representatives who stock or furnish repair parts for items or equipment. Divide manuals into three sections or books as follows:

1. Directions for and sequence of operation of each item of HVAC system, e.g. air handling units and boilers. Sequence shall list valves, switches and other devices used to start, stop and control system. Detail procedure to be followed in case of malfunctions. Include detailed approved flow diagrams of temperature control, heating, refrigerant diagram, etc. as appropriate for systems provided. Include approved valve directory showing each valve number, location of each valve and equipment or fixture controlled by valve.

2. Detailed maintenance and troubleshooting manuals containing data furnished by manufacturer for complete maintenance. Include copy of balancing report.

3. Lubrication instructions detailing type of lubricant, amount and intervals recommended by manufacturer for each item of equipment. Include additional instructions necessary for implementation of first class lubrication program. Include approved summary of lubrication instructions in chart form, where appropriate.

B. Furnish three copies of manuals to the Architect for approval and distribution to the Owner. Deliver manuals no less than 30 days prior to acceptance of equipment to permit the Owner's personnel to become familiar with equipment and operation prior to acceptance.

C. Provide framed and glazed charts as follows: mount as directed by the Architect.

1. Flow diagrams from first part of manual as described above.

2. Valve directory.

3. Lubrication chart from third part of manual.

D. Operating Instructions: Upon completion of installation or when the Owner accepts portions of building and equipment for operational use, instruct the Owner's operating personnel in any or all parts of the various systems. Instructions shall be performed by factory authorized personnel. The Owner shall determine which systems require additional instructions. The duration of instructions shall take equipment

through complete cycle of operation (at least five working days). Make adjustments under operating conditions.

E. Each contractor shall be responsible for his work and equipment until finally inspected, tested and accepted. Carefully store materials and equipment which are not immediately installed after delivery to site. Close open ends of work with temporary covers or plug during construction to prevent entry of obstructing material.

F. Each separate contractor shall protect the work and material of other trades that might be damaged by his work or workmen and make good all damage thus caused.

1.22 QUALITY ASSURANCE

A. The requirements of the State Building Code and Local regulations establish the minimum acceptable quality of workmanship and materials, and all work shall conform thereto unless more stringent requirements are indicated or specified herein.

B. All work shall comply with the latest editions of the codes as referenced herein.

C. Follow manufacturer's directions for articles furnished, in addition to directions shown on Drawings or specified herein.

D. Protect all work, materials, and equipment from damage during process of work. Replace all damaged or defective work, materials and equipment without additional cost to the Owner.

E. All equipment and materials for permanent installation shall be the products of recognized manufacturers and shall be new.

F. Equipment and materials shall:

1. Where normally subject to Underwriters Laboratory Inc. listing or labeling services, be so listed and labeled.

2. Be without blemish or defect.

3. Not be used for temporary purposes.

4. Be in accordance with the latest applicable ASHRAE standards.

G. Purchase products which will meet with the acceptance of all Authorities Having Jurisdiction over the work. Where such acceptance is contingent upon having the products examined, tested and certified by Underwriters or other recognized testing laboratory, the product shall be so examined, tested and certified.

H. Except for plans, all items of equipment or material of one generic type shall be the product of one manufacturer throughout.

I. For items which are to be installed but not purchased as part of the HVAC work, the Mechanical Contractor work shall include:

1. The coordination of their delivery.

2. Their unloading from delivery trucks driven into any point on the property line at grade level.

3. Their safe handling and field storage until the time of permanent placement in the project.

4. The correction of any damage, defacement or corrosion to which they may have been subjected. Replacement, if necessary, shall be coordinated with the Contractor who originally purchased the item.

5. Field erection and internal wiring as necessary for their proper operation.

6. Mounting in place, including the purchase and installation of all dunnage, supporting members, and fastenings, necessary to adapt them to architectural and structural conditions.

J. Items which are to be installed, but not purchased as part of the HVAC work shall be carefully examined upon delivery to the project. Claims that any of these items have been received in such condition that their installation will require procedures beyond the reasonable scope of the HVAC work will be considered only if presented in writing within one (1) week of the date of delivery to the project of the items in question. The mechanical work includes all procedures, regardless of how extensive, necessary to put into satisfactory operation, all items for which no claims have been submitted as outlined above.

1.23 DELIVERY, STORAGE AND HANDLING

A. All materials for the work of this section shall be delivered, stored and handled so as to preclude damage of any nature. Manufactured materials shall be delivered and stored in their original containers, plainly marked with the products' and manufacturer's name. Materials in broken containers or in packages showing watermarks or other evidence of damage shall not be used and shall be removed from the site.

1.24 FIRESTOPPING, SMOKEPROOFING & WATERPROOFING

A. All cutting, patching, firestopping and waterproofing shall be performed by the HVAC Subcontractor. Refer to Section 01 00 00 – CONSOLIDATED GENERAL REQUIREMENTS, 07 00 01 – WATERPROOFING, DAMPPROOFING & CAULKING, AND 07 84 13 PENETRATION FIRESTOPPING for project requirements.

PART 2 – PRODUCTS

2.1 DUCTWORK AND AIR DISTRIBUTION EQUIPMENT

A. Reference Standards:

1. Material, construction and installation shall meet requirements of most recent editions of the following standards and references, except for more stringent requirements specified or shown on the Drawings:

Standard:	As Applicable To:
SMACNA HVAC Duct Construction Standards Metal and Flexible	Sheetmetal Ductwork; Duct Liners; Adhesives; Fasteners; Flexible Ductwork
SMACNA HVAC Air Duct Leakage Test Manual	Duct Leakage Testing
ADC and TIMA Flexible Duct Performance Standards	Flexible Ductwork
NFPA 90A	Fire Dampers; Fire Resistance Standards for Ducts and Liners

B. General:

1. Provide supporting and hanging devices necessary to install the entire HVAC system including ductwork and equipment, and to prevent vibration.

2. Provide vertical and horizontal supports as required by code to meet minimum applicable earthquake resistance standards.

3. Ductwork shall be free from vibration under all conditions of operation. Dimensions shown on the Drawings for lined ductwork are net inside dimensions. Increase ductwork dimensions to accommodate lining requirements.

4. Pipe or conduit crossing duct: No pipe, conduit, hanger, Architectural element nor structural member shall pass through ductwork.

5. When making offsets and transformations necessary to accommodate structural conditions, preserve full cross-sectional area of the ductwork as shown on the Drawings.

6. Ductwork shall have pressure-velocity classifications as follows:

Duct Construction Class	Static Pressure Rating	Pressure	SMACNA Seal Class	SMACNA Leakage Class	Velocity
2”	2”	Pos. or Neg.	B	12	2500 fpm or less
1”	1”	Pos. or Neg.	B	12	2500 fpm or less
1/2”	1/2”	Pos. or Neg.	B	12	2000 fpm or less

   a. For negative pressures over 3” w.g., refer to SMACNA Round and Rectangular Industrial Duct Construction Standards for joint and intermediate reinforcement requirements

   b. Unless otherwise specified or shown on the Drawings, the following pressure classifications shall be used for the types of ductwork listed below:

      1) 2” Class: All ductwork.

7. Sealing requirements for Class B, Leakage Class 12, galvanized, non-welded, aluminum or non-welded stainless steel ductwork:

   a. Transverse Joints:

      1) During assembly seal all flanged transverse joints with sealing tape of quality equal to Hardcast Inc. Model 1902-FR. Corners shall be sealed as described by SMACNA and when applicable per manufacturer’s published procedures.

      2) Seal all non-flanged transverse joints with Hardcast Inc. Versa Grip Model 102 or approved equal.

   b. Longitudinal Seams: Seal all longitudinal seams during ductwork fabrication with Hardcast Inc. Cold Seal Model 1001 or approved equal.

8. Support:

   a. Space hangers as required by SMACNA (8 ft. max.) for horizontal duct on 8 ft. centers, unless concentrated loadings require closer spacing.

   b. Support vertical duct on each floor or slab it penetrates.

   c. Supports for ductwork and equipment shall be galvanized unless specified otherwise.

9. Connections:

   a. Connect inlets and outlets of air handling units and fans to ductwork with flexible connections unless fan has vibration isolator mounts inside unit with flexible connections and no external vibration isolators. Exception: Do not use flex on life safety smoke exhaust fans.

   b. Indoors, flexible connections shall be neoprene-coated fibrous glass fire retardant fabric, by Ventifabrics, or Durodyne. Outdoors, flexible connections shall be DuPont hyplon-coated fibrous glass fire, weather and UV-resistant by Ventifabrics or Durodyne.

   c. Secure flexible connections tightly to air handlers with metal bands. Bands shall be same material

as duct construction.

d. Connections from trunk to branch duct shall be as detailed on Drawings.

10. Construction:
    a. No sharp metal edges shall extend into air streams.
    b. Install drive slips on air-leaving side of duct with sheetmetal screws on 6" centers.
    c. Spin in collars shall NOT be used for branch connections in 3" or higher pressure class ductwork.

11. Joints:
    a. Longitudinal lock seams shall be double-locked and flattened to make tight joints.
    b. Make transverse joints, field connections, collar attachments and flexible connections to ducts and equipment with sheetmetal screws or bolts and nuts. Do not use rivets or staples.

12. Prefabricated Transverse Duct Joints:
    a. Transverse joints in galvanized sheetmetal ductwork may be made with galvanized gasketed frame and angle duct systems by Ductmate, TDF, TDC, or approved equal.

       Angles shall be at least 20 gauge. Prefabricated transverse duct joints shall not be used for duct 16 ga. and heavier, nor for duct 23 ga. and lighter.
    b. Secure angles to duct with screws (using clutched arbor) or spot-welds spaced as recommended by manufacturer for duct pressure class.

13. Elbows and Bends:
    a. Elbows and bends for rectangular ducts shall have centerline radius of 1-1/2 times duct width wherever possible. Elbows for grease exhaust and fume hood exhaust shall be full radius. Vanes or mitered duct are not allowed.
    b. Where centerline radius is less than 1-1/2 times duct width (on supply, return and exhaust ductwork), elbows shall be radius throat (square throat not allowed) with radius heel. For elbows whose width is greater than 48 inches and/or where shown on plans, provide splitter vanes. Install vanes in accordance with SMACNA. Where multiple elbows are separated by less than ten duct diameters use splitter (full length) vanes.
    c. For round ductwork provide stamped elbows, with centerline radii equal to 1-1/2 times duct diameter, or gored elbows as follows:

Elbow Angle	No. of Gores
0° - 36°	2
37° - 72°	3
73° - 90°	5

    d. Elbows for flat oval ducts shall have centerline radii equal to 1-1/2 times duct diameter in plane of bend, or gored elbows with gores as specified for round ducts.

14. Access Panels/Doors:
    a. Provide proper pressure and leakage rated, gasketed, duct mounted access panels/doors for the following items with minimum sizes, as indicated. Access doors shall be of double wall construction. Access doors in insulated ducts shall be insulated. Gauges of door materials, number of hinges, number and type of door locks shall be as required by the SMACNA Duct Construction Standards. Hinged doors are not acceptable, screwed or bolted access panels are not acceptable. Doors shall be chained to frame with a minimum length of 6" to prevent loss of door. For seal Class A, access doors shall be leakage rated, neoprene gasketed UL 94 HF1 listed, DUCTMATE "sandwich" or approved equal. Door metal shall be the same gauge as the attached duct material. For grease and high temperature ducts, door assembly shall be rated for 2300° F. The minimum sizes shall be:
        1) Fire dampers – 12" x 12", or larger.
        2) Combination Fire/Smoke dampers – 12" x 12", or larger.
        3) Smoke dampers – 6" x 6" minimum.
        4) Automatic control dampers – 6" x 6" minimum.
        5) Manual volume dampers 2 sq. ft. and larger – 6" x 6" minimum.
        6) Inlet side to all coils – 12" x 12", or larger.
        7) Suction and discharge sides of inline fans – 24" x 24" minimum
        8) At additional locations indicated on Drawings, or specified elsewhere – 12" x 12" minimum.
        9) Generally access doors are not shown on the Drawings, but shall be provided in accordance with the above.

15. Extractors shall have adjusting rod and locknut on outside of duct.

16. Connections to roof fans:
    a. Shall be at least 22 gauge galvanized steel soldered watertight.
    b. Solder side seams at least 12" up from bottom.
    c. Provide suitable dielectric gaskets to join dissimilar materials.

17. Plenums and Connections to Louvers:
    a. Shall be 18 ga. minimum cross-broken and properly reinforced with galvanized angle irons to SMACNA requirements.
    b. Shall have bottom and corner seams soldered watertight at least 12" up from bottom.
    c. Shall have neoprene gaskets or other non-corrodible material to make connections to louvers watertight.
    d. Shall pitch connection back towards the louver. Provide half-coupling drain connection at bottom of plenum unless noted otherwise. Pipe drain to nearest floor drain.
    e. Shall have unused portions of louvers blocked-off with sheetmetal; sealed air and watertight; insulated with 2" thick 6 lb. Density rigid or board insulation.

18. Duct Pressure Tests:

a. Pressure test ducts after takeoffs and wall penetrations are in place and before applying exterior insulation. Correct any leaks.

b. Pressure and leak test 20% of medium and low-pressure ductwork at 100% of operating system pressure. Duct shall be constructed so there is no joint or structural failure at the test pressure.

19. Materials:

a. Sheetmetal ducts shall be constructed of hot-dipped galvanized sheetmetal with G90 Commercial coating according to ASTM 527 unless specified otherwise.

b. Stainless steel (SS) ductwork shall be 18 gauge for gun cleaning hood and ductwork; and as required by SMACNA for other ducts. Materials shall be 316/No. 4 finish for exposed duct, 304/No. 1 finish for concealed ducts. Joints and seams shall be welded as required by SMACNA Guidelines for Welding Sheetmetal.

c. Aluminum ductwork shall be Alclad 3003-1414 or alloy 552-H32, of thickness required by the SMACNA duct construction standards with Alloy 6061 bracing angles, and Pittsburgh lock longitudinal corner and double-side seaming.

C. 2" and Lower Pressure Class Ductwork – Rectangular:

1. Ducts wider than 19" with more than 10 square feet of unbraced panel shall be beaded or cross-broken.

2. Internal stiffening struts shall only be used upon prior written approval of the Architect.

3. Make changes in duct size with tapered connections as required by SMACNA. Changes shall NOT exceed 30° from line of airflow. Take-off to the diffusers shall be 45° leading edge type or bellmouth type.

4. Transverse joints shall be TDF/TDC or slip joints; use flat or standing seam according to SMACNA. Where the duct size requires a standing seam but space restrictions dictate flat seam, notify Architect prior to fabrication.

D. 2" and Lower Pressure Class Ductwork – Round:

1. Joints:

a. Longitudinal joints shall be spiral seam, butt welded, lap and seam welded, or ACME lock-grooved seam. Snap lock seams shall be used on 1/2" w.g. pressure class duct only.

b. Transverse joints shall be beaded sleeve joint or other approved joints listed in SMACNA. Use three (3) or more sheetmetal screws at 15" uniform intervals along circumference of joints.

2. Branch fittings shall be conical tee (Buckley or equal) or combination tee as shown in SMACNA.

E. Flexible Duct:

1. Flexible ductwork shall be Flexmaster Triple-Lock Buck Duct Flexible Air Duct (insulated or non-insulated) as manufactured by Buckley Associates, ATCO, or equal. Flexible duct, non-insulated, shall be Underwriters Laboratory Listed UL 181 Class 0 air duct and constructed in accordance with NFPA Standards 90A and 90B. It shall have a smoke/flame spread rating of 50/25.

2. The duct shall be made from a tape of dead soft aluminum sheet, spiral wound into a tube and spiral corrugated to provide strength and stability. The joint shall consist of a triple lock mechanically performed without the use of adhesives to make a durable airtight seam. A double lock is not acceptable.

3. Flexible duct connected to insulated or lined duct shall also be insulated. Flexmaster insulated flex shall have a gray Fire Retardant Polyethylene outer jacket with a 1/2 lb. density, 1-1/2" thick fiberglass insulation blanket, factory wrapped providing a thermal performance of R-8 overall. Flexible Duct, insulated, shall be Underwriters Laboratory

4. listed and constructed in accordance with NFPA Standards 90A and 90B. It shall have a smoke/flame spread rating of 50/25.

5. The flexible duct shall be supported as required.

6. Flexible ductwork shall be rated at 12" positive pressure. Flexible ductwork from 3" to 16" in diameter shall have a negative pressure rating of 12". Flexible ductwork 18" to 20" in diameter shall have a negative pressure rating of 8".

7. All flexible ductwork shall be individually boxed and labeled for delivery to the jobsite for maximum protection.

8. Submittals shall include data on minimum thickness of aluminum core, in addition to other data listed above required to ensure that submitted product meets the requirements of these Specifications.

9. Provide sealing compound for installation. See further paragraphs in this Specification and details for other installation requirements.

10. Flexible duct length shall not exceed 5'-0" in length.

F. Fire Dampers:

1. Provide fire dampers throughout the air distribution system(s) as required by applicable codes, standards and Authorities. Provide an access door for each fire damper of sufficient size to repair the internal fusible link (see access panel/door section). Fire dampers indicated on the Drawings may not fully represent the exact number required for this project. It is the Contractor's responsibility, at no additional cost to the Owner, to provide all required dampers.

2. Fire dampers shall be the fusible link spring loaded type. Where in ductwork served by fans which shut off during a fire alarm condition, dampers shall be the static type, similar to Greenheck Model FD series. Where in ductwork served by fans which do not shut off during a fire alarm condition, dampers shall be the dynamic type, similar to Greenheck Model DFD series.

3. Fire damper frames shall be fitted with angle iron stop and stainless steel spring latch, and shall be securely fastened to building construction.

4. Seal spaces between damper frames and walls and between damper frames and floor with approved fire-retardant material.

5. The use of fire dampers shall NOT reduce net free area of duct below that shown on Drawings. Fire

dampers shall be Type B with the blades of the fire dampers out of the air stream.

6. Samples of fire dampers shall be submitted to and approved by Local Authorities Having Jurisdiction.

7. Dampers shall bear 1-1/2 hour UL-rating fire damper label and shall be constructed and installed as required by UL-555.

8. Fire dampers shall be Buckley, Greenheck, Ruskin, Nailor Industries, Pottorff or Prefco for use in the proper duct pressure classification.

9. Dampers shall be installed per SMACNA with breakaway connections and nose pieces on duct liner (see SMACNA HVAC Duct Construction Standards).

G. Ceiling Radiation Dampers and Fire-Rated Blankets: For fire-rated ceiling assemblies, provide at all ceiling diffusers, registers and grilles: Radiation dampers (Nailor Industries Series 0700 or approved equal) and Fire Blanket (Nailor Industries 0725 or approved equal) or fire assembly: radiation damper and blanket already assembled Nailor or equal.

H. Combination Fire/Smoke Dampers:

1. Provide and install combination fire and smoke dampers as required and as indicated on the drawings. As related work of this section, see also Electrical Specifications fire alarm system sequence of operations. Devices shall be FSD series as manufactured by Greenheck, Pottorff, or another approved equal.

2. Dampers shall have a UL 555 fire resistance rating of 1-1/2 hours when intended installation is in less than 3-hour rated fire-resistant assemblies. Rating shall be 3 hours when intended installation is in 3-hour or greater rated fire-resistant assemblies.

3. Fire closure temperature: Each combination fire smoke damper shall be equipped with a factory installed heat responsive device rated to close the damper when the temperature at the damper reaches 250°F.

4. Dampers shall have a UL 555S approved elevated temperature rating of 250°F minimum.

5. Dampers shall have a UL 555S Class II leakage class rating minimum and a differential pressure rating of 4 in. wg. Damper velocity rating shall be 2000 feet/min. minimum.

6. Frame construction: shall be 16 gauge galvanized steel formed into a 5 in. by 1 in. structural hat channel. Frames shall be 4-piece construction with 1-1/2 in. minimum integral overlapping gusset reinforcements in each corner.

7. Blade construction: shall be 16 gauge galvanized steel strengthened by three longitudinal 1 in. deep V-grooves running the entire length of each blade. Each blade shall be symmetrical relative to its axle pivot point for identical performance characteristics with air flowing in either direction through the damper.

8. Blade edge seals shall be extruded silicon rubber permanently bonded to the blade edges. Jambs shall be flexible stainless steel compression type.

9. Linkages shall be concealed in the jamb.

10. Axles shall be minimum 1/2 in. diameter plated steel. Frames shall be galvanized steel in the gauge required by manufacturer's UL listing.

11. Dampers shall be supplied as single assembly with an integral factory sleeve.

12. Dampers shall be supplied with factory retaining angles sized to provide installation overlap in accordance with the manufacturer's UL listing.

13. Axle bearing shall be sintered bronze sleeve type rotating in polished extruded holes in the damper frame.

14. Damper actuators shall be externally mounted 120 VAC,, two-position, fail closed.

15. Dampers shall be installed in accordance with the manufacturer's UL installation instructions, labeling and NFPA 90A at the locations indicated on the drawings. All damper installations not in accordance with the manufacturer's UL installation instructions must be approved prior to installation.

16. Dampers must be accessible to allow inspection, adjustment, and replacement of components. General Contractor shall furnish any access doors required in walls, ceilings, or other general building construction. Access points shall not affect the integrity of the fire-resistance rated assemblies nor reduce the actual fire resistance rating of the assembly. Access points shall be permanently identified on the exterior by a label having letters not less than 1/2 in. high reading "FIRE/SMOKE DAMPER".

17. Coordination with Electrical:

    a. Where combination fire/smoke dampers are installed in ducts, an approved smoke detector shall be installed in the same duct within 5 feet of the damper with no air outlets or inlets between the detector and damper. Detectors shall be listed for the air velocity, temperature and humidity anticipated at the point where it is installed.

I. Volume Dampers:

1. Provide manually adjustable rectangular parallel blade dampers for duct heights less than 12" with factory-installed locking hand quadrants extended 2" for all dampers installed in externally insulated duct:

    a. On each supply, return and general duct take-off.

    b. At each take-off to register, grille or diffuser (not all are shown on Drawings for clarity).

2. Volume dampers shall be manufactured approximately 5/16" smaller in width and 1/8" smaller in height than size of duct in which they are installed; e.g., nominal damper size is 24" x 10"; actual size is approximately 23-11/16" x 9-7/8".

3. Volume damper frames shall be constructed of #6063 extruded aluminum reinforced channel with minimum thickness of 0.050". Opposed damper blades shall be #6063 extruded aluminum with minimum thickness of 0.050" and shall include reinforcing ribs. Each blade shall be supported in the damper frame by individual Teflon axle bearings, and shall be driven by stainless steel connecting slide linkage controlled by 3/8" square steel control shaft.

4. All required volume dampers may not be indicated on Drawings, but volume dampers shall be provided as necessary for systems balancing.

5. Dampers 12” and larger in height shall be opposed multi-blade type.

6. Where volume dampers are inaccessible, use locking type ceiling regulators and miter gear or worm gear for all horizontal dampers. Bearing coupling for bottom duct control may be used for shaft on vertical blade dampers. The 3/8” rod between ceiling regulator and damper shall be provided by Contractor.

7. Damper blades shall be two gauges heavier than adjoining ductwork, and shall be riveted to supporting rods. Hem over edges parallel to rods.

8. Brackets shall be galvanized metal, secured to ductwork with sheetmetal screw with locking quadrant arms (see Seal Class Section for additional requirements). Provide 2” handle extension for all dampers on externally insulated ductwork.

9. Note: All required volume dampers may not be indicated on Drawings but dampers shall be provided as necessary for system balancing.

J. Remote Control Operated Balancing Dampers:

1. Round remote control operated balancing dampers applicable for use in HVAC systems with velocities to 2,600 fpm by United Enertech model i-3, Young Regulators or equal as approved by engineer.

2. Submit manufacturer’s product data including performance data.
   a. Include differential pressure ratings and maximum system velocity.
   b. Indicate materials, dimensions, construction, and installation details.
   c. Include damper pressure drop data based on procedures performed in accordance with AMCA 500-D.

3. Ratings:
   a. Temperature Rating 35°F to 120°F (2°C to 49°C)
   b. Maximum Velocity: 2600 fpm (13.2 m/s)
   c. Maximum Differential Pressure Rating: 3" w.g.

4. Construction:
   a. Frame: Min. 24 ga. galvanized steel, 8" deep
   b. Blade: Round, minimum 24 ga. galvanized steel, mechanically fastened to blade
   c. Axels: Zinc Plated Steel Pins
   d. Bearings: Nylon 6/6 Molded synthetic
   e. Mounting: Vertical and/or Horizontal
   f. Actuator: DC voltage, Direct Drive, Electronic pulse
   g. Remote: Portable hand held power pack with RJ-11 cable

h. Finish: Mill Galvanized

5. Accessories and Options (Engineer to select and edit as required)
   a. Custom RJ-11 cable length: 120 inches.
   b. Aluminum construction
   c. Stainless Steel construction
   d. Oval damper in lieu of round
   e. Choice of RJ-11 cable terminal points: J50, J100, or J150
6. Installation
   a. Install dampers at locations indicated n the drawings and in accordance with manufacturer's instructions.
   b. Install dampers round and free from racking. Do not stretch or compress damper frame or sleeve into the opening or duct.
   c. Handle dampers using the sleeve or frame. Do not move or lift the damper by the blades, cable, or actuator
   d. Install remote options (if applicable) of Model J50, J100, or J150 Terminal points.
   e. Connect RJ-11 cable from the damper to the female outlet, making sure cable is secured and cannot be pulled out of the terminal.
   f. Coordinate power requirements with electrician.

K. Automatic Dampers: Install automatic dampers furnished under Automatic Temperature Control Paragraph of this Section, as shown on Drawings, and as specified. Provide sealed wall penetrations for Seal Class A ductwork.

L. Diffusers, Registers and Grilles:

1. Provide diffusers, registers and grilles for supply, return and exhaust outlets, of size, type and design shown on Drawings. Acceptable manufacturers shall be, Price, Metal-Aire, or Titus. Refer to Drawing schedules for additional requirements.
2. Equipment shall be tested and rated per ASHRAE 91-70.
3. Equipment shall handle air quantities at operating velocities:
   a. With maximum diffusion within space supplied or exhausted.
   b. Without objectionable air movement as determined by Architect.
   c. With sound pressure level not to exceed NC 30.
4. Supply registers shall have two (2) sets of directional control blades.
5. Diffusers within same room or area shall be of same type and style to provide Architectural uniformity.
6. Diffusers, registers and grilles shall be furnished with gaskets and installed with faces set level and

plumb, tightly against mounting surface.

7. All finishes shall be as directed by the Architect.

8. Coordinate diffusers, registers and grilles with ceiling and wall construction. Refer to Architectural Drawings for exact lengths and for framing and mitering arrangements that may differ from those shown on Mechanical Drawings.

M. Branch Duct Take-off Fittings:

1. Contractor shall provide bellmouth take-offs at all branch duct locations.

2. Bellmouth fitting shall be provided with damper.

3. Bellmouths shall be constructed of heavy-duty galvanized steel. Bellmouths shall include an airtight neoprene gasket to ensure a tight fitting with minimal leakage. Pre-drilled holes shall be provided for quick mounting.

4. Standard damper hardware to be constructed of 26-gauge galvanized material with a quadrant damper and tight-fitting gasketing to ensure minimal leakage at damper pivot points.

5. Optional heavy-duty hardware shall be provided at locations of higher static pressure where shown on the Drawings.

6. Ninety-degree (90°) take-offs are not permitted on this project.

2.2 ACOUSTICAL DUCT LINING

A. Provide 2” thick acoustical lining by Certain-teed, Knauf, Owens Corning or Manville for following ductwork:

1. Supply and return ductwork, including plenums for minimum of 20 feet from dedicated outdoor air unit. Supply and return main duct from air handlers shall be lined.

2. Other ductwork indicated as lined on Drawings.

3. Increase duct dimensions to accommodate lining while maintaining inside clear dimensions shown on the Drawings.

4. Lining shall be as follows:

Lining for	Material	Minimum NRC	Maximum K-Factor At 75° F Mean
Low-pressure ductwork (below 4" S.P.)	Black, Matfaced, 2 lb. density, flexible glass	0.75	0.24
Medium and high-pressure ductwork (above 4" S.P.)	Black, Matfaced, 3 lb. density, rigid board	0.75	0.23

5. Materials and installation shall meet following standards, as applicable:
   a. NFPA-90A, UL723, NFPA-255.
   b. SMACNA Duct Liner Applications Standard.
   c. SMACNA Mechanical Fasteners Standard.
   d. Adhesive and Sealant Council: Adhesives Standard for Duct Liner – ASC-A-7001A
   e. ASTM E-84 fire hazard classifications of 25 flame spread, 50 smoke developed and 50 fuel contributed.

6. Duct liner shall be installed without interruptions or gaps, using 100% coverage of adhesive and mechanical fasteners. Mechanical fasteners shall be welded or secured mechanically to duct on 12" maximum centers.

7. Cut liner to ensure overlapped and compressed longitudinal joints at corners. Transverse joints in liner shall abut precisely. Seal joints against fiber entrainment with approved adhesive, as recommended by manufacturer. Use sheetmetal nosing at beginning of lining (in direction of flow) to prevent erosion.

8. The Contractor shall ensure the integrity of acoustical lining when slip-in duct heaters are installed; loose lining shall not flap about in the airstream. Secure edges of lining with sheetmetal nosing, where liner is interrupted to make room for slip in heaters.

9. Submit samples and catalog data for duct liner, mechanical fasteners and adhesives to Architect for approval.

10. Friction coefficient correction factor at 1000 FPM shall be no greater than 1.1. Liner shall be Certain-teed Ultra Liner, Knauf Duct Liner M or Johns Manville Linacoustic. Other liners from these manufacturers with friction coefficient correction factors greater than listed above, are not acceptable.

11. Mylar used for vapor barrier shall meet ASTM E-84 classification.

12. Any cut liner due to duct take-offs and branches shall be totally sealed at edges (with sheetmetal nose pieces) to prevent entrainment of loose fibers.

13. Do not insulate lined duct.

B. Acoustical Duct Wrap:

1. Where designated with specific notation on drawings, or as otherwise specified, provide acoustical duct wrap for noise control. Duct wrap shall be Sound Seal B10 Series, B-10 LAG/QFA-3 or equal.

2. Wrap shall be composite material with flexible one-pound per square foot reinforced-foil faced loaded vinyl noise barrier bonded to a 1-inch thick quilted fiberglass sound absorber.
   a. Nominal thickness: 1 inch.
   b. Standard width: 54 inches.
   c. Roll length: 30 ft.
   d. Weight: 1.2 lb / sqft.
   e. Temperature range: -20°F to +220°F.
   f. "R" factor: 4.0.
   g. Flammability: Class A (or 1) per ASTM E-84, Smoke Density index 19.5, Flame spread index 12.5.

3. Acoustical Performance:
   a. Sound transmission loss:

	OCTAVE BAND FREQUENCIES (Hz)						
Product	**125**	**250**	**500**	**1000**	**2000**	**4000**	**STC**
B-10 Lag/QFA-3	18	18	23	30	39	46	29

4. Where acoustical duct wrap is used o portions of the ductwork, it shall replace standard insulation use per "Duct Insulation" section below.

5. Seal all seams to provide a continuous sound and vapor barrier.

2.3 DUCT INSULATION

A. General:

1. Insulation shall be Certain-Teed, Knauf, Manville or Owens Corning. Install insulation, mastics, adhesives, coatings, covers, weather-protection and other work exactly as required by manufacturer's recommendations. Materials shall meet requirements of Adhesive and Sealant Council Standards and SMACNA.

2. Apply insulation after systems have been tested, proved tight and approved by Architect. Remove dirt, scale, oil, rust and other foreign matter prior to installation of insulation.

3. Leaks in vapor barrier or voids in insulation will not be accepted.

4. ASTM E-84 minimum fire hazard ratings shall be 25 flame-spread, 50 fuel contributed and 50 smoke developed.

5. Where ducts are insulated, flexible connections to ducts shall be insulated.

6. Insulate standing seams with same material and thickness as duct.

7. Acoustically lined ductwork shall not be insulated externally, except as noted otherwise.

8. Return ductwork in ceiling plenums shall not be insulated.

9. Insulation shall be continuous through wall and ceiling openings and in sleeves.

10. Transmission rates of vapor barriers shall not exceed 0.02 perms.

B. Concealed Rectangular, Flat Oval and Circular Ductwork:

1. Insulate supply and return air ductwork and plena in concealed spaces and return ductwork not in ceiling plenum with glass duct wrap; with foil-Kraft flame-resistant vapor barrier.

2. Insulation shall provide a minimum R-8 value when located in unconditioned spaces and a minimum R-12 value when located outside the building.

3. If insulation does not have pre-cut lap, make lapped butt joints by cutting 2” strip of insulation away from vapor barrier. Apply 6” strips of approved adhesive on 16” centers and wrap duct with insulation. Staple lapped joint with outward-clinching staples. Seal stapled joints airtight with approved matching pressure-sensitive tape.

4. For rectangular duct 24” or larger in any dimension, augment application method specified in item 3 with approved mechanical fasteners, such as weld pins with speed washers, on 18” centers on bottom of duct.

5. Cover breaks in vapor material with patches of same material, secured with adhesive and staples. Seal staples with approved pressure sensitive tape.

6. Fill voids in insulation at jacket penetrations and seal with pressure sensitive tape.

7. Seal and flash terminations and punctures with fibrous glass cloth between two (2) coats of pressure sensitive tape.

8. Terminate vapor barrier and extend insulation at standoff brackets.

C. Outdoor Duct Insulation and Waterproofing

1. Provide flexible unicellular elastomeric foam rubber sheet insulation by Armstrong (Armaflex), Manville, Owens Corning of Halstead-Nomaco (Insultube), with maximum K-factor of 0.27. Install as recommended by manufacturer.

2. Insulate standing seams with same thickness as duct.

3. Adhere insulation to duct and seal butt joints with full coverage of Armstrong 520 or approved pressure sensitive tape.

4. Insulation shall have an R-value of 6.0 per inch at 75 degrees f per ASTM c1289. Minimum outdoor

duct insulation R-value shall be 12.

5. Impale insulation on mechanical fasteners applied to duct surface on 12" centers. Use at least two (2) rows of fasteners on each side of duct. Provide fastener rows within 3" of seams and edges. Secure insulation with suitable speed washers or clips firmly embedded in insulation. Provide additional fasteners as necessary on cross-broken ducts.

6. Extend insulation to standing seams, reinforcing and other vertical projections 1" and less; do not carry over. Vapor barrier jacket shall be continuous across seams, reinforcing and projections. Insulation and jacket shall be carried over projections that exceed insulation thickness.

7. Transverse joints shall be butted tightly. Longitudinal joints shall be butted, ship-lapped or 45 mitered. Seal joints with 4" wide strips of approved vapor barrier patch material and adhesive, or with approved pressure sensitive vapor barrier tape.

8. Cover breaks, ribs and standing seam penetrations with patch of jacket material no less than 2" beyond break; secure with adhesive and staple. Seal staples and joints with approved pressure sensitive tape.

9. Fill voids in insulation at jacket penetrations and seal with approved pressure sensitive tape.

10. Seal and flash-terminations and punctures with fibrous glass cloth between two (2) coats of approved pressure sensitive tape.

11. Terminate vapor barrier and extend insulation at standoff brackets.

12. Seal weather tight with 3m Ventureclad system product number 1579 GCW or engineer approved equal.

2.4 DUCT SILENCERS

A. General:

1. Provide duct sound attenuators as manufactured by Kinetics Noise Control or approved equal. As a condition of approval, alternate manufacturers shall submit to the project engineer silencer test reports for a silencer tested in accordance with ASTM E477-13 in a test facility that is NVLAP-accredited for ASTM E477-13.

B. Performance Requirements:

1. The silencer manufacturer shall provide, for approval, acoustical system path calculations for all duct systems with silencers to demonstrate the submitted silencers will reduce mechanical fan noise to required NC-Levels in the occupied space. Use sound power levels of actual equipment to be installed on project. Analysis shall include breakout noise calculations.

2. Supplier shall include system effect pressure loss of the installed silencer based on duct conditions upstream and downstream of the silencer to ensure required airflow is provided. Supplier shall submit detailed pressure drop analysis for the installation and detailed procedure outlining methodology for site measurement of overall system pressure loss for approval prior to manufacture.

3. Maintain rooms NC level as defined in the ASHRAE Handbook-HVAC Applications.

4. Source quality-control reports:
    a. Silencer manufacturer to provide a copy of their laboratory NVLAP accreditation certificate for the ASTM E-477-06a test standard with the submittals. Data from non-NVLAP accredited test facilities will not be accepted.

5. The pressure loss of silencers shall not exceed those scheduled at the specified design flow rates. Airflow measurements shall be made in accordance with ASTM specification E-477 and applicable portions of ASME, AMCA, and ADC airflow test codes.

C. Construction:

1. Description: Duct section with solid, sheet metal outer casing, sound absorbing fill material, and inner splitter (baffle) of perforated sheet metal; incorporating interior splitter, baffles of similar construction. Fabricate in accordance with SMACNA HVAC Duct Construction Standards. Silencers shall include double retainers between each splitter (baffle).

2. Silencer manufacturer to provide submittal drawings detailing all duct silencer data specified in the mechanical drawing schedule.

3. General Requirements:
    a. Silencers shall be of the size, configuration, capacity, and acoustic performance as scheduled on the drawings. All silencers shall be factory fabricated and supplied by the same manufacturer.
    b. Silencer inlet and outlet connection dimensions must be equal to the duct sizes shown on the drawings. Duct transitions at silencers are not permitted unless shown on the contract drawings.
    c. Silencers shall be constructed in accordance with ASHRAE and SMACNA standards for the pressure and velocity classification specified for the air distribution system in which it is installed. Material gauges noted in other sections are minimums. Material gauges shall be increased as required for the system pressure and velocity classification. The silencers shall not fail structurally when subjected to a differential air pressure of 8 inches water gauge.
    d. All casing seams and joints shall be lock-formed, lock-formed and sealed, or stitch welded and sealed as noted on schedule. Airtight construction shall be achieved by use of a duct-sealing compound supplied and installed by the contractor at the jobsite.
    e. All perforated steel shall be adequately stiffened to insure flatness and form. All spot welds shall be located on maximum, 3-inch, spacing and factory protected with a corrosion resistant (zinc rich) coating.
    f. Fire-Performance Characteristics: Silencer assemblies, including acoustic media fill, film liner, sealants, and acoustical spacer, shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84, NFPA 255 or UL 723.
    g. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.

4. Rectangular Silencers as Scheduled shall be ASTM A 653/A 653m, G90 galvanized sheet steel, 22 gauge, unless otherwise noted on drawings or silencer schedule. All acoustical splitters (baffles) shall be internally radiused and aerodynamically designed for efficient turning of the air. Half and full splitters (baffles) are required as necessary to achieve the scheduled insertion loss. All elbow silencers with a turning cross-section dimension greater than 48” shall have at least two half splitters and one full

splitter. Silencers shall include double retainers between each splitter (baffle).

5. Transitional Silencers as Scheduled, Outer casing shall be ASTM A 653/A 653M, G90 galvanized sheet steel, 22 gauge, unless otherwise noted on drawings or silencer schedule. Transitioning shall occur internal to the silencer such that the height of the gap or air passage is uniformly changing with the length of the splitters (baffles).

6. Inner perforated metal liner: ASTM A 653/A 653M, G90 galvanized sheet steel.
   a. Rectangular Straight Silencers: 22 gauge.
   b. Rectangular Elbow Silencers: 22 gauge.
   c. Transitional Silencers: 22 gauge.
   d. Round Silencers: 22 gauge.

7. Principal Sound-Absorbing Mechanism
   a. Dissipative and Film Lined/Encapsulated Silencers
      1) Media shall be of acoustic quality, shot-free glass fiber insulation with fibers bonded with a thermosetting resin. Glass fiber density and compression shall be as required to insure conformance with laboratory test data. Glass fiber shall be packed with a minimum of 10% compression during silencer assembly. Media shall be resilient such that it will not crumble or break and conform to irregular surfaces. Media shall not cause or accelerate corrosion of aluminum or steel. Mineral wool will not be permitted as a substitute for glass fiber.
      2) Where indicated on the silencer schedule, media shall be lined/encapsulated in glass fiber cloth to help prevent shedding, erosion, and impregnation of the glass fiber
      3) The acoustic media shall be lined/encapsulated with polymer film (Tedlar) to help prevent shedding, erosion, and impregnation. The film shall be separated from the perforated metal by a factory-installed acoustically transparent spacer.
      4) The spacer shall be flame retardant and erosion resistant.
      5) Mesh, screen or corrugated perforated liner will not be acceptable as a substitute for the specified spacer.

8. Alternative Silencer Materials
   a. Where indicated on the drawing or silencer schedule. Type 304 or 316 stainless steel or aluminum 3003 H14 material can be used.

9. HTL Casing
   a. Where indicated on the silencer schedule, silencers shall have high transmission loss (HTL) outer casing to assure quality-controlled transmission loss. If requested by the Engineer, breakout noise calculations for each air handling and fan system shall be provided with the silencer submittal to ensure compliance with the room noise criteria. Breakout noise calculations shall be based on the sound power levels of the specified equipment.

D. Installation of Silencers:

1. Provide silencers where shown. Ensure that silencers are installed with airflow directional arrows in the

direction of airflow.

2. Support each silencer independent of connecting ductwork.

3. Properly layout ductwork for silencer locations to provide a minimum of five diameters of straight duct upstream of the silencer and ten diameters of straight duct downstream of the silencer.

4. Unless otherwise shown, do not install silencers in walls or slabs.

5. Where crosstalk silencers penetrate partition walls, seal the joint between the perimeter of the silencer and the wall, on both sides of the wall, with proper acoustic caulking.

6. Seal all silencer connections to ducts with proper fire/smoke rated duct sealer.

7. When silencer installations are complete, arrange and pay for the silencer manufacturer to examine the silencer installations. Do any corrective work required by the manufacturer, then obtain from the manufacturer and submit a signed letter certifying proper installation and operation of all silencers. Refer to the article entitled Equipment and System Manufacturer's Certification in the Mechanical Work General Instructions Section.

2.5 PIPING AND FITTINGS

A. General: Pipe materials and fitting materials shall be as indicated in Schedule of Pipe and Fitting Materials.

B. Schedule of Pipe and Pipe Fitting Materials:

Service	Systems Description	Pipe Size	Pipe Material	Joints	Fitting Material	Fitting Rating PSI/Class/ Weight
Hot Water	HWS/R	2" and under	Copper, B88, Type L	Soldered 95/5 Tin/ Antimony or Press	Wrought copper, B16.22	Class 150
Condensate Drain	CD	All	PVC. Schedule 40 Note 2	Solvent Welded	PVC, Schedule 40	Class 150
Refrigerant	R	All	Copper, ACR	Silver Brazed	Wrought Copper	200 PSI
Vents	V	All	Gal. St. A53 or A120, Smls or ERW, Schedule 40	Threaded	Gal. Malleable Iron, B16.3	Class 150

Note 1: Grooved piping systems may be used in lieu of welded piping for CHWS/R and CWS/R, HWS/R systems for sized 2-1/2" and over subject to the requirements listed in the Grooved Piping Section and in PART 4 of the Specification.

C. Connections:

1. Provide dielectric fittings at connections of dissimilar materials.

2. Provide eccentric reducing couplings to bring pipes flush on top for water service and flush on bottom for steam service.

3. Branch lines in welded piping shall be made with welding tees except that branch lines less than one half diameter of main may be made with Weld-O-Lets or Sock-O-Lets.

4. Nipples shall be same material, make and thickness as pipe with which they are used. Close nipples shall not be used.

5. Make piping connections 2-1/2" diameter and larger to valves and equipment with welding neck flanges, ANSI B16.5, pressure rating to match system, flat or raised face as required.

6. Make piping connections 2" diameter and smaller to valves and equipment with steel body, 300 psi brass seat unions on steel piping and with heavy semi-finished brass unions on copper tubing.

7. Fit flanged joints with Johns-Manville or approved equal full-face gaskets. Flanges shall be faced and drilled to ASA standards and fitted with semi-finished hexagon machine bolts and nuts of proper number and size.

8. Make screw joints tight with Teflon (polytetrafluoroethylene) tape or litharge-glycerin mixture applied to male threads. Use tapered threads.

9. Make fusion welded joints as required by ANSI B31.1. Make changes in direction of pipe with welded fittings only. Bevel connections before welding, mechanically or by flame cutting.

2.6 CHEMICAL TREATMENT – WATER SYSTEMS

A. Provide treatment systems and service for primary water systems. Do not operate systems without water treatment. Water treatment chemicals shall be by Barclay, Dearborn, Olin or Mogul. Pump and chemical drums shall be by the manufacturers of the chemicals or Liquid Metronics. Dearborn and Liquid Metronics model numbers are used to establish standards of quality.

B. Provide piping necessary for complete systems.

C. Water treatment shall include feeding devices necessary to feed chemical solution into piping system and bring chemical properties of water to within manufacturer's recommended operating limits, in order to minimize corrosion and reduce buildup of slime or other contaminants.

D. Furnish and install a coupon rack capable of accepting six (6) coupons in each chemically treated system. The Chemical Treatment Contractor shall make recommendations as to the use of coupons and shall include the furnishing and analysis of the coupons/system (steel and copper) each month.

E. The closed loop systems (chilled water and heating hot water) shall have water treatment consisting of Dearborn Model Type AV By-Pass Shot Feeder, to feed chemical solution into each piping system. Chemicals shall be Dearborn B-524 (Nitride Corrosion Inhibitor) to maintain control limits at 800-1,000 parts per million of sodium nitrite). A 2 gallon shot-feeder shall be provided.

F. Water treatment for open condenser water system shall consist of:

1. Equipment:
   a. Provide one (1) Hydac Modu-Max Control System, or equal by Uniloc, Lakewood or Great Lakes consisting of:
      1) Control box enclosure, NEMA 12 cabinet, 20 amperes 115V with internal circuit breakers.
      2) PH-TDS Conductivity Monitor and Control Module.
      3) Flow-through type probe assembly with flow control shutoff; pressurized, pre-piped and mounted.
      4) Digital display and readout for conductivity and PH controller.
      5) Electric contacting water meter.
      6) Water meter totalizer.
      7) Solenoid bleed valve, suitable for outdoor environment.
      8) Counter timer control module for inhibitor feed.
      9) Biocide programmable module – dual pumps.
   b. Water meter and solenoid bleed valve shall be sizes as follows:

System Capacity	Solenoid Bleed Valve Size	Water Meter Size	Water Meter Gallons Per Contact
Less than 400 tons	3/4"	3/4"	10
401 – 900 tons	3/4"	1”	50
901- 1,500 tons	1”	1-1/2”	100
1,501 – 3,000 tons	1-1/2”	2”	100

   c. Provide three (3) chemical metering pumps as follows:
      1) System size under 900 tons: Liquid Metronics AISI-191S, 24 gpd, 110 psi.
      2) System size above 900 tons: Liquid Metronics B111-95S, 30 gpd, 150 psi.
      3) If local water conditions warrant, provide an additional caustic or acid pump, of capacities listed above.

2. Chemical:
   a. Provide Dearborn C-381 cooling water inhibitor maintaining control limits of 100-125 parts per million and pH of 8.0 to 8.5.

b. Provide Dearborn A-100 and A-111 algaecides or provided equal.

G. Flush and clean all systems with Dearborn BC-45 cleaner after completion of installation. After cleaning, add Dearborn B-524 nitrite inhibitor to closed loop systems, control nitrite strength to 800-1,800 ppm maximum. Submit written report indicating that systems have been thoroughly cleaned and charged with corrosion inhibitor.

H. Effluent from HVAC system discharged to sewer shall meet requirements of applicable Local, State, and National Water Quality Standards.

I. One (1) year service shall include, but not be limited to, the following:

1. Delivery and maintenance of water treatment chemicals for one (1) year.

2. Collection and analysis of samples of circulating water every 30 days for one (1) year, and adjustments to the rate of chemical feed to suit each system.

3. Inspection and maintenance of chemical feeding devices for one (1) year. Inspection and maintenance should be performed at minimum intervals of every 30 days.

4. Water tests according to project requirements.

J. The Mechanical Contractor shall provide the steel support shelf for the chemical feed pumps.

K. Electrical Wiring and Controls Interlocking: Provide all necessary interlocking between solenoid bleed valve and respective conductivity controller. Provide power wiring for solenoid valves, pumps and controller.

L. Closed loop systems with glycol shall be filled to a 35% concentration of propylene glycol/water solution. An extra 55 gallon drum shall be provided to the Owner.

2.7 VALVES AND STRAINERS

A. Valves on hot water services shall be 125 psi unless noted otherwise. Pressure ratings of valves for steam and condensate services shall be as specified. Provide balancing valves where shown on Drawings.

B. Valves shall have name of manufacturer and guaranteed working pressure cast or stamped on bodies. Valves of similar type shall be by single manufacturer.

C. Provide bronze-body ball valves with reinforced Teflon seats, seals, bearings and packing. Ball valves shall be used for hot water services in sizes 2” and smaller. Do not use ball valves for balancing service. Valves on insulated piping shall have 2” extended stems. Valves shall be as manufactured by Apollo, Cannon, Nibco, Milwaukee or Watts. Valves shall be rated 600 psi W.O.G.

D. Check valves 2” and smaller shall be bronze, screwed ends, swing pattern. Check valves for hot water pump discharge shall be spring loaded, silent check, as manufactured by APCO, Milwaukee, Mueller or Stockham.

E. Relief valves shall be brass with external lever, ASME-approved. Pipe discharge to floor drain with open connection at floor. Pipe chiller refrigerant relief devices through roof to atmosphere.

F. Strainers:

1. Strainers 2” and smaller shall be 250 lb. bronze body, stainless steel, screen with 20 mesh screen opening, Y-pattern, screwed ends, as manufactured by Sarco Type BT, Mueller, Watts or Armstrong.

2. Provide blow-off valve on each strainer.

3. Pump suction strainers 2” and smaller shall have a 0.062 screen opening.

4. Strainer gaskets shall not contain asbestos.

G. Provide threaded vacuum breakers with ball, spring, O-ring flexible seat and screen. Ball shall be 440 stainless steel; seat shall be EPR. Spring shall be 316 stainless steel, screen and cap shall be 304 stainless steel and threaded collar shall be 416 stainless steel. Body shall be brass. Vacuum breakers shall be as manufactured by Johnson Series VB8 size 1-1/4 IPS, or equivalent by Watts or ITT Hoffman.

H. Provide unions for threaded end valves to facilitate removal from pipe.

I. Automatic Flow Control Valves:

1. Provide automatic pressure compensating flow control valves by Griswold, or Auto-flow where indicated on the Drawings. Valves shall have the capacities and pressure differential characteristics, as indicated, and conform to the following Specifications. Valves 2” and smaller shall be threaded bronze.

2. Valves shall be factory set and shall automatically limit the rate of flow to required engineered capacity within + 5% accuracy over an operating pressure differential of at least 14 times the minimum required for control.

3. The control mechanism of the valve shall consist of self-contained, open-chamber cartridge assembly with unobstructed flow passages that eliminate accumulation of particles and debris. All internal working parts shall be stainless steel or nickel-plated brass. Body shall be ductile iron, cast iron, or bronze.

4. The cartridge assembly shall consist of a spring-loaded cup. The cup shall utilize the full available differential pressure across the valve to actuate the cup and, thereby, reduce friction and hysteresis and eliminate binding.

5. Valves shall be available in minimum of three (3) pressure differential ranges, with the minimum range requiring less than 2 psig to control flow. Valve bodies shall be provided with inlet and outlet tapings suitable for connection of instruments for verification of flow rates and temperature and shall be marked to show direction of flow. Valve bodies shall be rated for use at not less than 150% of system designed operating pressures.

6. Certified performance data for the flow control valve, based on independent laboratory tests, supervised and witnessed by a registered Professional Engineer, shall be available.

7. All flow control valves shall be supplied by a single source responsibility.

8. Each automatic flow control valve shall be furnished with a valve kit consisting of 1/4" x 2” minimum

size nipples, quick-disconnect valves (to be located outside of insulation), and fittings suitable for use with the measuring instruments specified, as well as temperature.

9. Provide a metal identification tag, with chain, for each installed valve. The tag to be marked with zone identification, valve model number and rated flow in GPM.

10. Flow control valve shall be warranted for period of five (5) years from date of startup.

11. Provide Owner with dual hose meter kit including pressure gauge with 4-1/2" dial, 3-way push button operated valve, 5 foot long dual connection hoses, dual shutoff and vent valves, dual special valves for connection to standard valve kit, flow conversion chart and carrying case.

J. Suction Diffusers:

1. Suction diffusers/strainers shall have 200 psi cast iron body and stainless steel strainer with 5/32" perforations. Units shall include flanged connections, removable gasketed cover and straightening vanes. Diffusers shall be as manufactured by Taco, B&G or Mueller.

2. Provide 16 mesh startup strainer.

3. Provide blow-off tapping on bottom of unit.

4. Provide full size inlet and outlet.

K. Combination Balancing/Flow Measurement/Shut-off Valves:

1. Valves shall be Y-pattern style with multi-turn hand-wheel.

2. Valves shall be capable of being installed in any direction without affecting flow measurement and shall provide the following functions:

   a. Precise flow measurement.

   b. Precision flow balancing.

   c. Positive shut-off with no drip seat.

   d. 3/4" drain port suitable for hose bib fitting. (Sizes 2" and below.)

3. Valves shall have four (4) 360° adjustment turns (2" and below). Hand-wheels shall have digital indicators with hidden memory and tamper-proof setting features.

4. Valves 2" and below shall be non-ferrous, pressure die-cast, non-porous Ametal copper alloy, with soldered ends.

5. Pressure ratings shall be 300 psi for 2" and below, 250 psi for flanged and 300 psi for grooves ends.

6. Each valve shall have pressure/temperature readout ports with EPDM seals and attached shut-off valves.

7. One (1) computerized hand-held balancing meter shall be furnished to the Owner. The Testing and Balancing Contractor shall utilize this instrument for his work. The meter shall include the following:

a. Flow measurement direct in GPM.

b. Differential pressure measurement.

c. Temperature measurement.

d. Automatic calibration.

e. Automatic air pursing.

f. Extended data logging functions.

8. Balance valves 2" and under shall be Tour and Anderson Model STAS. Valves 2-1/2" and over shall be Tour and Anderson Models STAF-SG or STAG. The hand-held meter shall be Tour and Anderson Model CBI with PCB data logging features. Balance valves manufactured by Armstrong or Victaulic shall be considered equivalent.

2.8 PIPE INSULATION

A. Insulation shall be fibrous glass insulation with factory-applied fire retardant vapor barrier jacket by Owens Corning, Certain-Teed, Manville or Knauf, installed as required by manufacturer. ASTM E-84 fire hazard ratings shall be 25 flame spread, 50 smoke developed and 50 fuel contributed.

B. Apply insulation after systems have been tested, proved tight and approved by the Architect. Remove dirt, scale, oil, rust and foreign matter prior to installation of insulation.

C. Provide fibrous dual temperature insulation with factory applied vapor barrier jacket on condensate drain piping, unless noted otherwise.

D. Drain piping shall have 1/2" thick insulation.

E. Insulation Table:

TABLE C403.2.8

Minimum Pipe Insulation Thickness (thickness in inches)[a]

Fluid Operating Temperature Range and Usage (°F)	Insulation Conductivity		Nominal Pipe or Tube Size (Inches)				
	Conductivity Btu – In./(h . ft^2 . °F)[b]	Mean Rating Temperature, °F	<1	1 to <1½	1½ to < 4	4 to < 8	< 8
141 – 200	0.25 – 0.29	125	1.5	1.5	2.0	2.0	2.0
105 - 140	0.21 – 0.28	100	1.0	1.0	1.5	1.5	1.5
40 – 60	0.21 – 0.27	75	0.5	0.5	1.0	1.0	1.0
<40	0.20 – 0.26	75	0.5	1.0	1.0	1.0	1.5

1. For piping smaller than 1½ inch (38 mm) and located in partitions within conditioned spaces, reduction of these thicknesses by 1 inch (25 mm) shall be permitted (before thickness adjustment required in footnote b) but not to a thickness less than 1 inch (25 mm).

2. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

   a. $T = r (1 + t/r)K/k – 1)$ where:

      1) T = minimum insulation thickness,

      2) r = actual outside radius of pipe,

      3) t = insulation thickness listed in the table for applicable fluid temperature and pipe size,

      4) K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu x in/h x ft 2 x °F) and

      5) k = the upper value of the conductivity range listed in the table for the applicable fluid temperature.

F. Provide longitudinal lap and 6” wide vapor barrier joint seal strips secured with approved adhesive.

G. Seal ends of pipe insulation and seal insulation to pipe with approved fire retardant vapor barrier, at flanges, valves and fittings and at intervals of no more than 21 feet on continuous runs of piping.

H. Secure covers on concealed pipe with metal bands at least 3/4" wide and no more than 18” apart, spaced to hold ends and center of each section.

I. Insulation on Fittings, Valves and Flanges:

1. Fittings, valves and flanges shall be insulated with pre-cut, factory-supplied fibrous glass, by Certain-Teed, Knauf, Owens Corning or Manville.

2. Fittings, valves and flanges shall be insulated with same material and to same thickness as adjoining pipe insulation.

3. Pipe fittings shall be pre-tested, clean and dry before insulation.

4. Installation of insulation on fittings shall be as follows, in order:

   a. Wrap insulation around fitting and tuck ends into fitting throat.

   b. Edges of adjacent insulation shall be tufted and tucked in, to fully insulate fitting to thickness of adjacent pipe insulation. Use two or more thicknesses if necessary.

   c. If two layers of insulation are used on fittings, wrap and secure first layer with twine before applying second layer.

   d. Top layer of insulation shall be covered with one (1) piece PVC, Zeston molded fitting cover. Secure cover with stainless steel tack fasteners inserted into jacket thread overlap seam.

   e. Tape joints with pressure-sensitive vapor barrier tape; tape shall extend 2” on either side of joint.

5. Prior to taping of joints on chilled water lines, apply vapor barrier mastic (brushed on) to fitting cover, throat overlap and edges. Also apply vapor barrier mastic to pipe insulation jacket ends.

6. For strainers and other valves or fittings which need maintenance, provide preformed removable insulation section.

J. Refrigeration Line Insulation:

1. Suction lines, hot bypass lines and outdoor liquid lines shall be insulated with 0.5" thick on pipes less than 1" and 1" thick on pipes greater than 1" rigid closed cell foam insulation. Armstrong Rigid Armaflex, Manville, Owens Corning or Halstead/Nomaco (Insultube), except in computer room plena.

2. Installation shall meet manufacturer's recommendations. Seal butt joints with insulation manufacturers approved adhesive.

3. Outside above ground insulation shall be protected with two (2) coats of approved vinyl lacquer coating over woven glass mesh adhered to insulation with Insulcolor or approved equal lagging adhesive, as recommended by manufacturer.

4. Refrigerant piping in hung ceiling and under floor supply and return plena shall be insulated with 1" thick fibrous glass insulation that meets applicable requirements of this paragraph.

5. VRF systems require all refrigerant lines to be insulated from the outdoor unit to the indoor terminal units.

2.9 HIGH EFFICIENCY GAS-FIRED BOILERS

A. General:

1. This section includes gas-fired, high efficiency condensing hot water boilers with cast aluminum heat exchangers. Boilers shall be factory packaged low pressure hot water boilers as manufactured by Patterson-Kelley or as approved and accepted by the Engineer. An approved equal or alternate must demonstrate compliance with the requirements of this specification.

2. Quality Assurance:

a. The equipment shall, at a minimum, be in strict compliance with the requirements of this specification, shall perform as specified and shall be the manufacturer's standard commercial product unless specified otherwise.

b. Electrically operated components specified are to be "Listed" and/or "Labeled" as defined by NFPA 70, Article 100.

c. Boiler shall bear an ASME "H" stamp in accordance with ASME Section IV.

d. Boiler shall be CSA certified to the ANSI Z21.13 / CSA 4.9 standard for Gas Fired Low Pressure Steam and Hot Water Boilers and shall bear an authorized CSA rating label.

e. Boiler shall be AHRI listed and certified in accordance with the Commercial Boiler program and the BTS-2000 testing standard.

f. Boiler shall be SCAQMD certified *(relevant jurisdictions).*

g. Boiler shall undergo a Full Function Factory Fire Test and bear a fire test label.

h. Boiler shall be registered through the National Board from the factory.

i. The manufacturer shall make available, upon request, all quality assurance documentation and results of Full Function Factory Fire Test based on the boiler's serial number.

3. Coordination:
   a. Equipment shall be handled, stored and installed in accordance with the manufacturer's instructions.
   b. Factory Authorized Start-up must be completed after all appliance connections are completed, e.g. gas piping, hydronic piping, exhaust venting & electrical.

4. Warranty:
   a. The boiler manufacturer shall warrant each boiler, including boiler, trim, boiler control system, and all related components, accessories, and appurtenances against defects in workmanship and material for a period of twelve (12) months from date of startup, provided that startup is completed within six (6) months of shipment and the start-up report is furnished to the manufacturer within thirty (30) days of startup.
   b. The boiler manufacturer shall warrant the boiler's fuel burner for a period of five (5) years from date of startup, provided that startup is completed within six (6) months of shipment and the start-up report is furnished to the manufacturer within thirty (30) days of startup.
   c. The boiler manufacturer shall warrant the boiler's heat exchanger for a period of ten (10) years from date of startup, provided that startup is completed within six (6) months of shipment and the start-up report is furnished to the manufacturer within thirty (30) days of startup.
   d. The boiler manufacturer shall also warrant the boiler's heat exchanger against failure due to thermal shock for a period of ten (10) years from date of startup, provided that startup is completed within six (6) months of shipment and the start-up report is furnished to the manufacturer within thirty (30) days of startup.

5. Certification:
   a. Manufacturer's Certification - The boiler manufacturer shall certify the following:
      1) The products and systems furnished are in strict compliance with the specifications.
      2) The boiler, burner and other associated mechanical and electrical equipment have all been properly coordinated and integrated to provide a complete and operable boiler.
      3) The boiler shall be in compliance with ANSI Z21.13 / CSA 4.9 (latest edition).
      4) The boiler shall be CSA certified for at least 92% efficiency based on operating conditions specified for testing under ANSI Z21.13 / CSA 4.9.
      5) The boiler shall be in compliance with ASME Section IV (latest edition).
      6) The boiler shall be in compliance with ASME CSD-1 (latest edition).
   b. Contractor's Certification - The installing contractor shall certify the following:
      1) The products and systems installed are in strict compliance with the specifications and all applicable local and/or state codes.
      2) The specified field tests have been satisfactorily performed by a factory authorized startup agent.
      3) The equipment furnished contains inter-changeable parts with the specified equipment so that

all major equipment parts can be obtained from the specified manufacturer.

B. Components:

1. Cabinet Enclosure:
   a. Each boiler shall feature a fully assembled cabinet enclosure fabricated from Carbon Steel or Aluminum sheet metal (minimum 16 Gauge) with powder coat finish.
   b. The boiler's cabinet enclosure shall not exceed 32" in width and the completed boiler shall fit through a standard 32" wide doorway.
   c. The boiler's cabinet enclosure shall feature removable access panels / doors with quarter-turn type latches that can be easily opened with a coin or flathead screwdriver.
   d. The boiler's cabinet enclosure shall eliminate the use of refractory or other insulating materials by baffling the combustion air around the heat exchanger and the outer surface temperature shall not exceed 20°F above ambient temperature.
   e. The boiler's cabinet enclosure shall prominently display all required safety, instruction, compliance and factory runout labels.

2. Heat Exchanger:
   a. Each hot water boiler shall contain an ASME Section IV heat exchanger with an "H" stamp designed for a maximum allowable working temperature of 220°F and a maximum allowable working pressure of 80 PSIG.
   b. The boiler's completed heat exchanger shall be cast from an Aluminum alloy (AC43000 / EN ALSi10Mg or approved equal) that is suitable to resist the corrosive gases produced from flue gas condensation. The casting shall be a counter-flow design to maximize heat transfer with multiple flow paths arranged in a reverse-return configuration to ensure balanced flow through each section. Boiler designs that incorporate a primary and secondary heat exchanger assembly are not acceptable.
      1) Each completed heat exchanger shall be of the "Mono-Block" type, consisting of a single, contiguous Aluminum casting. In addition, each completed heat exchanger shall include a molded PolyPropylene condensate pan/collector, condensate drain, removable burner assembly, inlet temperature sensor, outlet temperature sensor, flue gas temperature sensor, heat exchanger temperature sensor, automatic air vent, low water cutoff probe, thermowell for high temperature limit capillary, and all necessary assembly hardware.
   c. The boiler's completed heat exchanger shall be of the water tube style and incorporate thousands of extended fireside surface area "pins" in order to maintain flue gas turbulence across the entire firing range and provide no less than the total fireside heating surface area.
   d. Each Aluminum casting shall incorporate waterside geometry designed to maintain water turbulence at the full published range of acceptable flow rates at various boiler conditions as described below:
      1) The maximum allowable flow rate will generate a 20°F ΔT when the boiler is operating at full capacity.
      2) The minimum allowable flow rate at full boiler capacity will generate a 40°F ΔT.
      3) The minimum allowable flow rate at ignition will generate a 40°F ΔT.

4) The minimum allowable flow rate will generate a 20°F ΔT at low fire.

e. The boiler's completed heat exchanger shall be capable of operating with a minimum outlet water temperature of 42°F.

f. Each heat exchanger must be hydrostatically tested by the manufacturer to a minimum of 1-1/2 times the maximum allowable working pressure for a minimum of 5 minutes. During this hydrostatic pressure test, the operator will inspect the pressure gauge and visually verify there are no water leaks.

g. Each completed heat exchanger shall be assembled and tested by the boiler manufacturer. Heat exchangers assembled by a 3rd party are not acceptable.

3. Main Gas Train:

a. Boilers configured for single fuel operation shall be equipped with an integral main gas valve train capable of burning either Natural Gas or Propane Gas.

b. Each single fuel gas valve train shall include at least the following:

1) One (1) upstream manual shutoff valve for field-connection.

2) One (1) combination Air-Gas ratio control and safety shutoff valve with dual solenoids (in-series) that can be independently energized for leak testing and integrated into a single body design. The combination gas valve shall operate as a "Zero Governor" and control to a neutral gas pressure inside the gas valve.

3) One (1) low gas pressure switch (manual reset).

4) One (1) high gas pressure switch (manual reset).

5) Two (2) gas pressure test ports.

6) One (1) downstream manual shutoff valve.

c. Boilers configured for dual fuel operation shall be equipped with two integral gas valve trains; the first capable of burning Natural Gas and the second capable of burning Propane Gas. Dual fuel boiler types shall feature a NG / LP toggle switch allowing the user to quickly change between the two fuel types. Operation of this switch shall not require the boiler to be powered off prior to changeover.

d. Each gas train shall be completely independent and include dedicated safety devices, shutoff valves, etc. Each gas train shall be individually identified by the manufacturer with labels and dedicated paint colors (Yellow = Natural Gas & Red = Propane Gas).

e. Each dual fuel gas valve train shall include at least the following:

1) One (1) upstream manual shutoff valve for field-connection to Natural Gas.

2) One (1) upstream manual shutoff valve for field-connection to Propane Gas.

3) One (1) Natural Gas combination Air-Gas ratio control and safety shutoff valve with dual solenoids (in-series) that can be independently energized for leak testing and integrated into a single body design. The combination gas valve shall operate as a "Zero Governor" and control to a neutral gas pressure inside the gas valve.

4) One (1) Propane Gas combination Air-Gas ratio control and safety shutoff valve with dual solenoids (in-series) that can be independently energized for leak testing and integrated into a single body design. The combination gas valve shall operate as a "Zero Governor" and control

to a neutral gas pressure inside the gas valve.

5) One (1) low gas pressure switch (manual reset) for Natural Gas.
6) One (1) low gas pressure switch (manual reset) for Propane Gas.
7) One (1) high gas pressure switch (manual reset) for Natural Gas.
8) One (1) high gas pressure switch (manual reset) for Propane Gas.
9) Two (2) gas pressure test ports for Natural Gas.
10) Two (2) gas pressure test ports for Propane Gas.
11) One (1) downstream manual shutoff valve for Natural Gas.
12) One (1) downstream manual shutoff valve for Propane Gas.

f. The main gas valve train(s) shall be factory assembled, piped, and wired and allow for operation at full rated boiler capacity from 4.0" W.C. up to the maximum inlet gas pressure of 14.0" W.C.

g. If the supplied gas pressure exceeds 14" W.C., the contractor shall supply a suitable intermediate gas pressure regulator of the lock-up type to reduce the gas pressure to acceptable levels.

4. Power Burner:

a. The boiler manufacturer must furnish an integral power type fuel burner with each boiler. The complete power fuel burner assembly must consist of a gas burner, combustion air blower, main gas valve train, and ignition system. The burner manufacturer must fully coordinate the burner design with the boiler's heat exchanger and the boiler control system in order to provide the required capacities, efficiencies, and performance specified. Boilers shipped without a power burner and field-equipped with a 3rd party power burner are not acceptable.

b. Each burner must be installed horizontally inside the combustion chamber with combustion gases flowing downward through the heat exchanger. The burner must consist of a stainless steel flange and woven fiber mesh cylindrical design.

c. The burner must incorporate fuel/air ratio control system to preserve exhaust oxygen levels as per boiler schedule, maintaining consistent flue dew point.

d. The system must be linkage-less without the use of electronic control loops and electronic oxygen sensors requiring calibration and renewal.

e. Low NOx burner must be certified by SCAQMD for NOx levels listed on schedule when O2 is corrected to 3%. No additional setup or adjustment, such as increasing excess air, will be necessary to achieve level listed

f. Each boiler must be equipped with direct spark ignition. Main flame must be monitored and controlled by a flame rod / ionization probe (rectification) system.

5. Boiler Safety and Trim Devices:

a. The boiler manufacturer shall furnish and test the following safety and trim devices with each boiler:

1) Safety relief valve shall be provided in compliance with the ASME code. Contractor is required to pipe the relief valve discharge piping to an acceptable drain.

2) Water pressure/temperature gauge.

3) Low Water / Flow cutoff.
4) Manual reset high limit water temperature controller.
5) Operating temperature control to control the sequential operation of the burner.
6) High and Low Gas Pressure switches.
7) Flame rod / ionization probe (rectification) system.

b. The boiler manufacturer shall provide a CSD-1 form identifying each safety and trim device.

c. The boiler shall be capable of interfacing with the following external safety devices:
1) Auxiliary Low Water Cutoff device.
2) Combustion Air Damper End Limit Switch.
3) Emergency Stop (E-Stop) switch.
4) External Safety Device w/ contact closure.

6. Boiler Control System:
a. Each boiler shall be provided with all necessary controls, all necessary programming sequences, and all safety interlocks. Each boiler control system shall be properly interlocked with all safeties.

b. Each boiler shall be provided with a "Full Modulating" firing control system whereby the firing rate is infinitely proportional at any firing rate between low fire and high fire as determined by the pulse width modulation input control signal. Both fuel input and air input must be sequenced in unison to the appropriate firing rate without the use of mechanical linkage.

c. The boiler's control system shall provide the minimum capabilities:
1) 7" color touchscreen display with one or more USB ports.
2) Standard on-board Ethernet port for wired internet connectivity and embedded wireless driver for optional wireless internet connectivity to remote monitoring and software update services.
3) Parameter uploads and downloads via external USB flash drive.
4) Software updates via external USB flash drive.
5) Capture screen shots from the control's display by saving digital image files to external USB flash drive.
6) Local Representative Screen can be programmed to provide contact information for the local boiler manufacturer's representative.
7) Programmable Relay Outputs for direct control of pumps, control valves, dampers and other auxiliary devices.
8) Multiple boiler "cascade" network up to 24 boilers without any external control panel. The installation of external sequencing control panels is not acceptable.
9) Automatic hybrid system control for multiple boiler "cascade" systems with both condensing and non-condensing boilers. This control logic prioritizes condensing boilers at low water temperatures and prioritizes non-condensing boilers at high water temperatures.
10) Auxiliary Boiler Relay for multiple boiler "cascade" systems which can be used to enable a 3rd party boiler platform in the event the "cascade" system is unable to satisfy the heating load.

11) Programmable Boiler and System pump control for multiple boiler "cascade" systems installed in a Primary-Secondary piping arrangement.
12) Programmable Control Valve logic for multiple boiler "cascade" systems installed in a Primary-Only piping arrangement.
13) Integration with external Building Management Systems (BMS) via MODBUS® RTU protocol. **NOTE:** Optional Protocol Converter for communication via LONWORKS® and BACnet® must be available for purchase from the boiler manufacturer.
14) Hardwire integration with Building Management Systems (BMS) via 4-20mA analog control signal for temperature or firing rate control.
15) Intuitive "Setup Wizards" ask the user a series of questions and allow for step-by-step configuration of the boiler control.
16) On-Screen error notifications with a comprehensive description of all alarm conditions and several troubleshooting steps.
17) Automatic flue gas temperature and outlet (supply) temperature compensation to prevent over-firing of the boiler equipment.
18) Automatic differential temperature compensation to prevent over-firing of the boiler equipment in a low flow condition.
19) Automatically adjust the temperature set point and shutdown the boiler based on the outdoor air temperature conditions.
20) Night Setback functionality via external point of closure (or BMS integration) for unique "Occupied" and "Unoccupied" temperature setpoint values.
21) Maintain single temperature set point with a minimum outlet (supply) water temperature of 42°F up to a maximum outlet (supply) water temperature of 194°F.
22) On-Board DHW Priority capable of seamless transition between Comfort Heat (CH) and Domestic Hot Water (DHW) operation.
23) On-Board CH&DHW operation for simultaneous Comfort Heat (CH) and Domestic Hot Water (DHW) operation.
24) Alarm Relay Output to announce alarm conditions which require manual reset.
25) Programmable Low Fire Delay to prevent excessive short-cycling of the boiler equipment.
26) Local Manual Operation.

d. The boiler control system shall be capable of interfacing with the following external control devices:
   1) Building Management System (MODBUS®). **NOTE:** Optional Protocol Converter for communication via LONWORKS® and BACnet® must be available for purchase from the boiler manufacturer.
   2) Domestic Hot Water Break-on-Rise Aquastat (Normally Closed).
   3) Domestic Hot Water Tank Temperature Sensor (12kΩ).
   4) External Header Temperature Sensor (12kΩ).
   5) Outdoor Air Temperature Sensor (12kΩ).

2.10 VARIABLE SPEED PUMPS

A. Subject to compliance with these specifications, the following manufacturers shall be acceptable:

1. Taco, Inc.

2. ITT Bell & Gossett

3. Grundfos

B. Manufactured Units

1. The self-sensing product shall consist of a factory prepackaged and preprogrammed pump, drive, motor, and integral controls package.

2. The drive shall be mounted and integral to the motor. It shall be mounted with rubber vibration mounts. The mounting and packing of the drive shall be done in a manner that transmitted acceleration levels will be three times below the allowable limits published by the drive manufacturer. These limits will apply to a frequency range of 0-10,000 HZ.

3. The performance speed of this package shall 1750 RPM nominal as standard. Exceptions for 3600 RPM will be noted in the schedules. 3600 RPM shall NOT be an allowable substitution for a specified 1750 PRM package. 3600 RPM products might be considered as a substitution for 1750 RPM only if that manufacturer provides a spare motor, drive, and seal for each pumping unit.

4. Pump logic controller, variable frequency drives, sensor/transmitters and related equipment shall be installed by the mechanical contractor as shown on the plans.

C. Components

1. Pump Logic Controller.
   a. The controller operation shall operate the system using a tested and proven program that safeguards against undesirable or damaging conditions including:
      1) Motor overload
      2) Pump flow surges
      3) Hydraulic cycling (hunting).
      4) End of curve unstable operation: The pump logic controller, through a factory pre-programmed algorithm, shall be capable of protecting the pumps from hydraulic damage due to operation beyond their published end-of-curve. This feature requires a flow meter for activation. The operator interface shall include an owner adjustable flow setpoint to set the parameters for this routine.
   b. The pump logic controller shall be capable of starting, unloading, and stopping pumps based on a system performance program that will minimize energy consumption , provide reliable performance and bumpless transitions.
   c. The integrated logic controller shall be capable of running four different hydronic optimization sub-routines

1) Setup one: This subroutine shall allow the pump package to track a quadratic system curve and will optimize a secondary distribution loop. It shall use a technology that allows the pump, drive, and motor package to translate the hydronic data from both a pump and system curve and translate it to electrical data. This allows the drive to know exactly where it is in the hydronic world.

    a) Setup two: This subroutine shall allow two pumps to run as backup for each other and shall alternate the pumps based on a real time clock.

    b) Setup three: This subroutine shall allow the package to run in a customer defined flow rate. The package will always seek to run at the user defined flow even with fouling causing system changes. It shall use a technology that allows the pump, drive, and motor package to translate the hydronic data from both a pump and system curve and translate it to electrical data. This allows the drive to know exactly where it is in the hydronic world.

    c) Setup four: This subroutine shall incorporate a traditional external sensing and control platform. It shall allow the option of controlling the pumps with three zones of differential pressure or central plant differential temperature. This optional setup shall allow the owner the option of external sensing without adding an external controller. This feature shall be equal to Taco System Logic (TSL) or equal.

    d) The control platform shall include a subroutine equal to the Taco Self-Sensing Series with ProBalance™. This subroutine shall allow for the automatic balancing of secondary system distribution pumps. The package shall automatically run system distribution pumps to a user defined duty point and will recognize that duty point and hold the pumps at a speed that matches the actual installed system quadratic system curve. The package will then use this data to set up a new duty point as the max point for the quadratic control curve. Use of external balancing devices or contractors will not be needed.

d. The package shall serve as a flow metering device and will display pump flow at the user interface.

e. Shall have optional ProView controller that automates pump balancing.

2. Software – ProView: A pre-programmed interface module that will easily integrate HVAC components into any Building Automation System (BAS).

    a. Features

        1) Pump Monitoring

            a) Horsepower (Power from the drive to the motor (not motor plus drive)

            b) KW

            c) Energy

            d) Runtime hours w/reset

            e) Head

            f) Flow

            g) Speed Hz, RPM, %

            h) Amps

            i) Volts

        2) Single button OneTouch ProBalance - Remote pump/system balancing controlled by Building

Automation System (BAS) that is activated by a web-based user interface.

3) BTU Monitoring
   a) Shall allow for BTU monitoring
   b) VFD drive shall allow (2) UI's which will be used for Delta-T readings.
4) Monthly calculations
   a) Software shall automatically have trends and graphs set up for the following:
   b) Software shall provide graphical load profile display – bar chart normal-distribution
5) Mode Selection
   a) Variable Flow
   b) Constant Flow
   c) Constant Pressure
   d) Standby
6) Pump Fault Monitoring
   a) Software shall display Application Faults, System Faults and Warnings
   b) Software shall initiate E-mail alerts
   c) Software shall provide system and pump performance snapshot at alarm point of entry

3. User Interface
   a. Hardware
      1) GCI/JENE-based - ProView shall be based on the Taco Graphical Controller Interface (GCI). The GCI itself consists of a Taco-specific-device and software templates, settings, and graphics.
      2) Capabilities
         a) DDC Integration into existing 3rd party controls platform
         b) The GCI allows for integration into the following Building Automation System (BAS) networks:
            (1) BACnet
            (2) LonWorks
            (3) Modbus
            (4) N2
   b. Supported Interfaces:
      1) Desktop Web: Views formatted for a computer screen. Visible through any Java-enabled web browser.
   c. User interface screen shall have the following layout features:

1) Monitoring Tab
   a) Dynamic graphical display of system pump performance point
   b) Dynamic graphical display of system performance curve
   c) Graphical display of pump performance range
   d) Dynamic graphical cost and energy comparison of SelfSensing variable speed pump and constant speed pump
   e) Status Tab
2) 2nd Monitoring Page for additional "Pump Monitoring" data points and Status Bits and Extended Status bits.
3) ProBalance Tab
   a) Button for One-Touch ProBalance
   b) Fields to enter setpoints:
      (1) Active Setup
      (2) Design Flow
      (3) No-flow Head
      (4) Max VFD speed
      (5) Min VFD Speed
      (6) Control head
      (7) Mode Selection
      (8) Setup Tab
   c) BTU Setup
4) Maintenance Tab
   a) Monitor cycles –
      (1) GCI to monitor number of cycles since last Seal change and bearing check/change
   b) Maintenance data logger
      (1) GCI PM reminder for seal change / Bearing maintenance
      (2) GCI based historical record of technician's notes e.g. note & timestamp
      (3) Alarms Tab:
   c) Pump Faults/Warnings

D. PUMPS (See pump schedule on plans for exact model, type, and duty points.)

1. Vertical Split Coupled Pumps.

a. Pumps shall be Taco Model KS or approved equal. The pumps shall be single stage vertical inline design. The seal shall be serviceable without disturbing the piping connections. The capacities and characteristics shall be as called for in the plans/schedules.

1) Pump casing shall be constructed of ASTM A48 class 30 cast iron. The pump casing/volute shall be rated for 250 psi working pressure for all jobs. The pump flanges shall be matched to suit the working pressure of the piping components on the job, with either ANSI Class 125 flanges or ANSI class 250 flanges. The pump casing shall be drilled and tapped for gauge ports on both the suction and discharge connections and for a drain port at the bottom of the casing. The casing shall have an additional tapping on the discharge connection to allow for the installation of a seal flush line. The pump cover shall be drilled and tapped to accommodate a seal flush line which can be connected to the corresponding tapping on the discharge connection, or to an external source to facilitate cooling and flushing of the seal faces.

2) All casings shall be flanged. Threaded casings not allowed unless extra unions and fittings are provided to allow servicing.

3) The pump shall have a factory installed vent/flush line to insure removal of trapped air from the casing and mechanical seal cooling. The vent/flush line shall run from the seal chamber to the pump discharge.

4) The impeller shall be ASTM B584-836/875 bronze and hydraulically balanced. The impeller shall be dynamically balanced to ANSI Grade G6.3 and shall be fitted to the shaft with a key. The impeller shall be cast by the hydraulically efficient lost foam technique to ensure repeatability of high quality.

5) The pump shall be manufactured with AISI 416 Stainless Steel shaft.

6) The pump shall be fitted with a single mechanical seal, with EPT elastomers and Carbon/Ceramic faces, rated up to 250ºF. The mechanical seal shall be an inside type seal yet engineered and applied in a manner that is as or more accessible than a specialty outside seal. This seal must be capable of being flushed externally via a tapping in the pump cover adjacent to the seal cavity. The entire pump line shall use no more than three different sizes of seals. Outside mechanical seals are NOT acceptable.

7) The pump shall be coupled via a high tensile aluminum split style coupling. The design must permit easy replacement of the mechanical shaft seal without removal of the motor. The motor mount must be designed to accept several different motor frame standards; CZ and HP. The motor shall be a TEFC, inverter rated motor with class F insulation and shaft grounding ring.

8) In order to both simplify and reduce the total cost of ownership, the manufacturer shall standardize on no more than three sizes of mechanical seals throughout the entire range of the family of pumps. The manufacturer shall not use multiple part numbers for the same part.

E. Variable Frequency Drives

1. The VFD shall convert incoming fixed frequency three-phase ac power into an adjustable frequency and voltage for controlling the speed of three-phase ac motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for the driven load and to eliminate the need for motor derating. When properly sized, the VFD shall allow the motor to produce full rated power at rated motor voltage, current, and speed without using the motor's service factor. VFDs utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

2. The VFD shall include an input full-wave bridge rectifier and maintain a fundamental (displacement) power factor near unity regardless of speed or load.

3. The VFD shall have a dual 5% impedance DC link reactor on the positive and negative rails of the dc bus to minimize power line harmonics and protect the VFD from power line transients. The chokes shall be non-saturating. Swinging chokes that do not provide full harmonic filtering throughout the entire load range are not acceptable. VFDs with saturating (non-linear) dc link reactors shall require an additional 3% AC line reactor to provide acceptable harmonic performance at full load, where harmonic performance is most critical.

4. The VFD's full load output current rating shall meet or exceed nec table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 120% of rated torque for up to 0.5 second while starting.

5. The VFD shall provide full motor torque at any selected frequency from 20 hz to base speed while providing a variable torque v/hz output at reduced speed. This is to allow driving direct drive fans without high speed derating or low speed excessive magnetization, as would occur if a constant torque v/hz curve was used at reduced speeds. Breakaway current of 160% shall be available.

6. A programmable automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continuously monitor the motor's speed and load to adjust the applied voltage to maximize energy savings.

7. The VFD must be able to produce full torque at low speed to operate direct drive fans.

8. Output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD.

9. An automatic motor adaptation algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to perform the test.

10. Galvanic isolation shall be provided between the VFD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog i/o and discrete digital i/o shall include additional isolation modules.

11. VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD operation while reducing motor noise. VFDs with fixed carrier frequency are not acceptable.

12. All VFDs shall contain integral EMI filters to attenuate radio frequency interference conducted to the ac power line.

13. The drive enclosure shall be standard as NEMA 12 (IP 55) and optional shall be NEMA 4X (IP 66). See schedules for project requirements.

14. Protective features

    a. A minimum of class 20 i2t electronic motor overload protection for single motor applications shall be provided. Overload protection shall automatically compensate for changes in motor speed.

1) Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFD shall display all faults in plain language. Codes are not acceptable.
2) Protect VFD from input phase loss. The VFD should be able to protect itself from damage and indicate the phase loss condition. During an input phase loss condition, the VFD shall be able to be programmed to either trip off while displaying an alarm, issue a warning while running at reduced output capacity, or issue a warning while running at full commanded speed. This function is independent of which input power phase is lost.
3) Protect from under voltage. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output, without faulting, with an input voltage as low as 70% of the nominal voltage.
4) Protect from over voltage. The VFD shall continue to operate without faulting with a momentary input voltage as high as 130% of the nominal voltage.
5) The VFD shall incorporate a programmable motor preheat feature to keep the motor warm and prevent condensation build up in the motor when it is stopped in a damp environment by providing the motor stator with a controlled level of current.
6) VFD shall include a "signal loss detection" algorithm with adjustable time delay to sense the loss of an analog input signal. It shall also include a programmable time delay to eliminate nuisance signal loss indications. The functions after detection shall be programmable.
7) VFD shall function normally when the keypad is removed while the VFD is running. No warnings or alarms shall be issued as a result of removing the keypad.
8) VFD shall catch a rotating motor operating forward or reverse up to full speed without VFD fault or component damage.
9) Selectable over-voltage control shall be provided to protect the drive from power regenerated by the motor while maintaining control of the driven load.
10) VFD shall include current sensors on all three output phases to accurately measure motor current, protect the VFD from output short circuits, output ground faults, and act as a motor overload. If an output phase loss is detected, the VFD will trip off and identify which of the output phases is low or lost.
11) If the temperature of the VFD's heat sink rises to 80□c, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. It shall also be possible to program the VFD so that it reduces its output current limit value if the VFD's temperature becomes too high.
12) In order to ensure operation during periods of overload, it must be possible to program the VFD to automatically reduce its output current to a programmed value during periods of excessive load. This allows the VFD to continue to run the load without tripping.
13) The VFD shall have temperature controlled cooling fan(s) for quiet operation, minimized losses, and increased fan life. At low loads or low ambient temperatures, the fan(s) may be off even when the VFD is running.
14) The VFD shall store in memory the last 10 alarms. A description of the alarm, and the date and time of the alarm shall be recorded.
15) When used with a pumping system, the VFD shall be able to detect no-flow situations, dry pump conditions, and operation off the end of the pump curve. It shall be programmable to take

appropriate protective action when one of the above situations is detected.

b. Internal Control Algorithm

1) This is a standard HVAC drive that has been upgraded and modified by pump experts for Hydronic applications. It is set up with a closed loop internal control sequence that will optimize life cycle, system comfort, and minimize energy consumption.

c. Interface Features

1) Hand, off and auto keys shall be provided to start and stop the VFD and determine the source of the speed reference. It shall be possible to either disable these keys or password protect them from undesired operation.

a) There shall be an "info" key on the keypad. The info key shall include "on-line" context sensitive assistance for programming and troubleshooting.

b) The VFD shall be programmable to provide a digital output signal to indicate whether the VFD is in hand or auto mode. This is to alert the building automation system whether the VFD is being controlled locally or by the building automation system.

c) Password protected keypad with alphanumeric, graphical, backlit display can be remotely mounted. Two levels of password protection shall be provided to guard against unauthorized parameter changes.

d) All VFDs shall have the same customer interface. The keypad and display shall be identical and interchangeable for all sizes of VFDs.

e) To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD's keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters. Keypad shall provide visual indication of copy status.

f) Display shall be programmable to communicate in multiple languages including English, Spanish and French.

g) A red fault light, a yellow warning light and a green power-on light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.

h) A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD. The VFD shall also have individual fan, pump, and compressor menus specifically designed to facilitate start-up of these applications.

i) A four-feedback PID controller to control the speed of the VFD shall be standard. This controller shall accept up to four feedback signals. It shall be programmable to compare the feedback signals to a common setpoint or to individual setpoints and to automatically select either the maximum or the feedback signal as the controlling signal. It shall also be possible to calculate the controlling feedback signal as the average of all feedback signals or the difference between a pair of feedback signals.

j) The VFD shall be able to apply individual scaling to each feedback signal.

k) For fan flow tracking applications, the VFD shall be able to calculate the square root of any or all individual feedback signals so that a pressure sensor can be used to measure air flow.

l) The VFD's PID controller shall be able to actively adjust its setpoint based on flow. This allows the VFD to compensate for a pressure feedback sensor which is located near the output of the pump rather than out in the controlled system.

m) The VFD shall have three additional PID controllers which can be used to control damper and valve positioners in the system and to provide setpoint reset.

n) Floating point control interface shall be provided to increase/decrease speed in response to contact closures.

o) Five simultaneous meter displays shall be available. They shall include at a minimum, frequency, motor current, motor voltage, VFD output power, VFD output energy, VFD temperature in degrees, among others.

p) Programmable sleep mode shall be able to stop the VFD. When its output frequency drops below set "sleep" level for a specified time, when an external contact commands that the VFD go into sleep mode, or when the VFD detects a no-flow situation, the VFD may be programmed to stop. When the VFD's speed is being controlled by its PID controller, it shall be possible to program a "wake-up" feedback value that will cause the VFD to start. To avoid excessive starting and stopping of the driven equipment, it shall be possible to program a minimum run time before sleep mode can be initiated and a minimum sleep time for the VFD.

q) A run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of initiating an output "run request" signal to indicate to the external equipment that the VFD has received a request to run.

r) VFD shall be programmable to display feedback signals in appropriate units, such as inches of water column (in-wg), pressure per square inch (psi) or temperature (°f).

s) VFD shall be programmable to sense the loss of load and signal this condition via a keypad warning, relay output and/or over the serial communications bus. To ensure against nuisance indications, this feature must be based on motor torque, not current, and must include a proof timer to keep brief periods of no load from falsely triggering this indication.

t) Standard Control And Monitoring Inputs And Outputs

2) Six dedicated, programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.

a) Two terminals shall be programmable to act as either as digital outputs or additional digital inputs.

b) Two programmable relay outputs, Form C 240 V AC, 2 A, shall be provided for remote indication of VFD status.

c) Each relay shall have an adjustable on delay / off delay time.

d) Two programmable analog inputs shall be provided that can be either direct-or-reverse acting.

e) Each shall be independently selectable to be used with either an analog voltage or current signal.

f) The maximum and minimum range of each shall be able to be independently scalable from 0 to 10 V dc and 0 to 20 mA.

g) A programmable low-pass filter for either or both of the analog inputs must be included to compensate for noise.

h) The VFD shall provide front panel meter displays programmable to show the value of each analog input signal for system set-up and troubleshooting,

i) One programmable analog current output (0/4 to 20 mA) shall be provided for indication of VFD status. This output shall be programmable to show the reference or feedback signal supplied to the VFD and for VFD output frequency, current and power. It shall be possible to scale the minimum and maximum values of this output.

j) It shall be possible through serial bus communications to read the status of all analog and digital inputs of the VFD.

k) It shall be possible to command all digital and analog output through the serial communication bus.

l) Optional Control And Monitoring Inputs And Outputs

3) It shall be possible to add optional modules to the VFD in the field to expand its analog and digital inputs and outputs.

a) These modules shall use rigid connectors to plug into the VFD's control card.

b) The VFD shall automatically recognize the option module after it is powered up. There shall be no need to manually configure the module.

c) Modules may include such items as:

d) Additional digital outputs, including relay outputs

e) Additional digital inputs

f) Additional analog outputs

g) Additional analog inputs, including Ni or Pt temperature sensor inputs

h) It shall be possible through serial bus communications to control the status of all optional analog and digital outputs of the VFD.

i) Standard programmable firefighter's override mode allows a digital input to control the VFD and override all other local or remote commands. It shall be possible to program the VFD so that it will ignore most normal VFD safety circuits including motor overload. The VFD shall display firemode whenever in firefighter's override mode. Firemode shall allow selection of forward or reverse operation and the selection of a speed source or preset speed, as required to accommodate local fire codes, standards and conditions.

d. A real-time clock shall be an integral part of the VFD.

1) It shall be possible to use this to display the current date and time on the VFD's display.

a) Ten programmable time periods, with individually selectable ON and OFF functions shall be available. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter setpoints and output relays. Is shall be possible to program unique events that occur only during normal work days, others that occur only on non-work days, and others that occur on specific days or dates. The manufacturer shall provide free PC-based software to set up the calendar for this schedule.

b) All VFD faults shall be time stamped to aid troubleshooting.

c) It shall be possible to program maintenance reminders based on date and time, VFD running hours, or VFD operating hours.

d) The real-time clock shall be able to time and date stamp all faults recorded in the VFD fault log.

e) The VFD shall be able to store load profile data to assist in analyzing the system demand and energy consumption over time.

e. The VFD shall include a sequential logic controller to provide advanced control interface capabilities. This shall include:

1) Comparators for comparing VFD analog values to programmed trigger values

a) Logic operators to combine up to three logic expressions using Boolean algebra

b) Delay timers

c) A 20-step programmable structure

d) The VFD shall include a cascade controller which allows the VFD to operate in closed loop setpoint (PID) control mode one motor at a controlled speed and control the operation of 3 additional constant speed motor starters.

f. Serial communications

1) The VFD shall include a standard eia-485 communications port and capabilities to be connected to the following serial communication protocols at no additional cost and without a need to install any additional hardware or software in the VFD:

a) Johnson Controls Metasys N2

b) Modbus RTU

c) Siemens FLN

d) BACnet MS/TP

e) Optional communication shall include:

f) LonWorks Free Topology (FTP)

2) VFD shall have standard USB port for direct connection of Personal Computer (PC) to the VFD. The manufacturer shall provide no-charge pc software to allow complete setup and access of the VFD and logs of VFD operation through the USB port. It shall be possible to communicate to the VFD through this USB port without interrupting VFD communications to the building management system.

3) The VFD shall have provisions for an optional 24 v DC back-up power interface to power the VFD's control card. This is to allow the VFD to continue to communicate to the building automation system even if power to the VFD is lost.

g. Adjustments

1) The VFD shall have a manually adjustable carrier frequency that can be adjusted in 0.5 khz increments to allow the user to select the desired operating characteristics. The VFD shall also be programmable to automatically reduce its carrier frequency to avoid tripping due to thermal loading.

a) Four independent setups shall be provided.

b) Four preset speeds per setup shall be provided for a total of 16.

c) Each setup shall have two programmable ramp up and ramp down times. Acceleration and deceleration ramp times shall be adjustable over the range from 1 to 3,600 seconds.

d) Each setup shall be programmable for a unique current limit value. If the output current from the VFD reaches this value, any further attempt to increase the current produced by the VFD will cause the VFD to reduce its output frequency to reduce the load on the VFD. If desired, it shall be possible to program a timer which will cause the VFD to trip off after a programmed time period.

e) If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: external interlock, under-voltage, over-voltage, current limit, over temperature, and VFD overload.

f) The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.

g) An automatic "start delay" may be selected from 0 to 120 seconds. During this delay time, the VFD shall be programmable to either apply no voltage to the motor or apply a DC braking current if desired.

h) Four programmable critical frequency lockout ranges to prevent the VFD from operating the load at a speed that causes vibration in the driven equipment shall be provided. Semi-automatic setting of lockout ranges shall simplify the set-up.

i) Optional features

2) All optional features shall be built and mounted by VFD manufacturer. All optional features shall be UL listed by the VFD manufacturer as a complete assembly and carry a UL label.

a) All panels shall be marked for their short circuit current rating in compliance with UL.

b) Service conditions

3) Ambient temperature, continuous, full speed, full load operation:

a) -10 to 45°C (14 to 113°F) through 125 HP @ 460 and 600 volt, through 60 HP @ 208 volt

b) -10 to 40°C (14 to 104°F) 150 HP and larger

c) 0 to 95% relative humidity, non-condensing.

d) Elevation to 3,300 feet without derating.

e) AC line voltage variation, -10 to +10% of nominal with full output.

f) No side clearance shall be required for cooling.

g) All power and control wiring shall be done from the bottom.

h) All VFDs shall be plenum rated.

2.11 PIPE HANGERS AND SUPPORTS

A. Provide pipe stands, supports, hangers and other supporting devices in accordance with ANSI B31.9 and MSS-69, as necessary to support work required by Contract Documents.

B. Secure vertical piping to building construction to prevent sagging or swinging.

C. Space hangers for horizontal piping as follows:

Pipe Size	Rod Diameter	Maximum Spacing
Up to 1-1/4”	3/8”	8 ft.-0”
1-1/2” and 2”	3/8”	10 ft.-0”
2-1/2” and 3”	1/2"	10 ft.-0”
4” and 5”	5/8”	12 ft.-0”
6”	3/4"	12 ft.-0”
8” and over	7/8”	12 ft.-0”

D. Horizontal copper tubing shall have maximum hanger spacing of 5 ft. for tubing 1-1/4” diameter and smaller and 10’ for tubing 1-1/2” and larger. Maximum spacing for PVC pipe hanger shall be 4”.

E. Reduce spacing to a maximum of 10’-0” apart, regardless of pipe size, as necessary for fittings, valves and other concentrated loads.

F. Support piping 4” diameter and larger from structure with pipe roll hangers with adjustable steel rod hangers, sized to accommodate insulation.

G. Support piping 3” diameter and under from structure with Carpenter and Patterson Fig. 100 clevis hangers or approved equal.

H. Hangers shall be as manufactured by Carpenter and Patterson, F&S or Grinnell Co. Figure numbers of Carpenter and Patterson are specified to establish standards of quality for performance and materials.

I. Provide spring hangers with travel stops as specified in Vibration Isolation Paragraph, where necessary and where shown on Drawings.

J. Pipe supports for 4” and larger pipe and insulated high-temperature piping shall have welded inserts of equal thickness to insulation to prevent compression of insulation. Other insulated pipe shall have 12”, 14 ga. shields at hangers, composed of 180° coverage of galvanized sheetmetal and high density, preformed rigid insulation. Where rollers are required, shield shall be steel pipe.

K. Hangers for horizontal lines shall be vertically adjustable to obtain pitch requirements of Piping Paragraph.

2.12 SLEEVES AND PENETRATIONS

A. Pipe Sleeves:

1. Sleeves through floors and through exterior, structural and fire-rated construction shall be hot-dipped galvanized Schedule 40 steel pipe.

2. Sleeves through partitions and non-rated construction shall be 26-gauge galvanized steel with lock longitudinal seams, or approved plastic pipe.

3. Provide waterproofing membrane locking devices at floors. Provide 150 lb. slip-on welding flanges at exterior wall penetrations.

B. Duct Sleeves and Openings:

1. Sleeves through floors, through exterior structure, through fire-rated construction and through smoke partitions that require smoke dampers shall be Schedule 40 galvanized steel pipe for round duct and shall meet the SMACNA Fire Damper and Heat Stop Guide for rectangular ducts. Fireproof packing shall be applied to seal any openings between sleeve and wall. Materials shall maintain the fire rating of the wall, and shall be installed in accordance with the SMACNA Fire Damper and Heat Stop Guide.

2. Openings in walls, partitions and other fire-rated construction that do not require smoke dampers shall meet NFPA 90A, Section 3-3.8.

3. Materials for prepared openings in partitions shall match construction penetrated.

C. Pipe Sleeve Packing:

1. Packing between the pipe and the sleeve (or wall or slab opening) in fire-rated walls or slabs shall be a combination of fireproof insulation and fireproof caulk. The combination of materials shall have the same fire rating, in hours, as the wall or slab, as tested in accordance with the latest edition of ASTME-814 (UL 1479). The combination of materials shall be classified by UL, (fill, void or cavity materials) for the fire rating required and shall be listed as a numbered system in the UL Fire Resistance Director. Fiberglass shall not be used as the insulation material.

2. Refer to Penetration and Firestopping 07 84 13 Section for acceptable fireproof insulation materials.

3. Packing for sleeves that do not require maintenance of fire rating shall be oakum, silicate foam, ceramic fiber or mineral fiber with approved sealant. Pack or foam to within 1” of both wall surfaces. Seal penetration packing with approved caulking and paintable waterproof mastic surface finish or silicone caulking.

4. All materials must be installed in accordance with manufacturer’ instructions; all gaps must be sealed. Finish caulk flush with wall or slab surface if piping runs exposed.

2.13 ESCUTCHEONS AND DUCT COLLARS

A. Provide adjustable escutcheons on exposed piping that passes through finished floors, walls and ceilings. Escutcheons shall be chromium-plated cast brass, sized to cover sleeve opening and to accommodate pipe and insulation.

B. Provide 4” wide, 20 gauge galvanized sheetmetal collars at sleeves and prepare openings, sized to cover entire duct penetration including sleeve and seal, and to accommodate duct and insulation as necessary. Edges shall have milled lips ground smooth. Paint to match finish of duct or as directed by the Architect.

C. Provide #316 stainless steel/No. 4 finish collar for emergency generator exhaust piping which passes through exterior wall.

2.14 HOT WATER COILS

A. Provide hot water coils suitable for duct installation with capacities, pressure drops and leaving air temperatures as shown on Drawings. Acceptable manufacturers shall be Trane, Aerofin, or Capital Coil.

B. Coil shall be 1/2" or 5/8" copper tube expanded mechanically into continuous aluminum fin collars, with copper or bronze headers and galvanized steel casings.

C. Proof test at 300 psi and leak test at 250 psi air pressure under water. Certify suitability for 200 psi working pressure.

D. Coil shall meet requirements of ARI 410-74.

2.15 UNIT HEATER (HYDRONIC)

A. Furnish and install, where indicated or schedules on plans, Sterlin model HAS horizontal hot water unit heaters. Units shall be equipped as specified herein. All units shall be installed neat and workmanlike manner in accordance with this specification and the manufacturer's installation instructions.

B. Casing:

1. Casings shall be 20 gauge die-formed steel. Pain finish shall be of lead-free, chromate free, polyester melamine resin base. Finish shall be baked at 400°F.

C. Coil Sizes 108A-136A:

1. Coil is a serpentine design with seamless copper tubing.

2. Aluminum fins shall have drawn collars to assure permanent bond with expanded tubes.

3. Tubing connection shall be 3/8 in copper tubing, type "M" (0.500 OD).

4. Coils shall be factory tested at 200 PSI.

5. Coils have a max operating temperature of 320°F.

D. Motors:

1. Motors shall be totally enclosed fan cooled, resilient mounted with class "B" windings.

2. All motors shall be designed for horizontal mounting.

E. Fans:

1. Fans shall be of aluminum blade type, designed and balanced to assure maximum air delivery, low motor horsepower requirements and quiet operation.

2. OSHA Fan Guards:

a. OSHA fan guards shall be welded steel, zinc plated or painted.

b. OSHA fan guards shall be standard on sizes 108A through 136A.

2.16 CABINET UNIT HEATER (HYDRONIC)

A. The contractor shall furnish and install Sterling Cabinet Unit Heaters as specified by engineer to meet or exceed job requirements. The Cabinet Unit Heaters will conform to the items listed below and will be certified under CSA/UL certification guidelines.

B. Cabinets:

1. All cabinets will be constructed with 18-gauge cold rolled steel, side panels and top. The front panel shall be furnished in 16-gauge cold rolled steel. It will have 1/2", 1-1/2 pound density insulation with a neoprene coated side in front of coil.

2. The internal cabinet shall be furnished in 18-gauge galvannealed steel. Adequate work area for installation of control valves or electrical equipment shall be provided on both sides of the internal cabinet.

3. The cabinet shall be provided with a neutral eggshell baked powder prime coat as standard. Optional powder coated finish in designer colors, as selected from standard color selector will be provided as specified. All cabinets shall be supplied with adjustable rear mounting brackets which will provide adjustment to correct alignment of the unit at installation to non-square or out of true walls, joists, studs or surfaces. Floor mounted cabinet units will be provided with adjustable leveling legs (two each base leg) when specified.

C. Coils:

1. Standard One Row Coil –
   a. Coils will have 1/2" O.D. copper tubes that are mechanically expanded to the aluminum fins. All coil header joints are brazed.
   b. The coil assembly is submersion tested at factory at 250 PSI and is rated at a working pressure of 300 PSI.
   c. All units are designed so that field modifications can be made to reverse the coil position if required.

2. High Capacity Two Row Coil –
   a. High Capacity, two row coil, option, as specified for hot water systems only, will have 1/2" O.D. copper tubes that are mechanically expanded to the aluminum fins. All coil header joints are brazed.
   b. The coil assembly is submersion tested at factory at 250 PSI and is rated at a working pressure of 300 PSI.
   c. All units are designed so that field modifications can be made to reverse the coil position if required.

3. Coil Connections:
   a. Coil connections provided will be 1-1/4" Nominal copper tube and will be factory installed for

connecting on the left hand side of the unit. Available as specified for right hand connection.

4. Electrical:
   a. All primary internal wiring shall be done at the factory. All units will be connected to electrical power to assure that all standard and optional electrical components operate as required at the factory prior to shipping.

D. Motors:

1. Standard PSC motors shall have integral thermal protection and start at 78% of rated voltage. PSC, High Static motors will be provided when specified and will be capable of operating in high static conditions up to.4 inches of water column. ECM and ECM high static motors provided as specified will have a solid state, digital control board and a 3 speed switch.

E. Fans:

1. Fan wheels will be centrifugal, forward curved, double width of nylon or electro galvannealed steel. Fan housings shall be of formed galvannealed sheet metal.

F. Filters:

1. All filters supplied as standard will be washable and reusable aluminum media with a 69% arrestance level. Filters shall be slide in type which will be secured into position with a cotter pin.

G. Cabinets:

1. RECESSED WALL UNITS:
   a. All recessed wall units shall be supplied with a wall seal assembly. The wall seal assembly will provide protection to the wall construction material. The wall seal will be supplied in an eggshell baked powder prime coat as standard.
   b. When specified, optional baked powder designer colors may be selected from the standard color selector.

2. CEILING MOUNT OR RECESSED UNITS:
   a. All "C" and "RC" units shall be supplied with a hinged front panel. The multiple hinges shall provide full swing through 90°. A safety chain shall be provided as standard to prevent the face panel from swinging fully open accidentally. This chain must be easily detached to allow full access for servicing.
   b. All recessed ceiling units shall be supplied with a wall seal assembly. The wall seal assembly will provide protection to the wall or ceiling construction material. The wall seal will be supplied in an eggshell baked powder prime coat as standard.
   c. When specified, optional baked powder designer colors may be selected from the standard color selector. The variable speed control switch will be packaged and placed inside the unit. A wiring diagram will be included for field installation at a desired location.

2.17 VIBRATION ISOLATION AND SEISMIC RESTRAINTS

A. General:

1. Intent:
   a. All mechanical equipment, piping and ductwork as noted on the equipment schedule or in the specification shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.
   b. All isolators and isolation materials shall be of the same manufacturer and shall be certified by the manufacturer.
   c. It is the intent of the seismic portion of this specification to keep all mechanical and electrical building system components in place during a seismic event.
   d. All such systems must be installed in strict accordance with seismic codes, component manufacturer's recommendations and building construction standards. Whenever a conflict occurs between the manufacturer's recommendations or construction standards, the most stringent shall apply.
   e. This specification is considered to be minimum requirements for seismic consideration and is not intended as a substitute for legislated, more stringent, national, state or local construction requirements (i.e. California Title 24, California OSHPD, Canadian Building Codes, or other requirements).
   f. Any variance or non-compliance with these specification requirements shall be corrected by the contractor in an approved manner.
2. The work of this section includes but is not limited to the following:
   a. Vibration isolation elements.
   b. Equipment isolation bases.
   c. Piping flexible connections.
   d. Seismic restraints for isolated and non-isolated mechanical and electrical items.
   e. Certification of seismic restraint designs and installation supervision.
   f. Certification of seismic attachment of housekeeping pads.
   g. All Mechanical and Electrical systems. Equipment buried underground is excluded but entry of services through the foundation wall is included.
3. Qualifications:
   a. Only firms having five years' experience designing and manufacturing seismic devices shall be capable of work in this specification.
4. Definitions:
   a. Life Safety Systems:
      1) All systems involved with fire protection including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, water tanks, fire dampers and smoke

exhaust systems.

2) All systems involved with and/or connected to emergency power supply including all generators, transfer switches, transformers and all flow paths to fire protection and/or emergency lighting systems.

3) All medical and life support systems.

4) Fresh air relief systems on emergency control sequence including air handlers, conduit, duct, dampers, etc.

b. Positive Attachment:

1) A positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead piping, ductwork, fire protection, electrical conduit, bus duct, or cable trays, or any other equipment are not acceptable on this project as seismic anchor points.

c. Transverse Bracing:

1) Restraint(s) applied to limit motion perpendicular to the centerline of the pipe, duct or conduit.

d. Longitudinal Bracing:

1) Restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.

e. Failure:

1) For the purposes of this project, failure is defined as the discontinuance of any attachment point between equipment or structure, vertical permanent deformation greater than 1/8" (3mm) and/or horizontal permanent deformation greater than 1/4" (6mm).

5. Submittals:

a. Submittal material shall include copies of descriptive data for all products and materials including but not limited to the following:

1) Descriptive Data:

a) Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the specification.

b) An itemized list showing the items to be isolated and/or seismically restrained, product type or model number to be used and loading and deflection data.

2) Shop Drawings:

a) Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.

b) Provide Drawings showing methods of suspension and support guides for conduit, piping, ductwork and ceiling hung equipment.

c) Where walls, floors, slabs or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points.

d) Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.

e) Drawings showing methods for isolation of conduits, pipes and ductwork penetrating walls and floor slabs.

f) Specific details of restraints including anchor bolts for mounting and maximum loading at each location, for each piece of equipment and/or pipe and duct locations.

3) Seismic Certification and Analysis:

a) Seismic restraint calculations must be provided for all connections of equipment to the structure. Calculations must be stamped by a registered professional engineer with at least five years of seismic design experience, licensed in the state of the job location.

b) All restraining devices shall have a preapproval number from California OSHPD or some other recognized government agency showing maximum restraint ratings. Preapprovals based on independent testing are preferred to preapprovals based on calculations. Where preapproved devices are not available, submittals based on independent testing are preferred. Calculations (including the combining of tensile and shear loadings) to support seismic restraint designs must be stamped by a registered professional engineer with at least five years of seismic design experience and licensed in the state of the job location. Testing and calculations must include both shear and tensile loads as well as one test or analysis at 45 degrees to the weakest mode.

c) Analysis must indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the forces detailed in section 1.06 acting through the equipment center of gravity. Overturning moments may exceed forces at ground level.

6. Contractor's Responsibilities:

a. Contractor to have the following responsibilities:

1) Determine vibration isolation and seismic restraint sizes and locations per specifications.

2) Provide and install isolation systems and seismic restraints as scheduled or specified.

3) Guarantee specified isolation system deflection.

4) Provide installation instructions, drawings and field supervision to assure proper installation and performance.

5) Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.

6) Substitution of "Internally Isolated" mechanical equipment in lieu of the specified isolation of this section is acceptable.

7. Seismic Force Levels:

a. Installations shall be designed to safely accept external forces determined in accordance with the International Building Code –2009, Section 16 in any direction for all rigidly supported equipment without failure and permanent displacement of the equipment. Seismic restraints shall not short circuit vibration isolation systems or transmit objectionable vibration or noise.

8. Project Record Documents:
    a. Submit under provision of Division 1.
    b. Record actual locations and installation of vibration isolators and seismic restraints including attachment points.

B. Products:

1. Manufacturers:
    a. Mason Industries Inc. (basis for model numbers listed below).
    b. Novia Associates or equal.

2. Product Descriptions:
    a. Vibration Isolators and Seismic Restraint Specifications:
        1) Specification 1 – Neoprene Pad:
            a) Two layers of 3/4" (19mm) thick neoprene pad consisting of 2" (50mm) square waffle modules separated horizontally by a 16 (1.5mm) gauge galvanized shim. Load distribution plates shall be used as required.
            b) Pads shall be Type Super "W" as manufactured by Mason Industries, Inc.
        2) Specification 2 – Bridge-Bearing Neoprene Mountings:
            a) Bridge-bearing neoprene mountings shall have a minimum static deflection of 0.2" (5mm) and all directional seismic capability. The mount shall consist of a ductile iron casting containing two separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge-bearing specifications. Mountings shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings.
            b) Mountings shall be Type BR as manufactured by Mason Industries, Inc.
        3) Specification 3 – Bushing Assemblies:
            a) Sheet metal panels shall be bolted to the walls or supporting structure by assemblies consisting of a neoprene bushing cushioned between 2 steel sleeves. The outer sleeve prevents the sheet metal from cutting into the neoprene. Enlarge panel holes as required. Neoprene elements pass over the bushing to cushion the back panel horizontally. A steel disc covers the inside neoprene element and the inner steel sleeve is elongated to act as a stop so tightening the anchor bolts does not interfere with panel isolation in 3 planes. Bushing assemblies can be applied to the ends of steel cross members where applicable. All neoprene shall be bridge bearing quality.
            b) Bushing assemblies shall be type PB as manufactured by Mason Industries, Inc.
        4) Specification 4 - Neoprene Bushing:
            a) A one piece molded bridge bearing neoprene washer/bushing. The bushing shall surround the anchor bolt and have a flat washer face to avoid metal to metal contact.
            b) Neoprene bushings shall be type HG as manufactured by Mason Industries, Inc.

5) Specification 5 – Spring Isolators:

   a) Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4" (6mm) neoprene acoustical friction pad 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 deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height.

   b) Mountings shall be Type SLF as manufactured by Mason Industries, Inc.

6) Specification 6 – Restrained Spring Mountings:

   a) Restrained spring mountings shall have an SLF mounting as described in Specification 5, within a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking

      during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of 1/2" (12mm) 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 operation. Since housings will be bolted or welded in position there must

      be an internal isolation pad. Housing shall be designed to resist all seismic forces. Mountings shall have Anchorage Preapproval "R" Number from OSHPD in the state of California certifying the maximum certified horizontal and vertical load ratings.

      b) Mountings shall be SLR as manufactured by Mason Industries, Inc.

7) Specification 7 – Spring Mountings:

   a) Spring mountings as in specification 5 built into a ductile iron or steel housing to provide all directional seismic snubbing. The snubber shall be adjustable vertically and allow a maximum of 1/4" (6mm) travel in all directions before contacting the resilient snubbing collars. Mountings shall have an Anchorage Preapproval "R" number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings.

   b) Mountings shall be SSLFH as manufactured by Mason Industries, Inc.

8) Specification 8 – Air Springs:

   a) Air Springs shall be manufactured with upper and lower steel sections connected by a replaceable flexible nylon reinforced neoprene element. Air spring configuration shall be multiple bellows to achieve a maximum natural frequency of 3 Hz. Air Springs shall be designed for a burst pressure that is a minimum of three times the published maximum operating pressure. All air spring systems shall be connected to either the building control air or a supplementary air supply and equipped with three leveling valves to maintain leveling within plus or minus 1/8" (3mm). Submittals shall include natural frequency, load and damping tests performed by an independent lab or acoustician.

   b) Air Springs shall be Type MT and leveling valves Type LV as manufactured by Mason Industries, Inc.

9) Specification 9 – Restrained Air Springs:

   a) Restrained air spring mountings shall have an MT air spring as described in Specification

8, within a rigid housing that includes vertical limit stops to prevent air spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of 1/2" (12mm) shall be maintained around restraining bolts and between the housing and the air spring so as not to interfere with the air spring action. Limit stops shall be out of contact during normal operation. Housing shall be designed to resist all seismic forces.

b) Mountings shall be SLR-MT as manufactured by Mason Industries, Inc.

10) Specification 10 – Hangers:

a) Hangers shall consist of rigid steel frames containing minimum 1 1/4" (32mm) thick neoprene elements at the top and a steel spring with general characteristics as in specification 5 seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. To maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30o arc from side to side before contacting the rod bushing and short circuiting the spring. Submittals shall include a hanger drawing showing the 30o capability.

b) Hangers shall be type 30N as manufactured by Mason Industries, Inc.

11) Specification 11 – Hangers:

a) Hangers shall be as described in 10, but they shall be pre-compressed and locked at the rated deflection by means of a resilient seismic upstop 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 drawing of the hanger showing the 30o capability.

b) Hangers shall be type PC30N as manufactured by Mason Industries, Inc.

12) Specification 12 - Seismic Cable Restraints:

a) Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint. Cables must be pre-stretched to achieve a certified minimum modulus of elasticity. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two clamping bolts to provide

proper cable engagement. Cables must not be allowed to bend across sharp edges. Cable assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified load ratings.

b) Cable assemblies shall be Type SCB at the ceiling and at the clevis bolt, SCBH between the hanger rod nut and the clevis or SCBV if clamped to a beam all as manufactured by Mason Industries, Inc.

13) Specification 13 – Seismic Solid Braces:

a) Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint. Seismic solid brace end connectors shall be steel assemblies that swivel to the final installation angle and

utilize two through bolts to provide proper attachment. Seismic solid brace assembly shall have anchorage preapproval "R" number from OSHPD in the state of California verifying the maximum certified load ratings.

b) Solid seismic brace assemblies shall be type SSB as manufactured by Mason Industries, Inc.

14) Specification 14 – Rod Clamp Assemblies:

a) Steel angles, sized to prevent buckling, shall be clamped to pipe or equipment rods utilizing a minimum of three ductile iron clamps at each restraint location when required. Welding of support rods is not acceptable. Rod clamp assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California.

b) Rod clamp assemblies shall be Type SRC as manufactured by Mason Industries, Inc.

15) Specification 15 – Clevis Hanger Cross Brace:

a) Pipe clevis cross bolt braces are required in all restraint locations. They shall be special purpose preformed channels deep enough to be held in place by bolts passing over the cross bolt. Clevis cross braces shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California.

b) Clevis cross brace shall be type CCB as manufactured by Mason Industries, Inc.

16) Specification 16 - All-Directional Seismic Snubbers:

a) All-directional seismic snubbers shall consist of interlocking steel members restrained by a one-piece molded neoprene bushing of bridge bearing neoprene. Bushing shall be replaceable and a minimum of 1/4" (6mm) thick. Rated loadings shall not exceed 1000 psi (.7kg/mm2). A minimum air gap of 1/8"(3mm) shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. Snubber end caps shall be removable to allow inspection of internal clearances. Neoprene bushings shall be rotated to insure no short circuits exist before systems are activated.

Snubbers shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings.

b) Snubber shall be Type Z-1225 as manufactured by Mason Industries, Inc.

17) Specification 17 - All-Directional Seismic Snubbers:

a) All directional seismic snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials compounded to bridge bearing specifications. Elastomeric materials shall be replaceable and a minimum of 3/4" (19mm) thick. Rated loadings shall not exceed 1000 psi (.7kg/mm2). Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8" (3mm) nor more than 1/4" (6mm). Snubbers shall be installed with

factory set clearances. The capacity of the seismic snubber at 3/8" (9mm) deflection shall be equal or greater than the load assigned to the mounting grouping controlled by the snubber multiplied by the applicable "G" force. Submittals shall include the load deflection curves up to 1/2" (12mm) deflection in the x, y and z planes. Snubbers shall have an anchorage preapproval "R" number from OSHPD in the state of California verifying the maximum certified horizontal and vertical load ratings.

b) Snubbers shall be series Z-1011 as manufactured by Mason Industries, Inc.

18) Specification 18 – Stud Wedges:

a) Stud wedge anchors shall be manufactured from full diameter wire, not from undersized wire that is "rolled up" to create the thread. The stud anchor shall also have a safety shoulder which fully supports the wedge ring under load. The stud anchors shall have an evaluation report number from the I.C.B.O Evaluation Service, Inc. verifying its allowable loads.

b) Drill-in stud wedge anchors shall be type SAS as manufactured by Mason Industries, Inc.

19) Specification 19 – Female Wedge Anchors:

a) Female wedge anchors are preferred in floor locations so isolators or equipment can be slid into place after the anchors are installed. Anchors shall be manufactured from full diameter wire, and shall have a safety shoulder to fully support the wedge ring under load. Female wedge anchors shall have an evaluation report number from the I.C.B.O Evaluation Service, Inc. verifying to its allowable loads.

b) Drill-in female wedge anchors shall be type SAB as manufactured by Mason Industries, Inc.

20) Specification 20 – Equipment Bases:

a) Vibration isolation manufacturer shall furnish integral structural steel bases. Rectangular bases are preferred for all equipment. Centrifugal refrigeration machines and pump bases may be T or L shaped where space is a problem. Pump bases for split case pump shall include supports for suction and discharge elbows. All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 14" (350mm) 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 1" (25mm).

b) Bases shall be type WF as manufactured by Mason Industries, Inc.

21) Specification 21 – Inertia Foundations:

a) Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating and inertia foundations. Bases for split case pumps shall be large enough to provide for suction and discharge elbows. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6" (150mm). The base depth need not exceed 12" (300mm) unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of 1/2" (12mm) bars welded in place on

6" (150mm) centers running both ways in a layer 1 1/2" (38mm) above the bottom. Forms shall be furnished with steel templates to hold the anchor bolts sleeves and anchors while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a 1" (25mm) clearance below the base. Wooden formed bases leaving a concrete rather than a steel finish are not acceptable.

b) Base shall be type BMK or K as manufactured by Mason Industries, Inc.

22) Specification 22 – Curbs:

a) Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind and seismic

forces. All directional neoprene snubber bushings shall be a minimum of 1/4" (6mm) thick. Steel springs shall be laterally stable and rest on 1/4" (6mm) thick neoprene acoustical pads. Hardware must be plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curbs waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2" (50mm) of insulation. The roof curbs shall be built to seismically contain the rooftop unit. The unit must be solidly fastened to the top floating rail, and the lower Z section anchored to the roof structure. Curb shall have anchorage preapproval "R" from OSHPD in the state of California attesting to the maximum certified horizontal and vertical load ratings.

b) Curb shall be type RSC as manufactured by Mason Industries, Inc.

23) Specification 23 – Expansion Joints:

a) Flexible spherical expansion joints shall employ peroxide cured EPDM in the covers, liners and Kevlar7 tire cord frictioning. Any substitutions must have equal or superior physical and chemical characteristics. Solid steel rings shall be used within the raised face rubber flanged ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes 2" (50mm) and larger shall have two spheres reinforced with a ductile iron external ring between spheres. Flanges shall be split ductile iron or steel with hooked or similar interlocks. Sizes 16" (400mm) to 24" (600mm) may be single sphere. Sizes 3/4" (19mm) to 1 2" (38mm) may have threaded two piece bolted flange assemblies, one sphere and cable retention. Connectors shall be rated at 250 psi (1.72MPa) up to 170o F (77oC) with a uniform drop in allowable pressure to 215 psi (1.48MPa)at 250o F (121oC) in sizes through 14"(350mm). 16" (400mm) through 24" (600mm) single sphere minimum ratings are 180 psi (1.24MPa) at 170o F (77oC) and 150 psi (1.03 MPa) at 250o F (121oC). Higher rated connectors may be used to accommodate

service conditions. All expansion joints must be factory tested to 150% of rated pressure for 12 minutes before shipment. Safety factors to burst and flange pullout shall be a minimum of 3/1. Concentric reducers to the above ratings may be substituted for equal ended expansion joints.

b) Expansion joints shall be installed in piping gaps equal to the length of the expansion joints under pressure. Control rods need only be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods. If control rods are used, they must have 2" (12mm) thick Neoprene washer bushings large enough in diameter to take the thrust at 1000 psi (.7 kg/mm2) maximum on the washer area.

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 on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves.

d) Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc.

24) Specification 24 – Flexible Stainless Steel Hoses

a) Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3" (75mm) and larger shall be flanged. Smaller sizes shall have male nipples. Minimum

lengths shall be as tabulated:

Flanged		Male Nipples	
3 x 14	10 x 26	1/2 x 9	1 1/2 x 13
4 x 15	12 x 28	3/4 x 10	2 x 14
5 x 19	14 x 30	1 x 11	2 1/2 x 18
6 x 20	16 x 32	1 1/4 x 12	
8 x 22			

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

c) Hoses shall be type BSS as manufactured by Mason Industries, Inc.

25) Specification 25 - All-Directional Acoustical Pipe Anchor:

a) All-directional acoustical pipe anchor, consisting of two sizes of steel tubing separated by a minimum 1/2" (12mm) thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 psi (.35 kg/mm2) and the design shall be balanced for equal resistance in any direction.

b) All-directional anchors shall be type ADA as manufactured by Mason Industries, Inc.

26) Specification 26 – Pipe Guides:

a) Pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2" (12mm) thickness of 60 durometer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and reinsertable.

to allow for selection of pipe movement. Guides shall be capable of + 1 5/8" (41mm) motion, or to meet location requirements.

b) Pipe guides shall be type VSG as manufactured by Mason Industries, Inc.

27) Specification 27 - Split Wall Seals:

a) Split Wall Seals consist of two bolted pipe halves with minimum 3/4" (19mm) thick neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum of l" (25mm) past either face of the wall. Where temperatures exceed 240o F (115oC), 10# (4.5kg) density fiberglass may be used in lieu of the sponge.

b) Seals shall be Type SWS as manufactured by Mason Industries, Inc.

28) Specification 28 - Horizontal Thrust Restraint:

a) The horizontal thrust restraint shall consist of a spring element in series with a neoprene molded cup as described in specification 5 with the same deflection as

specified for the mountings or hangers. The spring element shall be designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4" (6mm) movement at start and stop. The assembly shall be furnished with 1 rod and angle brackets for attachment to both the equipment and the duct work or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrical on either side of the unit.

b) Horizontal thrust restraints shall be type WBI/WBD as manufactured by Mason Industries, Inc.

C. Execution:

1. General:

a. Vibration isolators and seismic restraint systems shall control excessive noise and vibration in the buildings due to the operation of machinery or equipment, and/or due to interconnected piping, ductwork, or conduit. [The installation of all vibration isolators and seismic restraint units, and associated hangers and bases, shall be under the direct supervision of the vibration isolation manufacturer's representative.]

b. All vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

c. Installation of vibration isolators and seismic restraints must not cause any change of position of equipment, piping or ductwork resulting in stresses or misalignment.

d. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

e. The contractor shall not install any equipment, piping, duct or conduit that makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.

f. Coordinate work with other trades to avoid rigid contact with the building.

g. Any conflicts with other trades that will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the architects/engineers attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor’s expense.

h. Bring to the architects/engineers attention any discrepancies between the specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible contractor’s expense.

i. Correct, at no additional cost, all installations that are deemed defective in workmanship and materials at the contractor’s expense.

j. Overstressing of the building structure must not occur because of overhead support of equipment. Contractor must submit loads to the structural engineer of record for approval. Generally bracing may occur from:

1) Flanges of structural beams.

2) Upper truss cords in bar joist construction.

3) Cast in place inserts or wedge type drill-in concrete anchors.

k. Specification 12 cable restraints shall be installed slightly slack to avoid short circuiting the isolated suspended equipment, piping or conduit.

l. Specification 12 cable assemblies are installed taut on non-isolated systems. Specification 13 seismic solid braces may be used in place of cables on rigidly attached systems only.

m. At locations where specification 12 or 13 restraints are located, the support rods must be braced when necessary to accept compressive loads with specification 14 braces.

n. At all locations where specification 12 or 13 restraints are attached to pipe clevis's, the clevis cross bolt must be reinforced with specification type 15 braces.

o. Drill-in concrete anchors for ceiling and wall installation shall be specification type 18, and specification type 19 female wedge type for floor mounted equipment.

p. Vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not permitted on this project. Each fan and motor assembly shall be supported on a single structural steel frame.

q. Hand built elastomeric expansion joints may be used when pipe sizes exceed 24" or specified movements exceed specification 23 capabilities.

r. Where piping passes through walls, floors or ceilings the vibration isolation manufacturer shall provide specification 27 wall seals.

s. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust in relation to the equipment weight. Horizontal thrust restraint shall be specification type 28 (see selection guide).

t. Locate isolation hangers as near to the overhead support structure as possible.

u. Provide resiliently mounted equipment, piping, and ductwork with seismic snubbers. Each inertia base shall have minimum of four seismic snubbers located close to isolators. Snub equipment designated for post disaster use to 0.05 inch (1.5 mm) maximum clearance. Other snubbers shall have clearance between 0.15 inch (4 mm) and 0.25 inch (7 mm).

2. Vibration Isolation and Seismic Restraint Installation:

a. Horizontal pipe isolation: The first three pipe hangers in the main lines near the mechanical equipment shall be as described in specification 11. Specification 11 hangers must also be used in all transverse braced isolated locations. Brace hanger rods with SRC clamps specification 14. Horizontal runs in all other locations throughout the building shall be isolated by hangers as described in specification 10. Floor supported piping shall rest on isolators as described in specification 6. Heat exchanger's and expansion tanks are considered part of the piping run. The first three isolators from the isolated equipment 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 ceilings under occupied spaces the first three hangers shall have 0.75" (19mm) deflection for pipe sizes up to and including 3" (75mm), 1 1/2" (38mm) deflection for pipe sizes up to and including 6" (150mm), and 2 1/2" (64mm) deflection

thereafter. Hangers shall be located as close to the overhead structure as practical. Where piping connects to mechanical equipment install specification 23 expansion joints or specification 24 stainless hoses if 23 is not suitable for the service.

b. Riser isolation: Risers shall be suspended from specification 10 hangers or supported by specification 5 mountings, anchored with specification 25 anchors, and guided with specification

26 sliding guides. Steel springs shall be a minimum of 0.75" (19mm) except in those expansion locations where additional deflection is required to limit load changes to + 25% of the initial load. Submittals must include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on the building structure, spring deflection changes and seismic loads. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist in the proposed design.

c. Building expansion joints: Install swing joints at piping crossing expansion joints and brace piping either side of the expansion joint.

d. Seismic Restraint of Piping:

1) Seismically restrain all piping listed as a, b or c below. Use specification 12 cables if isolated. Specification 12 or 13 restraints may be used on unisolated piping.

a) Fuel oil piping, gas piping, medical gas piping, and compressed air piping that is 1" (25mm) I.D. or larger.

b) Piping located in boiler rooms, mechanical equipment rooms, and refrigeration equipment rooms that is 1 1/4" (32mm) I.D. and larger.

c) All other piping 2 1/2" (64mm) diameter and larger.

2) Transverse piping restraints shall be at 40' (12m) maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

3) Longitudinal restraints shall be at 80' (24m) maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

4) Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.

5) For fuel oil and all gas piping transverse restraints must be at 20' (6m) maximum and longitudinal restraints at 40' (12m) maximum spacing.

6) Transverse restraint for one pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24" (600m) of the elbow or TEE or combined stresses are within allowable limits at longer distances.

7) Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.

8) Branch lines may not be used to restrain main lines.

9) Cast iron pipe of all types, glass pipe and any other pipes joined with a four band shield and clamp assembly in Zones 2B, 3 and 4 shall be braced as in sections 3.2.D.2 and 3. For Zones 0, 1 and 2A, 2 band clamps may be used with reduced spacings of 1/2 of those listed in sections 3.2.D.2 and 3.

e. Vibration Isolation of Ductwork:

1) All discharge runs for a distance of 50' (15m) from the connected equipment shall be isolated from the building structure by means of specification 10 hangers or specification 5 floor isolators. Spring deflection shall be a minimum of 0.75" (19mm).

2) All duct runs having air velocity of 1000 fpm (5 m/s) or more shall be isolated from the building structure by specification 11 hangers or specification 5 floor supports. Spring

deflection shall be a minimum of 0.75" (19mm).

3) Flexible duct connections shall be provided at inlet and discharge ducts. Refer to Section 15 91 00.

f. Seismic Restraint of Ductwork:

1) Seismically restrain all duct work with specification 12 or 13 restraints as listed below:

a) Restrain rectangular ducts with cross sectional area of 6 sq.ft. (.5 m2) or larger.

b) Restrain round ducts with diameters of 28" (700mm) or larger.

c) Restrain flat oval ducts the same as rectangular ducts of the same nominal size.

2) Transverse restraints shall occur at 30' (9mm) intervals or at both ends of the duct run if less than the specified interval. Transverse restraints shall be installed at each duct turn and at each end of a duct run.

3) Longitudinal restraints shall occur at 60' (18m) intervals with at least one restraint per duct run. Transverse restraints for one duct section may also act as a longitudinal restraint for a duct section connected perpendicular to it if the restraints are installed within 4' (1.2m) of the intersection of the ducts and if the restraints are sized for the larger duct. Duct joints shall conform to SMACNA duct construction standards.

4) The ductwork must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze.

5) A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.

6) Walls, including gypsum board non-bearing partitions, which have ducts running through them may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.

7) Chimneys and stacks passing through floors are to be bolted at each floor level or secured above and below each floor with riser clamps and specification type 13 for seismic solid brace restraints.

8) Chimneys and stacks running horizontally to be braced every 30’ with specification type 12 seismic cable restraints or specification type 13 for seismic solid brace restraints.

g. Seismic Restraint of Electrical Services:

1) All electrical conduit 2 1/2" (64mm) in diameter and larger shall be restrained with specification type 12 seismic cable restraints or specification type 13 for seismic solid brace restraints.

2) All electrical bus ducts, cable trays and ladder trays shall be restrained with specification type 12, seismic cable restraints or specification 13 seismic solid brace restraints.

3) Transverse restraints shall occur at 30' (9m) intervals or both ends if the electrical run is less than the specified interval. Transverse restraints shall be installed at each electrical services turn and at each end of the electric run.

4) Longitudinal restraints shall occur at 60' (9m) intervals with at least one restraint per electric run. Transverse restraints for one electric section may also act as a longitudinal restraint for a

duct for an electric section connected perpendicular to it if the restraints are installed within 4' (1.2m) of the intersection of the electric run and if the restraints are sized for the larger electric run.

5) All rigid floor mounted equipment must have a resilient media between the equipment mounting hole and the anchor bolt. Anchor bolts shall be designed in accordance with section 1.9 seismic forces. Neoprene bushings shall be specification type 4 and anchor bolts shall be specification type 18 or 19.

6) Wall mounted panels shall be mounted with specification type 3 bushings. Floor mounted panels shall be mounted on specification type 4 bushings. Anchor bolts shall be specification type 18 or 19.

h. All fire protection piping shall be braced in accordance with NFPA 13 and 14.

i. Vibration Isolation and Seismic Restraint of Mechanical Equipment

1) All mechanical equipment shall be vibration isolated and seismically restrained as per the schedules in part 3.5 of this specification.

2) Equipment mounted on housekeeping pads: Pads shall be properly doweled or expansion shielded to deck to meet acceleration criteria.

3) Requirements for installation on concrete inertia bases shall be as follows:

a) Minimum operating clearance between concrete inertia and base and housekeeping pad or floor shall be 2".

b) The equipment structural steel or concrete inertia base shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the machine or isolators.

c) The isolators shall be installed without raising the machine and frame assembly.

d) After the entire installation is complete and under full operational load, the isolators shall be adjusted so that the load is transferred from the blocks to the isolators. When all isolators are properly adjusted, the blocks or shims shall be barely free and shall be removed.

e) Install equipment with flexibility in wiring connection.

f) Verify that all installed isolator and mounting systems permit equipment motion in all directions. Adjust or provide additional resilient restraints to flexibly limit start-up equipment lateral motion to 1/4".

g) Prior to start-up, clean out all foreign matter between bases and equipment. Verify that there are no isolation short circuits in the base, isolators, or seismic restraints.

3. Seismic Restraint Exclusions:

a. General: All mechanical and electrical components and systems that are considered exempt from the requirement for seismic restraint, in accordance with The International Building Code – 2003, Section 1621, shall not require seismic restraint.

b. Piping:

1) Piping in boiler and mechanical rooms less than 1 1/4" (32mm) inside diameter.

2) All other piping less than 2 1/2" (64mm) inside diameter.

3) All piping suspended by individual hangers 12" (300mm) or less as measured from the top of the pipe to the bottom of the support where the hanger is attached. However, if the 12" (300mm) limit is exceeded by any hanger in the run, seismic bracing is required for the run.

4) The 12" (300mm) exemption applies for trapeze supported systems if the top of each item supported by the trapeze qualifies.

c. Ductwork:

1) Rectangular and square and ducts that are less than 6 square feet in cross sectional area.

2) Oval ducts that are less than 6 square feet (.5m2) in cross sectional area based on nominal size.

3) Round duct less than 28" (.5m2) in diameter.

4) All duct suspended by hangers 12" (300mm) or less in length as measured from the top of the duct to the point of attachment to the structure. Hangers must be attached within 2" (50mm) of the top of the duct with a minimum of two #10 sheet metal screws. If the 12" (300mm) limit is exceeded by any hanger in the run, seismic bracing is required for the run.

d. Electrical:

1) All conduit less than 2 1/2" (64mm) diameter suspended by individual hanger rods.

2) All conduits suspended by individual hangers 12" (300mm) or less as measured from the top of the conduit to the bottom of the support where the hanger is a attached. However, if the 12" (300mm) limit is exceeded by any hanger in the run, seismic bracing is required for the run.

3) The 12" (300mm) exemption applies for trapeze supported systems if the top of each item supported by the trapeze qualifies.

4. Inspection:

a. Examine systems under provisions of Division 1.

b. On completion of installation of all vibration isolation devices herein specified, the local representative shall inspect the completed system and report in writing any installation error, improperly elected isolation devices, or other faults in the system that could affect the performance of the system. Contractor shall submit a report to the Owner, including the manufacturers representatives' final report, indicating all isolation reported as properly installed or requiring correction, and include a report by the Contractor on steps taken to properly complete the isolation work.

5. Schedules:

	ISOLATION, DEFLECTION AND SEISMIC RESTRAINT CRITERIA FOR SOLID CONCRETE FLOORS 4" AND THICKER (NOTE 7)									
	Ground Supported Slab or Basement		20' Floor Span Possible Floor Defl. – 0.67"		30' Floor Span Possible Floor Defl. – 1.0"		40' Floor Span Possible Floor Defl. – 1.33"		50' Floor Span Possible Floor Defl. – 1.67"	
SPECIFICATION SELECTION GUIDE	Isol. & Seismic Spec.	Isol. Defl.	Isol. & Seismic Spec.	Isol. Defl.	Isol. & Seismic Spec.	Isol. Defl.	Isol. & Seismic Spec.	Isol. Defl.	Isol. & Seismic Spec.	Isol. Defl.
REFRIG. MACHINES										
Reciprocating Chillers or Heat Pumps										
500 rpm to 750 rpm	6-23	0.75	6-23	1.5	6-23	1.5	6-20-23	2.5	6-20-23	3.5
751 rpm and Over	6-23	0.75	6-23	0.75	6-20-23	1.5	6-20-23	2.5	6-20-23	3.5
PUMPS										
Closed Coupled										
Thru 5 hp	2-21-23	0.35	5-16-21-23	0.75	5-16-21-23	0.75	5-16-21-23	1.5	5-16-21-23	1.5
7 ½ hp and Larger	5-16-21-23	0.75	5-16-21-23	0.75	5-16-21-23	1.5	5-16-21-23	1.5	5-16-21-23	2.5
FACTORY ASSEMBLED H & V UNITS										
Curb Mounted Roof Top Units			22	1.0	22	2.5	22	2.5	22	2.5
Suspended Units (for Fan Heads see Blowers Guide)										
Thru 5 hp	10-12	1.0	10-12	1.0	10-12	1.0	10-12	1.0	10-12	1.0
7 ½ hp and Larger – 275 rpm to 400 rpm	10-12	1.5	10-12	1.5	10-12	1.5	10-12	1.5	10-12	1.5

SPECIFICATION SELECTION GUIDE	ISOLATION, DEFLECTION AND SEISMIC RESTRAINT CRITERIA FOR SOLID CONCRETE FLOORS 4" AND THICKER (NOTE 7)									
	Ground Supported Slab or Basement		20' Floor Span Possible Floor Defl. – 0.67"		30' Floor Span Possible Floor Defl. – 1.0"		40' Floor Span Possible Floor Defl. – 1.33"		50' Floor Span Possible Floor Defl. – 1.67"	
	Isol. & Seismic Spec.	Isol. Defl.	Isol. & Seismic Spec.	Isol. Defl.	Isol. & Seismic Spec.	Isol. Defl.	Isol. & Seismic Spec.	Isol. Defl.	Isol. & Seismic Spec.	Isol. Defl.
7 ½ hp and Larger – 401 rpm and Over	10-12	1.0	10-12	1.0	10-12	1.0	10-12	1.5	10-12	2.5
AIR COMPRESSOR										
Tank Mounted Type	5-16-21-24	0.75	5-16-21-24	0.75	5-16-21-24	1.5	5-16-21-24	2.5	5-16-21-24	3.5
V – W Type	5-16-21-24	0.75	5-16-21-24	0.75	5-16-21-24	1.5	5-16-21-24	2.5	5-16-21-24	3.5
Horz, Vert, 1 or 2 Cylinders										
275 rpm to 499 rpm	5-16-21-24	2.5	5-16-21-24	2.5	5-16-21-24	2.5	5-16-21-24	3.5	5-16-21-24	3.5
500 rpm to 800 rpm	5-16-21-24	1.5	5-16-21-24	1.5	5-16-21-24	2.5	5-16-21-24	3.5	5-16-21-24	3.5

SPECIFICATION SELECTION GUIDE	DEFLECTION AND MOUNTING CRITERIA FOR SOLID CONCRETE FLOORS 4" OR THICKER (NOTE 7)					
	Ground Supported Slab or Basement		20' Floor Span Possible Floor Defl. – 0.67"	30' Floor Span Possible Floor Defl. – 1.0"	40' Floor Span Possible Floor Defl. – 1.33"	50' Floor Span Possible Floor Defl. – 1.67"
	Engr Spec	Min Static Defl (in) (note 1)	Engineer Specifications and Minimum Static Deflection as tabulated below (note 1)			
Blowers						
Utilities Set						

	DEFLECTION AND MOUNTING CRITERIA FOR SOLID CONCRETE FLOORS 4" OR THICKER (NOTE 7)					
	Ground Supported Slab or Basement		20' Floor Span Possible Floor Defl. – 0.67"	30' Floor Span Possible Floor Defl. – 1.0"	40' Floor Span Possible Floor Defl. – 1.33"	50' Floor Span Possible Floor Defl. – 1.67"
SPECIFICATION SELECTION GUIDE	Engr Spec	Min Static Defl (in) (note 1)	Engineer Specifications and Minimum Static Deflection as tabulated below (note 1)			
Floor Mounted (note 5)	2	0.35	Spec 7 for 0.75" and 1/5" deflection and Spec 5-20-16 for over 1.5" deflection with deflection from Blower Minimum Deflection Guide, but not to exceed 2.5"			
Roof Mounted			Spec 5-21-16 with deflection from Blower Minimum Deflection Guide. If roof will not handle concrete base load use Spec 6 for 0.75 and 1.5" deflection and Spec 6-20 for over 1.5" deflection			
Suspended Unit (note 5)			Spec 10-12 with deflection from Blower Minimum Deflection Guide, not to exceed 2.5" deflection			
Centrifugal Blowers (note 6)	2-21	0.35	Spec 5-21-16 with deflection from Blower Minimum Deflection Guide			
Fan Heads						
Floor Mounted	2-28	0.35	Spec 7-28 if 0.75" or 1.5" deflection or Spec 5-20-16-28 for deflection over 1.5" to 4.5" from Blower Minimum Deflection Guide.			
Suspended Units			Spec 10-12-28 with deflection from Blower Minimum Deflection Guide			
Tubular Centrifugal and Axial Fans						
Suspended Units			Spec 10-12 with deflection from Blower Minimum Deflection Guide, Spec 10-12-28 for over 4" static pressure			
Floor Mounted with Motor on/in Fan Casing	2	0.35	Spec 7 for 0.75" to 1.5" deflection and Spec 5-20-16 for over 1/5" deflection with deflection from Blower Minimum Deflection Guide, Spec 5-21-16 or 5-16-28 for over 4" static pressure			
Floor Mounted Arrangement 1 or any Separately Mounted Motor	2-21	0.35	Spec 5-21-16 with deflection from Blower Minimum Deflection Guide			
Cooling Towers & Condensing Units	2	0.35	Spec 6 with deflection from Blower Minimum Deflection Guide			

Blower Minimum Deflection Guide					
Fan Speed RPM	Required Deflection for Ground Supported Slab or Basement	Required Deflection for 20’ Floor Span	Required Deflection for 30’ Floor Span	Required Deflection for 40’ Floor Span	Required Deflection for 50’ Floor Span
500 and up	0.35”	0.75”	1.5”	2.5”	3.5”
375-499	0.35”	1.5”	2.5”	3.5”	3.5”
300-374	0.35”	2.5”	2.5”	3.5”	3.5”
225-299	0.35”	3.5”	3.5”	3.5”	3.5”
175-225	0.35”	3.5”	4.5”	4.5”	4.5”
When blowers are 60 HP or larger, select deflection requirements for next larger span. A minimum of 2.5" should be used unless larger deflections are called for on the chart or these fans are located in the lowest sub-basement or on a slab on grade.					

6. Notes:
   a. Minimum deflection called for in this specification are not 'nominal' but certifiable minimums. The 0.75", 1.5", 2.5", 3.5", and 4.5" minimums should be selected from manufacturer’s nominal 1", 2", 3", 4" and 5" series respectively. Air spring isolation specifications 8 & 9 may be substituted for steel springs above in highly sensitive noise free locations.
   b. Vacuum, Condensate or Boiler Feed Pumps shall be mounted with their tanks on a common spec. 21 base with deflections as specified for base mounted pumps.
   c. The base described in specification 20 is used under the drive side. Individual mountings as described in specification 6 are used under the Cooler and Condenser.
   d. This type of compressor is highly unbalanced and sometimes requires inertia bases weighing 5 to 7 times equipment weight to reduce running motion.
   e. Limit deflection f or utility sets 18" wheel diameter and smaller to 1 1/2".
   f. FLOATING CONCRETE INERTIA BASES. Floating concrete inertia bases do not reduce vibration transmitted to the structure through the mountings. These bases will reduce vibratory motion, provide a very rigid machine base and minimize spring reactions to fan thrust. Engineers preferring steel bases rather than the concrete mentioned above in specification 5-21 should change the designation to 5-20. Concrete is preferred for all fans operating at static pressure above 4" and on roof tops.
   g. LIGHT FLOOR CONSTRUCTION. When floors or roofs are lighter than 4" solid concrete a localized mass shall be introduce under the vibration mountings in the form of a sub-base. This sub-base should be 12" thick and 12" longer and wider than the mechanical equipment above it. When this mass is provided the 30' minimum static deflection requirements will suffice even in longer bays. The mass is also useful for unusually large bays over 50'. When floors are lighter than the 4" concrete or the location is in a particularly sensitive area and the mass described above cannot be introduced, select deflection requirements for the next larger span.
   h. For equipment where increased resiliency and decreased accelerations are required change

specification 16 snubbers to specification 17 snubbers.

2.18 ROOF PENETRATION SYSTEM

A. Manufacturers:

1. Acceptable Manufacturer: Roof Penetration Housings, or engineer approved equal.

2. Warranty: Product to Carry a 20-Year Limited Insured Warranty.

B. The Vault®:

1. Product: The Vault® by Roof Penetration Housings.

2. Construction:
   a. 0.080 inch (2mm) thick aluminum housing and curb.
   b. UV protected powder coated finish (2 mil (.05 mm) thick).
   c. Stainless Steel. V.P. fasteners.
   d. Gasketed lid to housing and housing to curb connection joints to ensure compliance to ICC 2015 Air Permeance Levels.
   e. Standard Color: Bright White to meet an initial SRI of 88.2 .
   f. Seismic Available upon request. Seismic calculations, conditions to be furnished to RPH by engineer.
   g. Constructed to withstand wind to 225+ MPH, third party tested.

C. Style & Sizes:

1. Series AWI Vault – All Aluminum Construction, Zero Plastic, Wind rated to +225 mph and pre-insulated (R-2 for Condensate) V.P./S.S. Fasteners meets ICC 2015 Energy Code for Air Permeance Levels. Pre-Insulated curb, 6” Thick, R-40 Factor, to meet ICC – 2015 Energy Code.
   a. Small Vault®
      1) Model: AWI-161010
      2) L – 16 ½” W – 9 ¾” H – 10”
   b. Medium Vault®
      1) Model: AWI-201412
      2) L – 20 ½” W – 14 ½” H – 12”
   c. Mega Vault®
      1) Model: AWI-343424
      2) L – 34” W – 34” H – 24”
         a) NOTES:
            (1) Exit Seal capacities are dependent on size of seals required. Based on Series 5000.

(2) Products shown may not reflect current design refinements. Dimensions may vary.

d. ICE Pre-Insulated curb extension: Aluminum Extension between housing and curb is 7" wide on each side of Vault® to accommodate 6" Insulation (R-40 Rating) supplied by RPH on the outside of the curb, +1" to accommodate roofing material.

1) NOTE: Sizes above – housing only – Specifier to choose:

a) 14" or 18" curb (18" recommended for AWI Series).

b) Add curb height to housing height less 3" for overlap.

2. Exit Seals: Design: Weather tight seal for vertical surface/plane penetrations. Seal construction to be manufactured in all aluminum construction and 100% Sil-X-14 silicone gaskets.

a. Series 5000 - .25" to 1.90"

b. Series 6000 – 2" to 3.125"

c. Series 7000 – 3.5" Large Diameter Double Gasketed inside and out

d. Penetration Pipe Type as Applicable: Copper K and L, copper ACR, steel Schedule 40, PVC Schedule 40 and 80, electrical EMT, electrical rigid, aluminum, liquid light, and A/C or Plumbing Ducts.

2.19 DEDICATED OUTDOOR AIR UNITS (PACKAGED)

A. General

1. Section Includes:

a. Packaged outdoor air unit.

b. Dehumidification/Cooling.

c. Heating.

d. Electrical Ratings and Connections

e. Unit Controls

f. Powered Exhaust

g. Energy Recovery

h. Roof curb

i. Execution

2. References:

a. ANSI/AHRI Standard 920 (I-P) 2020 - "Performance Rating of Direct-Expansion Dedicated Outdoor Air System Units"

b. ANSI/ASHRAE 15-2019 - "Safety Standard for Refrigeration Systems"

c. ANSI/ASHRAE/IES 90.1-2022 – "Energy Standard for New Buildings Except Low-Rise Residential Buildings"

d. Safety of Household And Similar Electrical Appliances, Part 1: General Requirements UL60335-

1:2016 Ed.6 and CSA C22.2#60335-1:2016 Ed.2

e. Household and Similar Electrical Appliances – Safety - Part 2 - 40: Particular Requirements for Electrical Heat Pumps, Air-Conditioners, and Dehumidifiers UL 60335-2-40:2022 Ed.4 and CSA C22.2#60335-2-40:2022 Ed.4

f. ANSI Z83.4-2017/CSA 3.7-2017 – "Non-recirculating direct gas-fired heating and forced ventilation appliances for commercial and industrial application"; ANSI Z83.8-2016/ CSA 2.6-2016 – "Gas unit heaters, gas packaged heaters, gas utility heaters, and gas-fired duct furnaces"

g. ANSI/NFPA 70 - National Electric Code 2023

h. International Fuel Gas Code (2021) & CMR 4.00- Massachusetts Fuel and Gas Code

i. NFPA 90 A (2024) – "Standard for the Installation of Air-Conditioning and Ventilating Systems"; NFPA 90B (2024) – "Standard for the Installation of Warm Air Heating and Air-Conditioning Systems"

j. CMR 4.00- Massachusetts Fuel and Gas Code (2021)

3. Submittals:

a. Submit unit performance data including capacity, nominal and operating performance.

b. Submit Mechanical Specifications for unit and accessories describing construction, components, and options.

c. Submit drawings indicating overall dimensions as well as installation, operation and services clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.

d. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety and start-up instructions.

e. Drawings submitted for approval shall be accompanied by a copy of the purchase agreement between the Contractor and an authorized service representative of the manufacturer for check, test and start up and first year service.

4. Delivery, Storage and Handling:

a. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

b. Protect units from physical damage. Leave factory shipping covers in place until installation.

c. Units to be secured via base rail tie-down locations.

5. Warranty:

a. Provide parts warranty extending either 12-months from date of unit start-up or a maximum of 18-months from unit ship date.

b. Provide twenty-five-year heat exchanger limited warranty from unit ship date.

c. 5-year compressor warranty for units 25 tons and below.

d. OPTION: The manufacturer shall furnish an alternative price for:

1) Extended 5-year compressor warranty for units above 25 tons.

2) Extended parts and labor by manufacturer to be provided to the owner for a period up to 5

years.

6. Maintenance Service:
   a. Furnish complete parts and labor service and maintenance of packaged outdoor air units for five years from Date of Substantial Completion
   b. Provide maintenance service with a two-month interval as maximum time period between calls. Provide 24-hour emergency service on breakdowns and malfunctions.
   c. Include maintenance items as outlined in manufacturer's operating and maintenance data.
   d. Submit copy of service call work order or report and include description of work performed.
   e. Must have twenty factory-certified and factory-trained technicians within a four-hour radius of the jobsite.

7. Regulatory Requirements:
   a. Unit shall conform to the appropriate standards listed in Section 103 as well as be listed and labeled by a Nationally Recognized Testing Laboratory (NRTL) for compliance with the following applicable standards.
   b. Household and Similar Electrical Appliances – Safety - Part 2 - 40: Particular Requirements for Electrical Heat Pumps, Air-Conditioners, and Dehumidifiers [UL 60335-2-40:2022 Ed.4] and [CSA C22.2#60335-2-40:2022 Ed.4]
   c. ANSI Z83.4-2017/CSA 3.7-2017 – "Non-recirculating direct gas-fired heating and forced ventilation appliances for commercial and industrial application"; ANSI Z83.8-2016/ CSA 2.6-2016 – "Gas unit heaters, gas packaged heaters, gas utility heaters, and gas-fired duct furnaces"
   d. In the event the unit is not approved by an NRTL for compliance with the appropriate standards, the manufacturer shall, at manufacturer's expense, provide for a field certification and labeling of unit by an NRTL to the appropriate standards. Manufacturer shall, at manufacturer's cost, complete any and all modifications required by NRTL prior to certification and field labeling. Manufacturer shall include coverage of all modifications in unit warranty.

8. Extra Materials:
   a. Provide one set of filters.

B. Products

1. Summary:
   a. The contractor shall furnish and install packaged outdoor air unit(s) as shown and scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the specified conditions as scheduled.
   b. Approved Manufacturers
      1) Trane: Horizon™ Model OA (Packaged Outdoor Air Unit)
      2) Substitutions: as indicated under the general and/or supplemental conditions of these specifications. Bidding contractor shall be responsible for electrical and mechanical and structural modifications required when substituting a product other than the specified product. It shall be the responsibility of the bidding contractor to make the specifier aware of any

modifications. As built drawing changes is the responsibility of the contractor submitting the substitution.

2. General Unit Description:
   a. Unit(s) furnished and installed shall be packaged outdoor air unit(s) as scheduled on contract documents and described in these specifications. Unit(s) shall be designed for dehumidification, cooling and/or heating of 100% Outdoor Air. For dehumidification and cooling modes the evaporator temperature or supply air dewpoint shall be monitored, reported at unit controller. Compressor controls shall modulate capacity to maintain evaporator leaving set point for dehumidification mode. Hot Gas Bypass shall not be used to control compressor capacity. Compressor Hot Gas Reheat (HGRH) shall be factory installed. To prevent rehydration of evaporator condensate the reheat coil face shall be located a minimum of 6" downstream from the leaving face of the evaporator coil. Heating system shall include modulating controls. Compressor on-off only or primary heating on-off only controls shall not be acceptable control strategies.
   b. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.
   c. Unit discharge airflow configuration shall be:
      1) Horizontal discharge through side of unit.

3. Cabinet:
   a. Cabinet panels: 2" double-wall foamed panel with thermal break construction throughout the indoor section of unit to provide nonporous, cleanable interior surfaces. All interior seams exposed to airflow shall be sealed.
   b. Insulation: 2" polyurethane foam metal encapsulated with no exposed edges. Initial R value of 6.6 per inch of thickness.
   c. Cabinet base shall be double wall construction designed to prevent trapping or ponding of water within the unit base. Cabinet floor shall be insulated with 2" double-wall foamed panel with thermal break construction throughout the indoor section of unit to provide nonporous, cleanable interior surfaces. All interior seams exposed to airflow shall be sealed. Insulation shall not be applied to underside of unit base.
   d. Cabinet Base Rails: Side base rails shall include openings for forklift and/or tie-down and lift access. To protect unit base from fork damage side rails shall include removable heavy gauge fork pockets.
   e. Shipping anchors attach to and/or through unit base rails. Straps over unit shall not be used to secure unit for shipping.
   f. Cabinet material interior and base rails: shall be G-90 zinc-coated galvanized steel. Material gauge shall be a minimum of 14-gauge for base rails, 16-gauge for structural members and 22-gauge for access doors and cabinet panels.
   g. Exterior Corrosion Protection: Exterior cabinet panels shall be a base coat of G-90 galvanized steel with both exterior and interior surfaces cleaned, phosphatized, and finished with a weather-resistant baked enamel finish. Unit's surface shall be in compliance with ASTM B117 salt spray testing at a minimum of 672-hour duration.
   h. Cabinet construction shall provide hinged panels providing easy access for all parts requiring routine service.

i. Cabinet top cover shall be one-piece construction or where seams exist, it shall be double-hemmed and gasket-sealed.

j. Hinged Access Panels: Water- and air-tight hinged access panels shall provide access to all areas requiring routine service including air filters, heating section, electrical and control cabinet sections, optional ERV and power exhaust fan section, supply air fan section, evaporator and reheat coil sections. Insulated doors shall be constructed to allow the access door to open in either direction or be removed without removal of a hinge.

1) Latches with locking hasp or tool operated closure devices shall be factory installed on all hinged access panels.

k. Drain Pan material shall be Type 304 Stainless steel drain and constructed to slope in two directions to ensure positive drainage with corners exposed to standing water and drain fittings welded liquid tight to prevent leaks. Pan shall have a minimum depth of 2" and be fully insulated by no less than 1" of R-6.6 insulation.

l. Provide openings on either side of unit or thru the base for power, control, and gas connections.

m. Cabinet shall include optional interior liner constructed of Type 304 stainless steel with sealed seams.

n. Air inlet hood shall be factory installed and shall not require field assembly. Hood shall include 2" thick removable aluminum mesh mist eliminators sized for a velocity not to exceed 500 FPM at maximum unit rated airflow. Service access shall be hinged and held in place with thumb latches that shall not require tools for service access.

o. Unit shall be equipped with a 6" filter rack upstream of the evaporator. Frame shall be field-adjustable to match any filter combination specified in the following section.

4. Air Filters:

a. Unit inlet hood shall include 2" thick aluminum mesh removable mist eliminators with hinged access cover. Inlet velocity shall not exceed 500 FPM.

b. Evaporator Inlet shall include a full complement of pleated media air filters. Filters shall be:

1) 2" deep MERV 13

2) 4" deep MERV 14

5. Dampers:

a. Unit shall include a motor operated outdoor air damper constructed of galvanized steel.

b. Damper blades shall be v-groove design with rubber edge seals designed not to exceed a 4 CFM/SQ FT leakage rate exceeding ASHRAE 90.1 damper leakage requirements. Airfoil design Class 1A rated dampers are optional.

c. Damper actuator shall be factory mounted and wired sealed spring return and either two-position or fully modulating.

d. Dampers air velocity shall not exceed 2000 fpm.

e. OPTIONAL Return Air damper shall be of same material, construction, and leakage rate as outdoor air damper. Return air damper actuator shall be factory mounted and wired sealed spring fully modulating and operate based on outdoor air damper feedback signal to properly regulate RA airflow.

6. Dehumidification/Cooling:
   a. Compressors
   b. All units shall have direct drive, scroll type compressors.
   c. Optional Digital Scroll Compressor
      1) Circuit One
      2) Circuit One and Circuit Two
   d. Motor shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage.
   e. Internal overloads shall be provided with the scroll compressors.
   f. Each compressor shall have a crankcase heater or equivalent to minimize the amount of liquid refrigerant present in the oil sump during off cycles.
   g. Each compressor shall be mounted on rubber vibration isolators, to reduce the transmission of noise.
   h. Provide each unit with 1 hermetically sealed refrigerant circuit(s) factory-supplied completely piped with liquid line filter-drier, liquid line charging port, suction and liquid line pressure ports, sight glass, and thermal expansion valve.
   i. Provide each circuit with automatic reset high and low pressure and high temperature switches for safety control.

7. Coils:
   a. Evaporator, Condenser and Hot Gas Reheat coils shall be constructed with copper tubes mechanically bonded to configured aluminum plate fins.
   b. Coils shall be factory leak tested in accordance ANSI/ASHRAE 15-1992 at a minimum pressure of 500 PSIG.
   c. The condenser coil shall have a fin designed for ease of cleaning.
   d. Evaporator coil shall include (six / four) rows of cooling interlaced for superior sensible and latent cooling with a maximum of 14 FPI for ease of cleaning.
   e. Reheat coil shall be fully integrated into the supply airstream and be capable of delivering design supply air temperature.
   f. To prevent re-hydration of condensate from evaporator coil, the evaporator coil face and the hot gas reheat coil face shall be separated by a minimum of six inches.
   g. Coil Coating: Coil will have a flexible epoxy polymer e-coat uniformly applied to all coil surface areas with no material bridging between fins. The coating process will ensure complete coil encapsulation and a uniform dry film thickness from 0.6 – 1.2 mills on all surface areas including fin edges and meet 5b rating cross hatched adhesion per ASTM B3359- 93.Corrosion durability will be confirmed through testing with no less than 5,000 hours salt spray resistance per ASTM B117-90 using scribed aluminum test school coupons. The coil coating will meet the following test standards:
      1) MIL-C-46168 Chemical Agent Resistance – DS2, HCL Gas
      2) CIDA-A-52474-A (GSA)

3) MIL-STD810F, Method 509.4 (Sand and Dust)

4) MIL-P-53084 (ME)-TACOM Approval

5) MIL-DTL-12468 Decontamination Agent (STB)

6) DPG (Dugway Proving Grounds) Soil & Water Exposure Tests

7) GM9540P-97 Accelerated Corrosion Test (120 cycles)

8) ASTMB117-G85 Modified Salt Spray (Fog) Testing-2,000 hours (tested by ARL for Lockheed Martin)

h. The unit(s) must comply per above - spray coatings not acceptable

i. Condenser coil hail guards shall be factory installed.

8. Condenser Section:

   a. Outdoor Fans: Shall be direct drive vertical discharge design with low-noise corrosion resistant glass reinforced polypropylene props, powder coated wire discharge guards and electro-plated motor mounting brackets.

   b. Fans shall be statically and dynamically balanced.

9. Compressor Capacity Control:

   1) Electronic Control: Compressor output capacity shall be controlled by the Main Control Module. (refer to unit control and sequence sections of this specification)

10. Fans and Motors:

    a. Indoor fan shall be direct drive plenum fan, factory installed and wired to on-board Variable Frequency Drive and shall be equipped with slide out service access.

    b. All fan motors shall be premium efficiency ODP and meet the U.S. Energy Policy Act of 2005/10 (EPACT).

    c. All fan motors shall either be permanently lubricated and/ or have internal thermal overload protection.

    d. Outdoor fans shall be direct drive with premium efficiency motors, statically and dynamically balanced, draw through in the vertical discharge position with either internal or external thermal protection. .

    e. Provide shafts constructed of solid hot rolled steel, ground and polished, with keyway, and protectively coated with lubricating oil.

11. Heating:

    a. Modulating Indirect Gas Fired Heating System

       1) Completely assembled and factory installed heating system shall be in the primary heating position located beneath the indoor fan assembly and be integral to unit and approved for use downstream from refrigerant cooling coils in units mounted outdoors. Threaded gas connection shall terminate at field provided manual shut-off valve. Provide capability for sidewall gas piping.

       2) Heaters shall include high turn-down burners firing into individual stainless-steel tubular heat

exchangers. Heat exchangers shall be constructed of type 439 stainless steel and be a high efficiency dimpled tubular design capable of draining internal condensate. Units with multiple heaters shall include one fully modulating high turndown heater with additional on-off heater sections. Total heater turndown shall be based on heater gas input capacity 5:1 when ≤150 MBH or a minimum of 10:1 when >150 MBH.

3) Heater outdoor air inlet shall be hooded and include internal baffle system to prevent rain blow thru. To prevent recirculation of flue gas and to prevent flue gas condensate from draining onto and obstructing the heater air inlet the inlet shall be hooded and shall be located a minimum of 8" beneath the flue outlet. Inlet hood shall include bird screen.

4) Heater flue outlet(s) shall include hooded outlet with wire cloth all constructed of Type 430 stainless steel. Hooded outlet shall be sealed to prevent flue gas recirculation.

5) Gas Burner Safety Controls: Provide safety controls for the proving of combustion air prior to ignition, continuous air proving monitoring following ignition and continuous electronic flame supervision.

6) Unit controls shall monitor heat output and shall discontinue all heating attempts and or unit operation in the event the heating section fails to ignite or fails to maintain programmed supply air temperature/time.

7) Inducer fan shall be direct drive high pressure centrifugal type with two speeds and shall include built- in thermal overload protection.

8) Limit controls: High temperature automatic reset limits shall be located on blower wall and in indoor fan chamber to shut off gas flow in the event of excessive temperatures resulting from restricted indoor airflow, or loss of indoor airflow.

9) Flame roll-out safeties shall provide continuous monitoring of proper burner operation.

12. Electrical Ratings and Connections:

a. All high voltage power components such as fuses, switches and contactors shall include a service personnel protection barrier or shall be a listed as touch-safe design.

b. Field wiring access to be provided thru unit base into isolated enclosure with removable cover.

c. Power wiring to be single point connection.

d. Wiring internal to the unit shall be colored and labeled for identification.

e. Unit shall be factory wired to field wiring terminal block mounted in isolated enclosure.

f. Factory wired main power disconnect and overcurrent device shall be rated for total unit connected power

g. SCCR rating shall be a minimum of 65kA

h. Factory wired Voltage/Phase monitor shall be included as standard. In the event of any of the following, the units will be shut down and a fault code will be stored in the monitor for the most recent 25 faults. Upon correction of the fault condition the unit will reset and restart automatically.

1) Phase Unbalance Protection: Factory set 3%

2) Over/Under/Brown Out Voltage Protection: +/-10% of nameplate voltage

3) Phase Loss/Reversal

i. Factory to mount and wire optional 115-volt convenience outlet. Field wiring of convenience outlet

not acceptable.

j. All low voltage field wiring connections shall be made at factory installed low voltage terminal strip.

13. Unit Controls:

a. Main Unit Controller (MCM) shall be a microprocessor based controller with resident control logic. Controller program logic shall include

1) Include single program with field selectable

a) Discharge Air control with unit conditioning modes enabled based on outdoor air conditions and controlled to maintain discharge air setpoints.

b) Space control with unit conditioning modes enabled and controlled to maintain space setpoints.

2) Single Zone Variable Air Volume (SZVAV) with unit conditioning modes enabled based on space temperature cooling setpoint and modulate supply fan to maintain setpoint. Cooling will be staged to maintain discharge air cooling setpoint. Heat will modulate to maintain space temperature with indoor fan held at maximum design airflow.

b. MCM shall:

1) Prevent simultaneous operation of any conditioning modes.

2) Accept separate setpoints for Occupied and Unoccupied states.

3) Call for Dehumidification based on dew point setpoints. When no call for Dehumidification is present MCM shall control calls for Cooling, Heating and Economizer modes based on sensible or enthalpy temperature setpoints. MCM shall have onboard clock and scheduling function for occupancy.

4) Include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.

5) Enable HGRH dehumidification and cooling modes and control modulation to maintain (discharge air temperature / space temperature).

6) Unit shall include minimum discharge air control.

c. MCM Touch Screen shall include full color display and shall be field mounted remote from unit and field wired up to a maximum of 300 ft. and provide a full list of points included in the MCM. The display shall provide a list and history of all unit alarms.

d. System Sensors shall include: Factory installed and wired Outdoor Air Temperature, Outdoor Air Humidity and Evaporator Leaving Air Temperature and factory furnished, field installed Discharge Air Temperature.

e. Space Control or Single Zone VAV: Factory shall furnish Space Temperature and Space Humidity sensor for field installation and connection to the unit

1) Economizer Option includes Return Air Temperature and Humidity sensor

f. Powered Exhaust with Economizer includes duct pressure sensor to be field installed.

g. System controls shall include:

1) Anti-cycle timing.

2) Minimum compressor run/off-times.

h. Optional Smoke Detectors to sense (Return Air / Discharge Air / Return and Discharge Air) stream(s) shall be factory installed and wired.

14. Refrigerant Detection System (RDS):
    a. Systems with refrigerant classified as A2L shall include RDS.
    b. RDS shall engage mitigation measures at 12% of LFL.
    c. Mitigation will continue for 5 minutes once the alarm is cleared.
    d. Detection of refrigerant leak(s) in the airstream shall:
        1) De-energize compressors, UV Lights, heaters, and fan motors, excluding Indoor Fan Motor(s).
        2) Run indoor fan motor(s) at minimum Hz.
        3) For building comfort, to avoid freezing or overheating the space, the damper command will not change, and the unit will still provide full dilution of any leaked refrigerant.
            a) Except for units with 2 position dampers and no return duct. In which case the damper shall be commanded open.
        4) 24VAC status terminal will energize on OAUTS.
    e. Detection of refrigerant leak(s) in a non-airstream compartment shall:
        1) De-energize all loads including: compressors, motors and heaters.
        2) Energize the mechanical ventilation fans internal to the unit.
    f. E-stop shall be given priority control of the unit over that of the RDS.

15. Power Exhaust – Barometric Relief:
    a. Provide a factory installed power exhaust assembly that shall be designed to ventilate return air to atmosphere.
    b. Plenum mounted direct drive airfoil design exhaust wheel material shall be heavy gauge aluminum, welded construction and rated for up to Class III speed/pressure performance. Factory install and wire fan motor to on-board Variable Frequency Drive. Belt-drive and/or forward curve plenums fans shall not be used.
    c. Exhaust to discharge through gravity dampers located on each side of unit cabinet.

16. Roof Curb:
    a. Refer to Section 2.17

C. Execution

1. Examination:
    a. Contractor shall verify that roof is ready to receive work and opening dimensions are as approved within Shop Drawings.
    b. Contractor shall verify that proper power supply adequate to supply the unit.

2. Installation:
    a. Contractor shall install in accordance with manufacturer's instructions.
    b. Mount units on factory-built roof mounting frame providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.
3. Manufacturer's Field Services:
    a. Unit start-up and commissioning shall be completed by a Factory-trained and factory-certified technician.
    b. Manufacturer must have twenty factory-authorized and factory-trained technicians within a 50-mile radius of job site.
    c. The contractor shall furnish manufacturer complete submittal wiring diagrams of the package unit as applicable for field maintenance and service.

2.20 PACKAGED ROOFTOP HVAC UNITS

A. General

1. References:
    a. UL 60335-2-40 - Standard for Safety, Household and Similar Electrical Appliances - Safety - Part 2-40.
    b. AHRI 210 / 240 - Performance Rating of Unitary Air Conditioning
    c. AHRI 340 / 360 - Performance Rating of Commercial and Industrial Unitary Air-conditioning
    d. ASHRAE 90.1 - Energy Standard for New Buildings Except Low-Rise Residential Buildings
    e. AHRI 270 or 370 Sound Rating of Outdoor Refrigeration and Air Conditioning Equipment, as applicable.
    f. Gas-fired heaters shall comply with ANSI Z21.47
2. Submittals:
    a. Submit drawings indicating components, dimensions, weights and loadings, required clearances, and location and size of field connections.
    b. Submit product data indicating rated capacities, weights, accessories, service clearances and electrical requirements.
    c. Submit manufacturer's installation instructions.
3. Operation And Maintenance Data:
    a. Submit operation and maintenance data.
    b. Include manufacturer's descriptive literature, start-up and operating instructions, installation instructions, and maintenance procedures.
4. Handling:
    a. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

b. Protect units from physical damage. Leave factory shipping covers in place until installation.

5. Warranty:
   a. Provide a full parts warranty for one year from start-up or 18 months from shipment, whichever occurs first (ALL EQUIPMENT).
   b. OEM provides several Extended Warranty options to include:
   c. Whole Units Parts Warranty (Year 2 plus)
   d. Compressor Parts or Gas Heater Exchanger Parts Option
   e. Whole Unit Labor Warranty (Year 1 plus)
   f. Compressor Warranty Option
   g. Refrigerant Warranty Option
6. Maintenance Service:
   a. All work on units shall be accomplished by OEM factory trained and authorized servicing technicians.
7. Summary:
   a. The contractor shall furnish and install packaged rooftop air conditioning unit(s) and packaged rooftop energy recovery unit(s) as shown and as scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the conditions specified, scheduled or as shown on the contract drawings.

B. Products

1. Casing:
   a. Unit casing shall be zinc coated, heavy gauge, galvanized steel.
   b. Weather resistant painted metal with galvanized substrate.
   c. Meets ASTM B117, 672 hour salt spray test.
   d. Removable single side maintenance access panels.
   e. Exposed vertical panels and top covers in the indoor air section insulated with a cleanable foil-faced, fire-retardant permanent, odorless glass fiber material.
   f. Base pan with no penetrations within the perimeter of the curb other than the raised 1-inch downflow supply/return openings to provide an added water integrity precaution, if the condensate drain backs up.
   g. Base of the unit insulated with 1/8-inch, foil-faced, closed-cell insulation.
   h. Unit base provisions for forklift and/or crane lifting on three sides of unit.
2. Microchannel Coils:
   a. Optimal heat transfer performance due to flat, streamlined tubes with small ports, and metallurgical tube to fin bond.
   b. Reduce system refrigerant charge by up to 50 precent leading for better compressor reliability.

c. All-aluminum construction minimizes galvanic corrosion.

d. Strong aluminum brazed structure provides better fin protection.

e. Flat streamlined tubes more dust resistant and easy to clean.

f. Coils leak tested at the factory to verify the pressure integrity.

3. Coil Guards:

   a. Provides condenser coil protection.

4. Compressors:

   a. All units have direct-drive, hermetic, scroll type compressors with centrifugal type oil pumps.

   b. Suction gas-cooled motor with voltage utilization range of plus or minus 10 percent of unit nameplate voltage.

   c. Internal overloads shall be standard with scroll compressors.

   d. Crankcase heaters shall be standard on all compressors.

5. Units with Variable Speed Compressor Systems:

   a. All unit have a variable speed compressor matched with a variable frequency drive that modulated the speed of the compressor motor.

   b. Compressor motors shall include permanent magnet motor with voltage utilization range of plus or minus 10 percent of unit nameplate voltage.

   c. 3-15 ton units shall have a single variable speed compressor. Units 17.5 to 25 ton shall have a single variable speed compressor manifolded to a fixed speed compressor.

   d. Variable speed modulation to 15 HZ equating to 27% or less of full capacity.

   e. Variable speed shall be commanded by the unit controller and shall be based on the temperature offset to space temp set point.

6. Filters:

   a. 2-inch MERV 8 and MERV 13 filters.

7. Frostat™:

   a. Frostat shall be standard on all units.

8. Gas Heating Section

   a. Gas heating section includes a tubular heat exchanger in low, medium and high heat capacities and shall be made of corrosion-resistant aluminized steel tubes and burners.

   b. Burner system shall have an induced draft combustion blower.

   c. Heater uses a direct spark ignition (DSI) system and a flame sensor.

   d. Units are designed for use with natural gas or propane (field-installed propane conversion kit).

   e. Manufacturer shall offer optional stainless steel heat exchanger with 409 stainless steel tubes and 439 stainless steel burners. Stainless steel heat exchanger shall have a 15 year warranty.

9. Indoor Fan:
    a. All other models shall have direct drive plenum fans with ECM motors. Plenum fan shall be backward-curved fan wheel along with an external rotor direct drive variable speed indoor motor.
    b. Plenum fan design – backward-curved fan wheel along with an external rotor direct drive variable speed indoor motor.
    c. Supply fan speed adjustments can be made using the unit controller or using a manufacturer supplied app. The connection between the unit control and the app shall be Bluetooth.
    d. Motors are electronically protected.
10. Powered Convenience Outlet:
    a. Powered GFCI, 120V/15A, 2 plug, convenience outlet or unpowered GFCI, 120V/20A, 2 plug, convenience outlet shall be available.
    b. Powered outlets must include a service receptacle disconnect. This outlet shall be powered from the line side of the disconnect or circuit breaker, and will remain powered when the disconnect or circuit breaker is in the open position.
11. Stainless Steel Drain Pan:
    a. Optional factory installed, 304 stainless steel drain pan shall be available.
12. Through-the-Base Electrical with Disconnect Switch:
    a. Optional 3-pole, molded case, disconnect switch with provisions for through-the-base electrical connections shall be available.
    b. Disconnect switch installed within unit and shall be protected from outdoor elements.
    c. Wiring shall be provided from the switch to the unit high voltage terminal block.
    d. Switch shall be cULus recognized.
    e. Provided disconnect switch does not satisfy the need for overcurrent protection. When disconnect switch is factory provided, overcurrent protection shall be provided by others.
13. Through-the-Base Gas Piping:
    a. Through-the-base gas provisions shall be available. Piping shall include black steel manual gas shut-off valve, elbows, and union.
    b. Manual shutoff valve shall have 1/8-inch NPT pressure tap.
14. Economizer:
    a. Economizer shall be available with barometric relief. It shall be fully modulating from 0 to 100 percent and shall include provision for a minimum position setting. Assembly also includes, preset linkage, wiring harness with plug, and spring return actuator.
    b. Barometric relief provides a pressure-operated, gravity-closing damper.
    c. Barometric relief prevents entrance of outside air during the equipment off cycle.
    d. Control options include comparative enthalpy.
    e. A standard discharge air sensor shall be included on all units with economizers.

f. Optional low leak economizer shall meet the low leak requires of ASHRAE 90.1, IECC, and CA Title 24 (4 CFM/sq. ft.@ 1" Wg exterior air/return air).

g. Comparative enthalpy measures and communicates humidity for both outdoor and return air conditions, and return air temperature.

h. Unit receives and uses information to maximize use of economizer cooling, and to provide maximum occupant comfort control.

i. Factory provided comparative enthalpy control

15. Motorized Outside Air Damper:

a. If optional motorized outside air damper is provided, when indoor fan starts the outdoor air dampers open to set position. The damper fully closes when the indoor fan shuts down.

16. Ventilation Override Operation:

a. Unit can be set to transition up to 3 different pre-programmed sequences for smoke purge, pressurization, and exhaust.

17. Leak Detection Sensors:

a. Unit shall be furnished with a leak detection system from the factory when a circuit refrigerant charge exceeds 3.91 lbs. The leak detection system shall consist of one or more refrigerant detection sensors. When the system detects a leak, the unit controller shall initiate mitigation actions.

C. Accessories

1. Roof Mounting Curb:

a. Refer to Section 2.17

2. Energy Recovery Wheel:

a. The energy recovery module will be constructed with 16ga structural channels and walls, painted to match the unit and insulated with 1" thick foil faced fiberglass insulation.

b. The module shall include access panels for the energy recovery wheel, damper actuators, and exhaust fan(s).

c. Outdoor air mist eliminators shall be factory installed and located on the end of the module.

d. Additional lifting lugs shall be added to assist in crane lift.

e. Field provided and installed pedestal required for module support.

f. The UWCH wheel is optimized for total recovery performance (smaller flutes) while still providing a good pressure loss characteristics.

g. The rotor media is made of aluminum formed into a fluted, honeycomb matrix which is coated to prohibit corrosion.

h. All surfaces are coated with a non-migrating zeolite desiccant composite designed to maximize latent recovery while reducing the transfer of airborne contaminants compared to silica gel or oxidized aluminum recovery wheels.

i. The wheel media is a permanent component with an estimated 20 year life and not a "throw away" item. The component is compatible with all heating sources without damage and designed to accommodate operating conditions up to 180 F.

j. The product is AHRI certified. The recovery media has been independently tested by a recognized laboratory to show compliance with UL-900 requirements with regard to smoke generation and combustibility.

k. The energy recovery wheel and exhaust fans will be enabled upon a supply fan call. Return air will be pulled through the wheel and be exhausted out the sides of the unit. Outside air will be pulled through the energy recovery wheel and into the unit.

1) The exhaust fans will ramp up to a minimum preset exhaust speed (field adjustable). The exhaust fans will modulate based upon building space pressure.

2) The wheel will run at full speed whenever the supply fan is enabled and the unit is not in wheel economizer mode.

3) The energy recovery wheel will be disabled when the supply fan is off or during wheel economizer mode.

4) During wheel economizer mode, the energy recovery wheel will remain off for 3 minutes and cycle on for 10 seconds then back off for 3 minutes. This cycle will continue throughout the economizer mode to properly clean the wheel.

5) During economizer mode, the control expansion module will disable the energy recovery wheel and open both the return air and outdoor air bypass dampers to divert air around the wheel for free cooling. Economizer mode will be enabled whenever the unit's outdoor air damper signal rises above 50%.

Controls Expansion Module Points	
Analog Inputs	**Binary Inputs**
Exhaust Fan Min Speed Pot	
Space Pressure	**Binary Outputs**
Analog Outputs	Recovery Wheel Start/Stop
Exhaust Fan Speed	
OA Wheel Bypass Damper	**Binary Values**
RA Wheel Bypass Damper	Supply Fan Status
Analog Values	MZVAV Configuration
Outdoor Air Damper Signal	Economizer Mode
Space Pressure Setpoint	Wheel Jog/Stop Mode
Space Pressure Deadband Setpoint	

3. Purge Section:
    a. The unit must be available with a purge sector designed to limit cross-contamination of the exhaust airstream concentration when operated under appropriate design conditions.

4. Electronic Zone Sensors:
    a. Remote Sensor shall be available to be used for remote zone temperature sensing capabilities when zone sensors are used as Remote panels
    b. Integrated Comfort System sensors shall be available with sensor only, sensor with timed override, and sensor with local temperature setpoint adjustment with timed override.
    c. Humidity Sensor - Monitors the humidity levels in the space for 1) Humidification and/or 2) Modulating Hot Gas Reheat.

2.21 AUTOMATIC TEMPERATURE CONTROLS

A. Provide and install a Building Management System as outlined in subsequent section Facility Management & Control System (FMCS). Provide all sensors, wiring, relays and all required accessories for a complete operational networked control system as described herein.

B. Thermostats (space temperature sensors):

1. Units shall be low voltage (24 VAC) wired from the internal low voltage circuit of the equipment served plus include battery backup.

2. Mounting: (2) screws for unit back-plate wall mounting.

3. Each unit shall provide a backlit, liquid crystal display (LCD) touch-screen with the following minimum features:
    a. 7-day programming.
    b. Individual heating and cooling occupied and unoccupied setpoints.
    c. Daily program schedules: (2) occupied cycles and (2) unoccupied cycles per day.
    d. Temperature control override (defaults back to schedule and cycle temperature once next cycle becomes current).
    e. Fan run status: ON/AUTO
    f. 1°F control increment (1°F to 5°F dead band setpoints).
    g. Change/check indicator icon for unit filter replacement/cleaning.
    h. Non-volatile memory storage (permanent day and time).

C. Interconnecting Wire and Cable:

1. All wiring regardless of service and/or voltage shall comply with the Contract Document Division for Electrical System Specifications, the National Electric Code (NEC) and any/all applicable local codes and other Authorities Having Jurisdiction (AHJ).

2. All wiring regardless of service and/or voltage shall be in conduit in accordance with Electrical

Specifications “Raceways and Boxes for Electrical Systems” and “Cable Trays for Electrical Systems” and shall be routed parallel to or at right angles with the structure, properly supported every six (6) feet at a minimum and installed in a workmanlike manner, except that exposed wiring in all spaces other than utility rooms, closets, and storage rooms shall be in raceway to match the raceway indicated in the Fire Alarm System portions of these contract documents.

3. Where permitted by all applicable specifications, local codes, NEC and AHJ; plenum-rated control cabling may be used where final application will be concealed but accessible. Where plenum-rated cable is allowed, it shall be routed parallel to or at right angles with the structure, properly supported every six (6) feet at a minimum and installed in a workmanlike manner.

D. General Field Devices:

1. Control relays shall be UL listed with contacts and coils rated for the application. Relays used for inline control start/stop of line voltage motors shall have a current rating at least 150% full load amps.

2. Control transformers shall be CSA and UL listed. Primary and secondary sides shall be fused in accordance with the NEC or shall be Class 2 current limiting type. Transformers shall be sized such that the connected load is not greater than 80% of the transformer rated capacity.

3. Emergency shut-off switches shall be heavy duty, two-position push-pull, maintained contact, and illuminated 1-3/8-inch in diameter mushroom style push button switch. Provide hinged easy open protective clear cover to prevent accidental operation of switch.

E. Analog Sensors:

1. Temperature sensors:
   a. Linear precision element thermistor type.
   b. Duct sensor (single point)- 316 stainless steel or platinum sensing element, junction box for wiring connections and gasket to prevent air leakage and vibration noise.
   c. Outdoor air sensor- single device, ventilated non-metallic sun shield, utility box for termination and watertight gasket to prevent water seepage.
   d. Space sensor- element within a ventilated cover.
   e. Sensors shall be manually calibrated on site so that wiring length does not detract from the sensor accuracy specified.
   f. Where necessary due to structural cavities, masonry walls, proximity to exterior openings, unconditioned spaces, etc., insulated mounting base shall prevent temperature of mounting location from affecting sensor temperature reading.

2. Pressure Sensors:
   a. Static air pressure sensor- linear output voltage signal, field adjustable "zero" and "span", tubing connected to pitot tube or other pressure/airflow sensing device (under no circumstances shall tubing pass through equipment housing or ductwork).
   b. Pitot tube probe shall be brass with 8 inch lead tube.
   c. Air differential sensors shall have linear output voltage signal, capable of over-pressurization to 10 PSI without zero-shift and have a field adjustable zero and span.

d. Snubbers shall be required to prevent system pressure hammers and surges from being transmitted to the sensor.

3. Position Sensors:

a. Damper position indicators- potentiometer mounted in housing. Damper position end switches shall employ mechanical position proving.

b. Control valve position indicator- potentiometer mounted on valve actuator.

c. Float type level switch with single pole-double (SPDT) throw snap acting contacts, housed in a watertight enclosure.

d. Proximity limit switch- oil-tight, roller type, SPDT snap acting switch with adjustable trim arm.

F. Automatic Control Dampers:

1. All dampers shall bear AMCA seal indicating compliance with the AMCA Certified Ratings Program.

2. A single damper section shall have blades that do not exceed 48” in length and shall be no higher than 72”. Damper blades shall not exceed 8” in width. Applications requiring larger dampers shall be achieved by combining single damper sections.

3. Frame construction shall be a minimum of #14 gauge galvanized steel formed into channels and welded, 14 gauge galvanized roll-formed steel or extruded aluminum at a minimum 4-1/2” by 1’ by 0.125” thick.

4. Blades and baffles shall be fabricated of minimum 16 gauge steel with corrosion resistant galvanized finish or extruded aluminum 6” by 0.08”.

5. All dampers shall be provided with nylon, cycoloy or oilite bearings, stainless steel or elastomeric side seals, and zinc plated hardware as standard.

6. Axles shall be a minimum of 1/2” diameter and be locked to blade with rivets or welded.

7. Dampers shall be made up of 6" or 8" blades or combination of the two. Dampers shall have a minimum of four brakes running the entire length. Silicone or polyurethane blade edging shall be furnished on all dampers.

8. Maximum leakage rate through any 48" by 48" closed damper in any application shall not exceed 10.0 cfm per sq. ft. of damper face area at 4" of water pressure differential and a maximum closing torque of 4 inch-lbs./sq. ft. of damper face area. Damper leakage ratings shall be certified in accordance with AMCA Standard 500-D.

9. Blades mounted vertically shall be supported by thrust bearings.

10. All Automatic Control Dampers in modulating applications shall be sized so as to achieve linear airflow characteristics.

11. Automatic Flow Control Dampers specifically indicated to be provided by Mechanical Equipment manufacturer and/or as a component of packaged equipment shall not be provided by the Contractor.

12. To minimize leakage, blade edges shall be interlocked and blade seals shall be compressible at all contact points. Channel frames shall also be provided with jamb seals.

13. All Outdoor Air Damper components shall be suitable for applications operating in the temperature range of -40 deg. C (-40 deg. F) to 75 deg. C (167 deg. F).

14. Damper shall be rated for a minimum velocity of 2000 ft/min.

15. Mechanical Ventilation, Miscellaneous Utility Dampers (Parallel Blade Operational Style):
    a. Parallel Blade Automatic Flow Control Dampers shall be permitted as indicated on the drawings for applications not requiring Opposed Blade operation pursuant with that specification section and for:
        1) Two-position (fully-open or fully-closed) applications.
        2) Applications where the damper constitutes the primary source of total system pressure loss.
        3) Applications where greater control is required at the upper end of airstream volume operating range.
        4) Mechanical Space ventilation and exhaust, combustion intake & exhaust, &c.
    b. Shall comply with AMCA 500-D Class 4 and shall not leak in excess of 80cfm per sq/ft at 4inwc static pressure when closed.
    c. Damper shall be rated for a minimum velocity of 1500 ft/min.

16. Operating Linkages and Damper Accessories:
    a. All operating linkages and/or damper accessories required for installation and application in accordance with specification design intent and manufacturer's installation procedures shall be provided.
    b. Operating linkages provided external to dampers (crank arms, connecting rods, shaft extensions, &c.) for transmitting motion from the actuator/operator to dampers shall be designed as to functionally operate a load equal to or in excess of 300% of the maximum required operating force for the damper.
    c. Crank arms and connecting rods shall be adjustable. Linkages shall be brass, bronze, zinc-coated steel, or stainless steel.
    d. Adjustments of Crank Arms shall control the position of the damper.
    e. Use of Operating Linkages external to damper drive shaft shall neither delay nor impede operation of the damper in a manner of performance less than a direct-coupled damper actuator. Operating linkages shall not under any circumstances be permitted to flex, warp, shift and curve under normal operation of connected damper sections.

G. Automatic Control Damper Actuators:

1. Control damper actuators shall be electronic type. Actuators shall have a means for reversing drive direction and a manual override accessible at the front cover.

2. Single bolt or setscrew type fasteners are not acceptable.

3. The actuator shall have electronic overload or digital rotation sensing circuitry. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.

4. For spring return fail-safe applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.

5. All non-spring return actuators shall have an external manual clutch/gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque capacity shall have a manual crank for this purpose.

2.22 FACILITY MANAGEMENT & CONTROL SYSTEM (FMCS)

A. Summary:

1. The intent of this Specification is to provide an open source Facility Management Control System (FMCS) based on the Tridium Niagara Network Area Controller (NAC) and the Honeywell Spyder Interoperable Digital Controller/Interoperable BACnet Controller (IDC/IBC). The Honeywell Spyder Interoperable Digital Controller/Interoperable BACnet Controller (IDC/IBC) shall be fully programmable via the embedded Niagara WorkBench tool requiring only a web browser.

2. Products requiring a licensed, off site, non-embedded programming tool are not acceptable. Open source as referred to herein shall mean the Tridium Niagara Network Area Controller (NAC) and Honeywell Spyder Interoperable Digital Controller/Interoperable BACnet Controller (IDC/IBC) products are available from multiple contractor and vendor sources, affording the Owner freedom of choice and competitive bidding for the initial installation of the (FMCS) and future system expansions and modifications not limited by contractor, vendor or networking protocol. No territorially restricted OEM brands, single vendor or "branch only" products are acceptable.

3. Successful bidder shall demonstrate to the Owner via a product website dealer/contractor locator, that there are multiple contractors and vendors in the project geographic area to choose from. No exceptions to this requirement will be allowed.

4. Furnish all labor, materials, equipment, and service necessary for a complete and operating Temperature Control System (TCS) and Facility Management system (FMCS), utilizing Direct Digital Controls as shown on the drawings and as described herein. Drawings are diagrammatic only.

5. All labor, material, equipment and software not specifically referred to herein or on the plans, that is required to meet the functional intent of this Specification, shall be provided without additional cost to the Owner.

B. System Description:

1. The entire Temperature Control System (TCS) shall be comprised of a network of inter-operable, stand-alone digital controllers communicating via BACnet communication protocols to a Network Area Controller (NAC). Temperature Control System products shall be manufactured by Tridium. Equivalent BACnet products must be approved in writing by the Consulting Engineer and be submitted for approval ten (10) days prior to the date of the bid submittal.

2. The Facility Management and Control System (FMCS) shall be comprised of Network Area Controller or Controllers (NAC) within each facility. The NAC shall connect to the Owner's local or wide area

network, depending on configuration. Access to the system, either locally in each building, or remotely from a central site or sites, shall be accomplished through standard Web browsers, via the Internet and/or local area network. Each NAC shall communicate to BACnet (IBC) controllers and other open protocol systems/devices provided under Division 23 or Division 26.

3. The Facility Management and Control System (FMCS) as provided in this Division shall be based on the Tridium Niagara System incorporating the Niagara Framework™. Equivalent products must be approved in writing by the Consulting Engineer and be submitted for approval ten (10) days prior to the date of the bid submittal. Systems not developed on the Niagara Framework platform are unacceptable.

C. Submittal:

1. An electronic copy (.PDF) of shop drawings of the components and devices for the entire control system shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions for all controllers, valves, dampers, sensors, routers, etc. Shop drawings shall also contain complete wiring and schematic diagrams, software descriptions, and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings. A complete written Sequence of Operation shall also be included with the submittal package. Division 26 contractors supplying products and systems, as part of their packages shall provide catalog data sheets, wiring diagrams and point lists to the Division 23 contractor for proper coordination of work.

2. Submittal shall also include a trunk cable schematic diagram depicting operator workstations, control panel locations and a description of the communication type, media and protocol. Though the Division 23 and 26 contractors shall provide these diagrams for their portions of work, the Systems Integrator shall be responsible for integrating those diagrams into the overall trunk cable schematic diagrams for the entire Wide Area Network (WAN).

3. Submittal shall also include a complete point list of all points to be connected to the TCS and FMCS. Division 23 and 26 contractors shall provide necessary point lists, protocol documentation, and factory support information for systems provided in their respective divisions but integrated into the FMCS.

4. Upon completion of the work, provide a complete set of ‘as-built’ drawings and application software (Web-Supervisor only, if applicable) on compact disk. Drawings shall be provided as pdf files. Division 23 and 26 contractors shall provide as-builts for their portions of work. The Division 23 contractor shall be responsible for as-builts pertaining to overall TCS and FMCS architecture and network diagrams.

D. Specification Nomenclature:

1. Acronyms used in this Specification are as follows:
   a. FMCS: Facility Management and Control System
   b. TCS: Temperature Control System
   c. NAC: Network Area Controller
   d. IDC: Interoperable Digital Controller
   e. IBC: Interoperable BACnet Controller

f. GUI: Graphical User Interface

g. WBI: Web Browser Interface

h. POT: Portable Operator's Terminal

i. PMI: Power Measurement Interface

j. DDC: Direct Digital Controls

k. LAN: Local Area Network

l. WAN: Wide Area Network

m. OOT: Object Oriented Technology (Graphical Programming Language)

n. PICS: Protocol Implementation Conformance Statement

E. Division of Work:

1. The Division 23 and 26 (if applicable) contractors shall be responsible for all controllers (IDC and IBC), control devices, control panels, controller programming, controller input/output and power wiring and controller network wiring.

2. The Division 23 contractor shall be responsible for the Network Area Controller(s) (NAC), software and programming of the NAC, graphical user interface software (GUI), development of all graphical screens, Web browser pages, setup of schedules, logs and alarms, LonWorks network management. The Division 23 contractor shall coordinate connection of the NAC to the Owner provided local or wide area network.

F. Related Work Specified Elsewhere:

1. Division 26, Electrical:

a. Providing motor starters and disconnect switches (unless otherwise noted).

b. Power wiring and conduit (unless otherwise noted).

c. Provision, installation and wiring of smoke detectors (unless otherwise noted).

d. Other equipment and wiring as specified in Division 26.

G. Agency and Code Approvals:

1. All products of the TCS and FMCS shall be provided with the following agency approvals. Verification that the approvals exist for all submitted products shall be provided with the submittal package. Systems or products not currently offering the following approvals are not acceptable.

a. UL-916; Energy Management Systems

b. C-UL listed to Canadian Standards Association C22.2 No. 205-M1983 "Signal Equipment"

c. CE

d. FCC, Part 15, Subpart J, Class A Computing Devices

H. Software License Agreement:

1. The Owner shall agree to 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.

2. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the Owner shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with the NAC, FMCS Server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required IDs and passwords for access to any component or software program shall be provided to the Owner. The Owner shall be free to contract with any vendor or contractor for future service, expansion and/or modifications.

I. Delivery, Storage and Handling: Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

J. Job Conditions: Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers, and structural and architectural features.

K. Materials:

1. General:

   a. The Temperature Control System (TCS) and Facility Management Control System (FMCS) shall be comprised of a network of interoperable, stand-alone digital controllers, Network Area Controllers (NAC) servers, printers, network devices, valves, dampers, sensors, and other devices as specified herein.

   b. The installed system shall provide secure password access to all features, functions and data contained in the overall FMCS.

2. Open, Inoperable, Integrated Architectures:

   a. The intent of this Specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate ANSI/ASHRAE Standard 135-2001 BACnet, LonWorks technology, MODBUS, OPC, and other open and proprietary communication protocols in one open, interoperable system.

   b. The supplied NAC and IDC/IBC shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI / ASHRAE™ Standard 135-2001, BACnet and LonMark to assure interoperability between all system components is required. Devices that do not have LonMark certification are not acceptable, For each BACnet device, the device supplier must provide a PICS document showing the installed device’s compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet (BACnet Ethernet/IP,) and/or RS-485 (BACnet MSTP) as specified.

c. All components and controllers supplied under this Division shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.

d. The supplied system must incorporate the ability to access all data using standard Web browser without requiring proprietary operator interface and configuration software or licenses. No installed software or license shall be required to view, modify or program the Niagara NAC OR the IDC/IBC field controllers. All engineering shall be performed by use of the embedded Niagara WorkBench tool utilizing only a web browser such as Microsoft's Windows Explorer or Mozilla's Fire-Fox web browser. Systems requiring proprietary database, interface programs and or configuration software shall not be acceptable.

e. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.

f. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.

g. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

3. Networks:

   a. The Local Area Network (LAN) shall be a 100 Megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, and SOAP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Area Controllers (NACs), user workstations and, if specified, a local server.

   b. Local area network minimum physical and media access requirements:

      1) Ethernet; IEEE standard 802.3

      2) Cable; 100 Base-T, UTP-8 wire, category 5e

      3) Minimum throughput; 100 Mbps.

4. Network Access:

   a. Remote Access: For Local Area Network installations, provide access to the LAN from a remote location, via the Internet (if desired). The Owner shall provide a connection to the Internet to enable this access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer's Intranet to a corporate server providing access to an Internet Service Provider (ISP). Customer agrees to pay monthly access charges for connection and ISP (if required).

5. Network Area Controller (NAC):

   a. The Division 23 contractor shall supply one or more Network Area Controllers (NAC) as part of this contract. Number of area controllers required is dependent on the type and quantity of devices provided under Divisions 23 and 26. It is the responsibility of the Division 23 contractor to coordinate with the Division 23 and 26 contractors to determine the quantity and type of devices.

   b. The Network Area Controller (NAC) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NAC. It shall be capable of executing application control programs to provide:

1) Calendar functions
2) Scheduling
3) Trending
4) Alarm monitoring and routing
5) Time synchronization
6) Integration of LonWorks controller data and BACnet controller data
7) Network Management functions for all LonWorks based devices

c. The Network Area Controller must provide the following hardware features as a minimum:
   1) Two Ethernet Port – 10/100 Mbps
   2) One RS-232 port
   3) One LonWorks Interface Port – 78KB FTT-10A
   4) One RS-485 ports
   5) Battery Backup
   6) Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity)
   7) The NAC must be capable of operation over a temperature range of 32 to 122°F
   8) The NAC must be capable of withstanding storage temperatures of between 0 and 158°F
   9) The NAC must be capable of operation over a humidity range of 5 to 95% RH, non-condensing

d. The NAC shall provide multiple user access to the system and support for ODBC or SQL (if specified). A database resident on the NAC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read trend history data stored within it.

e. The NAC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 32 simultaneous users.

f. Event Alarm Notification and Actions:
   1) The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
   2) The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network or wide-area network or via email.
   3) Alarm generation shall be selectable for annunciation type and acknowledgment requirements including but limited to:
      a) To alarm
      b) Return to normal
      c) To fault
   4) Provide for the creation of a minimum of eight of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
   5) Provide timed (schedule) routing of alarms by class, object, group, or node.

6) Provide capability for alarm generation from binary object "runtime" and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.

g. Control equipment and network failures shall be treated as alarms and annunciated.

h. Alarms shall be annunciated in any of the following manners as defined by the user:

1) Screen message text

2) Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:

a) Day of week

b) Time of day

c) Recipient

d) Pagers via paging services that initiate a page on receipt of email message

e) Graphic with flashing alarm object(s)

f) Printed message, routed directly to a dedicated alarm printer

i. The following shall be recorded by the NAC for each alarm (at a minimum):

1) Time and date

2) Location (building, floor, zone, office number, etc.)

3) Equipment (air handler #, accessway, etc.)

4) Acknowledge time, date, and user who issued acknowledgement

5) Number of occurrences since last acknowledgement

j. Alarm actions may be initiated by user defined programmable objects created for that purpose.

k. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.

l. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.

m. Provide a "query" feature to allow review of specific alarms by user defined parameters.

n. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

o. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

6. Data Collection and Storage:

a. The NAC shall have the ability to collect data for any property of any object and store this data for future use.

b. The data collection shall be performed by trend history extensions, resident in the NAC that shall have, at a minimum, the following configurable properties:

1) Designating the log as interval or deviation.

2) For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.

3) For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.

c. All log data shall be stored in a relational database in the NAC and the data shall be accessed from a server (if the system is so configured) or a standard Web browser or via a web Excel query.

d. All log data, when accessed from a server, shall be capable of being manipulated using standard BQL statements.

e. All log data shall be available to the user in the following data formats:

1) Niagara table or chart viewer.

2) OBIX

3) XML

4) PDF

5) Excel Comma or tab separated values (CSV)

f. Systems that do not provide log data in a RDBMS and csv formats at a minimum shall not be acceptable.

g. The NAC shall have the ability to archive its log data either locally (to itself), or remotely to a server or other NAC on the network. Provide the ability to configure the following archiving properties, at a minimum:

1) Archive on time of day.

2) Auto archive when a Web-Supervisor archive is being reviewed by a user (Live History).

7. Audit Log:

a. Provide and maintain an Audit Log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:

1) Time and date

2) User ID

3) Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.

8. Database Backup and Storage:

a. The NAC shall have the ability to automatically backup its database. The database shall be backed up once a day at a minimum.

b. Copies of the current database and, at the most recently saved database shall be stored in the NAC. The age of the most recently saved database is dependent on the user-defined database save interval.

c. The NAC database shall be archived to a Web-Supervisor (if present) on a monthly basis for extended system back-up, additionally an admin user shall be able to back-up the NAC database to

his/her PC via a standard web browser.

9. Interoperable Digital Controller (IBC)
   a. Advanced Unitary Controller: The controller platform shall be designed specifically to control HVAC – ventilation, filtration, heating, cooling, humidification, and distribution. Equipment includes: constant volume air handlers, VAV air handlers, packaged RTU, heat pumps, unit vents, fan coils, natural convection units, and radiant panels. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara AX Framework™, that allow standard and customizable control solutions required in executing the "Sequence of Operation" as outlined in Section 4.
   b. Minimum Requirements:
      1) The controller shall be capable of either integrating with other devices or stand-alone operation.
      2) The controller shall have two microprocessors. The Host processor contains on-chip FLASH program memory, FLASH information memory, and RAM to run the main HVAC application. The second processor for BACnet® network communications.
         a) FLASH Memory Capacity: 372 Kilobytes with 8 Kilobytes for application program.
         b) FLASH Memory settings retained for ten years.
         c) RAM: 8 Kilobytes
      3) The controller shall have an internal time clock with the ability to automatically revert from a master time clock on failure.
         a) Operating Range: 24 hour, 365 day, multi-year calendar including day of week and configuration for automatic day-light savings time adjustment to occur on configured start and stop dates.
         b) Accuracy: ±1 minute per month at 77° F (25° C).
         c) Power Failure Backup: 24 hours at 32° to 100° F (0° to 38° C), 22 hours at 100° to 122° F (38° to 50° C).
      4) The controller shall include Sylk Bus, a two wire, polarity insensitive bus that provides both 18 Vdc power and communications between a Sylk-enabled device and a Sylk-enabled controller.
      5) The controller shall have an internal DC power supply to power external sensors.
         a) Power Output: 20 VDC ±10% at 75 mA.
      6) The controller shall have a visual indication (LED) of the status of the device:
         a) Controller operating normally.
         b) Controller in process of download.
         c) Controller is in reflash mode
         d) No power to controller, low voltage, or controller damage.
         e) Processor and/or controller are not operating.
      7) The controller shall have a visual indication (LED) of the BACnet MS/TP communication status of the device:

a) Processor missing bootloader image.

b) Bootloader running and no MS/TP token present.

c) Bootloader running and there is MS/TP communication.

d) BACnet communications processor is not running

8) The minimum controller Environmental ratings

a) Operating Temperature Ambient Rating: -40° to 150° F (-40° to 65.5° C).

b) Storage Temperature Ambient Rating: -40° to 150° F (-40° to 65.5° C).

c) Relative Humidity: 5% to 95% non-condensing.

9) The controller shall have the additional approval requirements, listings, and approvals:

a) UL/cUL (E87741) listed under UL916 (Standard for Open Energy Management Equipment) with plenum rating.

b) BACnet Application Specific Controller (B-ASC)

c) CSA (LR95329-3) Listed

d) Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.

e) Meets Canadian standard C108.8 (radiated emissions).

f) Conforms to the following requirements per European Consortium standards:

(1) EN 61000-6-1; 2001 (EU Immunity)

(2) EN 61000-6-3; 2001 (EU Emissions)

10) The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5mm x 35mm).

11) The controller shall have sufficient on-board inputs and outputs to support the application.

a) Analog outputs (AO) shall be capable of being configured to support 0-10 V, 2-10 V or 4-20 mA devices.

b) Triac outputs shall be capable of switching 30 Volts at 500 mA.

c) Input and Output wiring terminal strips shall be removable from the controller without disconnecting wiring. Input and Output wiring terminals shall be designated with color coded labels.

d) Universal inputs shall be capable of being configured as binary inputs, resistive inputs, voltage inputs (0-10 VDC), or current inputs (4-20 mA).

12) The controller shall provide “continuous” automated loop tuning with an Adaptive Integral Algorithm Control Loop.

13) The controller platform shall have standard HVAC application programs that are modifiable to support both the traditional and specialized “sequence of operations” as outlined in Section 4.

a) Discharge air control and low limit

b) Pressure-dependent dual duct without flow mixing.

c) Variable air volume with return flow tracking.

d) Economizer with differential enthalpy.

e) Minimum air flow coordinated with CO2.

f) Unit ventilator cycle (1, 2, 3) 2-pipe.

g) Unit ventilator cycle (1, 2, 3) 2-pipe with face/bypass.

10. HVAC control shall be accomplished using BACnet based devices. The Division 23 contractor shall provide all programming, documentation and programming tools necessary to set up and configure the supplied devices per the specified sequences of operation.

11. The Division 23 contractor shall run the BACnet network trunk to the nearest Network Area Controller (NAC). Coordinate locations of the NAC to ensure that maximum network wiring distances, as specified by the BACnet wiring guidelines, are not exceeded. A maximum of 30 devices may occupy any one BACnet trunk and must be installed using the appropriate trunk termination device.

12. The Network Area Controller (NAC) will provide all scheduling, alarming, trending, and network management for the BACnet based devices.

13. The IBCs shall communicate with the NAC at a baud rate of not less than 38.4K baud. The IBC shall provide LED indication of communication and controller performance to the technician.

14. All IBCs shall be fully application programmable and shall at all times maintain their BACnet BTL certification. Controllers offering application selection only (non-programmable), require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the IBC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.

15. The Division 23 contractor supplying the IBC's shall provide documentation for each device, with the following information at a minimum:
    a. Analog In
    b. Analog Out
    c. Analog Value
    d. Binary
    e. Binary In
    f. Binary Out
    g. Binary Value
    h. Multi-State In
    i. Multi-State Out
    j. Multi-State Value
    k. Schedule object
    l. Calendar object

16. It is the responsibility of the Division 23 contractor to ensure that the proper BACnet objects are provided in each IBC, as required by the project.

17. The supplier of any programmable IBC shall provide one copy of the manufacturer's programming tool, with documentation, to the Owner.

L. Graphical User Interface

1. Operating System:
   a. The GUI shall be a standard web browser such as Microsoft Internet Explorer, Google Chrome or Mozilla Fire-Fox.
   b. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.
   c. Real-Time Displays. The GUI, shall at a minimum, support the following graphical features and functions:
      1) Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.
      2) Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URL's, and links to other graphic screens.
      3) Graphics shall support layering and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.
      4) Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.
         a) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
         b) Holidays shall be set by using a graphical calendar without requiring any keyboard entry from the operator.
      5) Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu.
      6) Adjustments to analog objects, such as set points, shall be done by right-clicking the selected object and using an override value input box to adjust the value.
   d. System Configuration. At a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:
      1) Create, delete or modify control strategies.
      2) Add/delete objects to the system.
      3) Tune control loops through the adjustment of control loop parameters.
      4) Enable or disable control strategies.

5) Generate hard copy records or control strategies on a printer.

6) Enable/disable points to be alarmed and define the alarm name, state or value, time delays etc.

7) Enable/disable points to be trended over a period of time and adjust trending parameters and names.

e. Security. Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.

f. System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

g. Alarm Console:

1) The system will be provided with a web browser based alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm.

2) An optional Alarm Console Service can be used to provide continuous alarm notification and monitoring by means of an alarm window that will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable. The Alarm Console Service is an option that can be installed on any PC for continuous alarm monitoring for a single site, or from multiple sites.

2. Web Browser Clients:

a. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™ , Google Chrome, or Mozilla Fire Fox™. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.

b. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the FMCS, shall not be acceptable.

c. The Web browser client shall support at a minimum, the following functions:

1) User log-on identification and password shall be required. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.

2) HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.

3) Storage of the graphical screens shall be in the Network Area Controller (NAC), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.

4) Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.

5) Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:

a) Modify common application objects, such as schedules, calendars, and set points in a graphical manner.

(1) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.

(2) Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.

b) Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu.

c) View logs and charts

d) View and acknowledge alarms

6) The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.

a) Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

3. Web-Supervisor Server Functions and Hardware:

a. A central server, located in the Maintenance Office, shall be provided. The server shall support all Network Area Controllers (NAC) connected to the customer's network whether local or remote.

b. Local connections shall be via an Ethernet LAN. Remote connections can be via ISDN, ADSL, T1 or dial-up connection.

c. It shall be possible to provide access to all Network Area Controllers via a single connection to the server. In this configuration, each Network Area Controller can be accessed from a remote Graphical User Interface (GUI) or from a standard Web browser (WBI) by connecting to the server.

d. The server shall provide the following functions, at a minimum:

1) Global Data Access: The server shall provide complete access to distributed data defined anywhere in the system.

2) Distributed Control: The server shall provide the ability to execute global control strategies based on control and data objects in any NAC in the network, local or remote.

3) The server shall include a master clock service for its subsystems and provide time synchronization for all Network Area Controllers (NAC).

4) The server shall accept time synchronization messages from trusted precision Atomic Clock Internet sites and update its master clock based on this data.

5) The server shall provide master scheduling for all Network Area Controllers and their underlying field control devices.

6) The server shall provide demand limiting that operates across all Network Area Controllers. The server must be capable of multiple demand programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shed lists for effective demand control.

7) The server shall implement priority array command prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to Network Area Controllers. Systems not employing this prioritization shall not be accepted.

8) Each Network Area Controller supported by the server shall have the ability to archive its log data, alarm data and database to the server, automatically. Archiving options shall be user-defined including archive time and archive frequency.

9) The server shall provide central alarm management for all Network Area Controllers supported by the server. Alarm management shall include:

   a) Routing of alarms to display, printer, email and pagers

   b) View and acknowledge alarms

   c) Query alarm logs based on user-defined parameters

10) The server shall provide central management of log data for all Network Area Controllers supported by the server. Log data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include:

   a) Viewing and printing log data

   b) Exporting log data to other software applications

   c) Query log data based on user-defined parameters

11) Server Hardware Requirements: The server hardware platform shall have the following requirements:

   a) The computer shall provide a small footprint tower format.

   b) The computer shall be an Intel Pentium i7 based computer (minimum processing speed of 3.0 GHz with 4 GB 800 MHz RAM and a 1 terabyte minimum hard drive), 2-USB ports, and DVD writer.

   c) A minimum 17" flat panel color monitor, 1280 x 1024 optimal preset resolution, 25 ms response time shall also be included.

   d) The server operating system shall be Microsoft Windows 10.

   e) Connection to the FMCS network shall be via an Ethernet network interface card, 100 Mbps.

4. System Programming:

   a. The Graphical User Interface software (GUI) shall provide the ability to perform system programming and graphic display engineering as part of a complete software package. Access to the programming functions and features of the GUI shall be through password access as assigned by the system administrator.

   b. A library of control, application, and graphic objects shall be provided to enable the creation of all

applications and user interface screens. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.

c. Programming Methods:

1) Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user's application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; i.e., internal, external, hardware, etc.

2) Configuration of each object will be done through the object's property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.

3) The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.

4) The system shall support object duplication within a customer's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

5. LonWorks Network Management:

a. The Graphical User Interface software (GUI) shall provide a complete set of integrated LonWorks network management tools for working with LonWorks networks. These tools shall manage a database for all LonWorks devices by type and revision, and shall provide a software mechanism for identifying each device on the network. These tools shall also be capable of defining network data connections between LonWorks devices, known as "binding". Systems requiring the use of third party LonWorks network management tools shall not be accepted.

b. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.

c. The network configuration tool shall also provide diagnostics to identify devices on the network, to reset devices, and to view health and status counters within devices.

d. These tools shall provide the ability to "learn" an existing LonWorks network, regardless of what network management tool(s) were used to install the existing network, so that existing LonWorks devices and newly added devices are part of a single network management database.

e. The network management database shall be resident in the Network Area Controller (NAC), ensuring that anyone with proper authorization has access to the network management database at all times. Systems employing network management databases that are not resident, at all times,

within the control system, shall not be accepted.

6. Object Libraries:
   a. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.
   b. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.
   c. In addition to the standard libraries specified here, the supplier of the system shall maintain an on-line accessible (over the Internet) library, available to all registered users to provide new or updated objects and applications as they are developed.
   d. All control objects shall conform to the control objects specified in the BACnet Specification.
   e. The library shall include applications or objects for the following functions, at a minimum:
      1) Scheduling Object. The schedule must conform to the schedule object as defined in the BACnet Specification, providing 7-day plus holiday & temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphical sliders to speed creation and selection of on-off events.
      2) Calendar Object. . The calendar must conform to the calendar object as defined in the BACnet Specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphical "point-and-click" selection. This object must be "linkable" to any or all scheduling objects for effective event control.
      3) Duty Cycling Object. Provide a universal duty cycle object to allow repetitive on/off time control of equipment as an energy conserving measure. Any number of these objects may be created to control equipment at varying intervals
      4) Temperature Override Object. Provide a temperature override object that is capable of overriding equipment turned off by other energy saving programs (scheduling, duty cycling etc.) to maintain occupant comfort or for equipment freeze protection.
      5) Start-Stop Time Optimization Object. Provide a start-stop time optimization object to provide the capability of starting equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled un-occupancy time just far enough ahead to take advantage of the building's "flywheel" effect for energy savings. Provide automatic tuning of all start / stop time object properties based on the previous day's performance.
      6) Demand Limiting Object. Provide a comprehensive demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, and gas). The object shall provide the capability of monitoring a demand value and predicting (by use of a sliding window prediction algorithm) the demand at the end of the user defined interval period (1-60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment set points to effect the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the set point, a message shall be displayed on the users screen (as an alarm) instructing the user to take manual

actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to effect both equipment protection and occupant comfort.

f. The library shall include control objects for the following functions. All control objects shall conform to the objects as specified in the BACnet Specification.

1) Analog Input Object - Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.

2) Analog Output Object - Minimum requirement is to comply with the BACnet standard for data sharing.

3) Binary Input Object - Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment run-time by counting the amount of time the hardware input is in an "on" condition. The user must be able to specify either input condition as the "on" condition.

4) Binary Output Object - Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as interstart delay must be provided. The BACnet Command Prioritization priority scheme shall be incorporated to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide sixteen levels of priority as a minimum. Systems not employing the BACnet method of contention resolution shall not be acceptable.

5) PID Control Loop Object - Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable as well as to be disabled to allow proportional control only, or proportional with integral control, as well as proportional, integral and derivative control.

6) Comparison Object - Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.

7) Math Object - Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.

8) Interlock Object - Provide an interlock object that provides a means of coordination of objects within a piece of equipment such as an Air Handler or other similar types of equipment. An example is to link the return fan to the supply fan such that when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming thereby eliminating nuisance alarms during the off period.

9) Temperature Override Object - Provide an object whose purpose is to provide the capability of overriding a binary output to an "On" state in the event a user specified high or low limit value is exceeded. This object is to be linked to the desired binary output object as well as to an analog object for temperature monitoring, to cause the override to be enabled. This object will execute a Start command at the Temperature Override level of start/stop command priority unless changed by the user.

g. The object library shall include objects to support the integration of devices connected to the Network Area Controller (NAC). At a minimum, provide the following as part of the standard library included with the programming software:

1) LonMark/LonWorks devices. These devices shall include, but not be limited to, devices for control of HVAC, lighting, access, and metering. Provide LonMark manufacturer-specific objects to facilitate simple integration of these devices. All network variables defined in the LonMark profile shall be supported. Information (type and function) regarding network variables not defined in the LonMark profile shall be provided by the device manufacturer.

2) For devices not conforming to the LonMark standard, provide a dynamic object that can be assigned to the device based on network variable information provided by the device manufacturer. Device manufacturer shall provide an XIF file, resource file and documentation for the device to facilitate device integration.

3) For BACnet devices, provide the following objects at a minimum:

a) Analog In

b) Analog Out

c) Analog Value

d) Binary

e) Binary In

f) Binary Out

g) Binary Value

h) Multi-State In

i) Multi-State Out

j) Multi-State Value

k) Schedule Export

l) Calendar Export

m) Trend Export

n) Device

4) For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.

5) For BACnet devices, provide the following support at a minimum

a) Segmentation

b) Segmented Request

c) Segmented Response

d) Application Services
e) Read Property
f) Read Property Multiple
g) Write Property
h) Write Property Multiple
i) Confirmed Event Notification
j) Unconfirmed Event Notification
k) Acknowledge Alarm
l) Get Alarm Summary
m) Who-has
n) I-have
o) Who-is
p) I-am
q) Subscribe COV
r) Confirmed COV notification
s) Unconfirmed COV notification
t) Media Types
u) Ethernet
v) BACnet IP Annex J
w) MSTP
x) BACnet Broadcast Management Device (BBMD) function
y) Routing

7. DDE Device Integration:
   a. The Network Area Controller shall support the integration of device data via Dynamic Data Exchange (DDE), over the Ethernet Network. The Network Area Controller shall act as a DDE client to another software application that functions as a DDE server.
   b. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of these devices into the FMCS. Objects provided shall include at a minimum:
      1) DDE Generic AI Object
      2) DDE Generic AO Object
      3) DDE Generic BO Object
      4) DDE Generic BI Object

8. MODBUS System Integration:

a. The Network Area Controller shall support the integration of device data from Modbus RTU, Ascii, or TCP control system devices. The connection to the Modbus system shall be via an RS-232, RS485, or Ethernet IP as required by the device.

b. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of the Modbus system data into the FPMS. Objects provided shall include at a minimum:

1) Read/Write Modbus AI Registers

2) Read/Write Modbus AO Registers

3) Read/Write Modbus BI Registers

4) Read/Write Modbus BO Registers

c. All scheduling, alarming, logging and global supervisory control functions, of the Modbus system devices, shall be performed by the Network Area Controller.

d. The FMCS supplier shall provide a Modbus system communications driver. The equipment system vendor that provided the equipment utilizing Modbus shall provide documentation of the system's Modbus interface and shall provide factory support at no charge during system commissioning

9. OPC System Integration:

a. The Network Area Controller shall act as an OPC client and shall support the integration of device data from OPC servers. The connection to the OPC server shall be Ethernet IP as required by the device. The OPC client shall support third party OPC servers compatible with the Data Access 1.0 and 2.0 Specifications.

b. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of the OPC system data into the BAS. Objects provided shall include at a minimum:

1) Read/Write OPC AI Object

2) Read/Write OPC AO Object

3) Read/Write OPC BI Object

4) Read/Write OPC BO Object

5) Read/Write OPC Date/Time Input Object

6) Read/Write OPC Date/Time Output Object

7) Read/Write OPC String Input Object

8) Read/Write OPC String Output Object

c. All scheduling, alarming, logging and global supervisory control functions, of the OPC system devices, shall be performed by the Network Area Controller.

d. The FMCS supplier shall provide an OPC client communications driver. The equipment system vendor that provided the equipment utilizing OPC shall provide documentation of the system's OPC server interface and shall provide factory support at no charge during system commissioning.

10. Other Control System Hardware:

a. Space Temperature Wall Module. Wall Module shall be Honeywell or equivalent.

   1) Wall module shall have a 20K Ohm NTC thermistor temperature sensor with operating range of 45 to 99 F under a locking cover/enclosure with UL 916 listing designed for mounting on a standard electrical switch box.

   2) Space temperature sensors shall be accurate to plus or minus one F degree.

   3) Where specified, space temperature sensors shall have a setpoint knob calibrated for warmer-cooler adjustments (option: calibrated to allow plus or minus adjustments to a software setpoint).

   4) Where specified, wall module shall also have an after-hours override pushbutton and LED override indicator.

   5) Where specified, the wall module shall have a fan coil unit fan control switch for (auto-off-on) (auto-off-low-med-hi) fan control. The wall module function is further specified in SECTION III Sequence of Operation.

b. Duct Mount, Pipe Mount and Outside Air Temperature Sensors: Temperature sensors with an accuracy of + 0.3° F. Temperature sensors shall be Honeywell or equivalent.

   1) Outside air sensors shall include an integral sun shield.

   2) Duct sensors shall have sensor approximately in center of the duct, and shall have selectable lengths of 6, 12, and 18 inches.

   3) Multipoint averaging element sensors shall be provided where specified and shall have a minimum of one foot of sensor length for each square foot of duct area (provide multiple sensors if necessary).

   4) Pipe mount sensors shall have copper, or stainless steel separable wells.

c. Current Sensitive Switches: Solid state, split core current switch that operates when the current level (sensed by the internal current transformer) exceeds the adjustable trip point shall be provided where specified. Current switches shall include an integral LED for indication of trip condition and a current level below trip set point.

d. Low Temperature Limit Switches. Limit switches shall be Honeywell or equivalent. Safety low limit shall be manual reset twenty foot limited fill type responsive to the coolest section of its length.

e. High Temperature Limit Switches. Limit and Safety switches shall be Honeywell or equivalent. Safety high limit (firestats) shall be manual reset type.

f. Humidity Sensors. Humidity sensors shall be Honeywell or equivalent.

   1) Duct and room sensors shall have a sensing range of 5% to 95%.

   2) Duct sensors shall be provided with a sampling chamber.

   3) Outdoor air humidity sensors shall have a sensing range of 20% to 95% RH. They shall have a compensated ambient temperature range of 40°F to 170° F.

g. Enthalpy Sensors. Enthalpy sensors shall be Honeywell or equivalent. Duct mounted enthalpy sensor shall include a temperature sensor and a humidity sensor constructed to close an electrical contact upon a drop in enthalpy (total heat) to enable economizer modes of operation where specified.

   1) (OPTION - C7400 – Select one) Where specified provide duct mounted sensor including solid

state temperature and humidity sensors with electronics which shall output a 4-20 ma signal input to the controller upon a varying enthalpy (total heat) to enable economizer modes of operation when outside air enthalpy is suitable for free cooling .

h. Annular Pitot Tube Flow Meter. Annular pitot tube shall be averaging type differential pressure sensors with four total head pressure ports and one static port made of austenitic stainless steel.

1) Sensor shall have an accuracy of ± .25% of full flow and a repeatability of ± .05% of measured value.

2) Transmitter shall be electronic and shall produce a linear output of 4 to 20 mAdc corresponding to the required flow span.

3) The transmitter shall include non-interacting zero and span adjustments.

4) Acceptable Manufacturers: Pitot Tube: Dieterich Annubar, Transmitter: Setra or Dieterich

i. Fast Acting Two Position Fire & Smoke Actuators (ML4115, ML8115). Actuators shall be Honeywell or equivalent. Fire/smoke damper actuators shall be direct connected (no linkages) two-position spring return types with stroke for 90 degree nominal rotation applications and designed for 60,000 full stroke cycles and normal operation between 0 and 130 F.

1) Actuators control shall be compatible with SPST control switch and with torque ratings of 30 lb-in.

2) Actuator timing shall be 25 seconds maximum in powered instances and shall spring-return in 15 seconds.

3) Actuators shall be UL listed with UL873 plenum rating with die-cast aluminum housing with integral junction box and conduit knockouts, and designed to operate reliably in smoke control systems requiring UL555S ratings up to 350F.

4) The actuator shall be designed to operate for 30 minutes during a one-time excursion to 350F.

5) Actuator shall require no special cycling during long-term holding, and shall “hold” with no audible noise at a power consumption of approximately half of the driving power.

6) Actuators shall be 24 volt (ML8115) or 120 volt (ML4115) with models for clockwise (add a B suffix) and counter-clockwise (add an A suffix) spring return.

j. Temperature Control Panels: Furnish temperature control panels of code gauge steel with locking doors for mounting all devices as shown. Control panels shall meet all requirements of Title 24, California Administrative Code. All electrical devices within a control panel shall be factory wired. All external wiring shall be connected to terminal strips mounted within the panel. Provide printed PVC nameplates identifying all devices mounted on the face of control panels. A complete set of ‘as-built’ control drawings (relating to the controls within that panel) shall be furnished within each control panel.

11. Installation:

a. All work described in this section shall be performed by system integrators or contractors that have a successful history in the design and installation of integrated control systems. The installing office shall have a minimum of five years of integration experience and shall provide documentation in the submittal package verifying the company's experience.

b. Install system and materials in accordance with manufacturer’s instructions, and as detailed on the project drawing set.

c. Drawings of the TCS and FMCS network are diagrammatic only and any apparatus not shown, but required to make the system operative to the complete satisfaction of the Architect shall be furnished and installed without additional cost.

d. Line and low voltage electrical connections to control equipment shown specified or shown on the control diagrams shall be furnished and installed by this contractor in accordance with these Specifications.

e. Equipment furnished by the HVAC Contractor that is normally wired before installation shall be furnished completely wired. Control wiring normally performed in the field will be furnished and installed by this contractor.

12. Wiring:

a. All electrical control wiring and power wiring to the control panels, NAC, computers and network components shall be the responsibility of the this contractor.

b. The electrical contractor (Division 26) shall furnish all power wiring to electrical starters and motors.

c. All wiring shall be in accordance with the Project Electrical Specifications (Division 26), the National Electrical Code and any applicable local codes. All FMCS wiring shall be installed in the conduit types specified in the Project Electrical Specifications (Division 26) unless otherwise allowed by the National Electrical Code or applicable local codes. Where FMCS plenum rated cable wiring is allowed it shall be run parallel to or at right angles to the structure, properly supported and installed in a neat and workmanlike manner.

d. All wiring that must be exposed in finished areas shall be run in electrical raceways:

1) Raceways, fittings and junction boxes for all wiring shall be Legrand Wiremold 500/700 series, in a color selectable by the Architect.

13. Warranty:

a. Equipment, materials and workmanship incorporated into the work shall be warranted for a period of one year from the time of system acceptance.

b. Within this period, upon notice by the Owner, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by this contractor at no expense to the Owner

14. Warranty Access:

a. The Owner shall grant to this contractor, reasonable access to the TCS and FMCS during the warranty period.

b. The Owner shall allow the contractor to access the TCS and FMCS from a remote location for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period.

15. Software License:

a. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s).

b. The Owner, or his appointed agent, shall receive ownership of all job specific software configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration

and programming that is generated for a given project and /or configured for use within Niagara Framework (Niagara) based controllers and/or servers and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required Ids and passwords for access to any component or software program shall be provided to the Owner.

16. Acceptance Testing:
    a. Upon completion of the installation, this contractor shall load all system software and start-up the system. This contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to insure that the system is functioning in full accordance with these Specifications.
    b. This contractor shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the DDC system operation.
    c. Upon completion of the performance tests described above, repeat these tests, point by point as described in the validation log above in presence of Owner's Representative, as required. Properly schedule these tests so testing is complete at a time directed by the Owner's Representative. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.
    d. System Acceptance: Satisfactory completion is when this contractor and the Division 26 contractor have performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner’s Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

17. Operator Instruction, Training:
    a. During system commissioning and at such time acceptable performance of the TCS and FMCS hardware and software has been established this contractor shall provide on-site or remote operator instruction to the Owner's operating personnel. Operator instruction shall be done during normal working hours and shall be performed by a competent representative, familiar with the system hardware, software and accessories.
    b. This contractor shall provide 12 hours of instruction to the Owner's designated personnel on the operation of the TCS and FMCS and describe its intended use with respect to the programmed functions specified. Operator orientation of the systems shall include, but not be limited to; the overall operation program, equipment functions (both individually and as part of the total integrated system), commands, systems generation, advisories, and appropriate operator intervention required in responding to the System's operation.
    c. The training shall be in three sessions as follows:
        1) Initial Training: One (4 hours) session after system is started up and at least one week before first acceptance test. Manual shall have been submitted at least two weeks prior to training so that the Owners' personnel can start to familiarize themselves with the system before classroom instruction begins.
        2) First Follow-Up Training: One (4 hours) session approximately two weeks after initial training, and before Formal Acceptance. These sessions will deal with more advanced topics and answer questions.
        3) Warranty Follow Up: One (4 hours) session to be scheduled at the request of the Owner during the one year warranty period. These sessions shall cover topics as requested by the Owner such as; how to add additional points, create and gather data for trends, graphic screen

generation or modification of control routines.

2.23 SEQUENCE OF OPERATIONS

A. General:

1. The terms Building Management System (BMS) and Facility Network & Control System (FMCS) will be used synonymously herein.

2. All mechanical systems shall be automatically controlled where no description of operation is indicated for a particular system or device. The Contractor shall select appropriate control scenarios and review them with the Engineer prior to proceeding. All controls shall be arranged and designed for maximum energy conservation.

3. All equipment shall be tied to the building automation system central controller for scheduling and owner's hours of operation.

4. Provide control points required to perform Sequence of Operation and to monitor and control equipment. Provide set-point and space temperatures for each space and equipment.

5. Provide all control panels, accessory modules and wiring, in full cooperation with the Mechanical Contractor, necessary to accomplish the sequence of operations indicated herein.

6. All sequences shall be capable of being executed by the BMS unless noted as being controlled locally or specifically noted as controlled by others.

7. All temperatures listed are in degrees Fahrenheit.

8. All equipment controlled by the Building Management System shall be capable of manual operation through HOA switches and starters.

9. For hydronic systems with sensors, refer to the flow diagrams for sensor locations. Coordinate to ensure proper upstream and downstream pipe diameters for all sensors.

10. For duct systems with sensors, provide sensors at locations dictated herein or as scheduled. Space sensors shall be placed where they are shown on plans or described herein.

11. Motor and compressor failures for all HVAC equipment (fans, pumps, drive, heat pumps, etc.) shall be monitored through the BMS utilizing current sensors or system manufacturer's integral sensor technology.

12. Appropriate delays shall be included in the programming to avoid nuisance and start-up alarm conditions; such delays are not included herein.

13. All inputs for controlling variable frequency drives shall be inputs to the BMS; inputs shall not be connected to the VFD directly. Inputs to VFD's shall be from the BMS. VFD fault contacts shall be connected to the BMS, and upon a fault condition of the VFD, there shall be an alarm.

B. Control Devices:

1. Devices and sensors shall be adjustable. The BMS shall display setpoints and actual conditions of all control devices and the position of all actuators at the front end.

2. Global limits shall be maintained through the BMS and be adjustable at the front end. The range of setpoint adjustment available shall be +/- 5°F at each user adjustable temperature controller. Global setpoints shall be as follows (and shall be adjustable at the front end).
   a. Occupied heating = 70°F
   b. Unoccupied heating = 62°F
   c. Occupied cooling = 75°F
   d. Unoccupied cooling = 82°F.

3. All user/occupant ajustable space/zone controllers:
   a. Enabled user features include:
      1) Temperature adjustment within the global range.
   b. Disabled features include:
      1) Mode (heat/cool auto).
      2) Fan speed control.
      3) Turning air system off completely.
      4) All other normally allowed local functions unless explicitly listed as “enabled” above.

C. Dedicated Outdoor Air System (DOAS) units:

1. General:
   a. Each unit shall include a BACnet interface card for connection to the BMS sub-network such that the full functionality of the unit can be monitored and controlled from the BMS.
   b. The operating mode of the unit shall be considered “Occupied” or “Unoccupied” in conjunction with the building programming schedule to be coordinated with the Owner’s Project Manager.
   c. Whenever a unit is off per the BMS, for any reason, all devices shall go to their fail-safe positions as follows:
      1) Supply and exhaust fans are de-energized.
      2) Outside air and exhaust dampers are fully closed.
      3) Compressors are de-energized.
      4) Furnace is locked out.

2. Fans:
   a. Supply Fan:
      1) Occupied: On.
      2) Unoccupied: Off, except on call for unoccupied heating.
   b. Exhaust Fan:

1) Occupied: On.
2) Unoccupied: Off.

3. Outdoor air and exhaust air dampers
   a. Occupied: Open
   b. Unoccupied: Closed, except on a call for unoccupied heating.

4. Energy recovery wheel:
   a. The energy recovery wheel shall be enabled to run whenever the DOAS unit is indexed on by the BMS.
   b. The ERV wheel shall modulate speed by variable frequency drive to maximize the energy transfer efficiency between air streams for heating and cooling functions.
   c. The ERV wheel shall be commanded to modulate for frost control based on internal algorithms, cycling the supply fan off and outdoor air damper closed, only providing exhaust air as required to prevent frost accumulation on the wheel. The unit defrost cycle time shall be minimized.
   d. The ERV wheel shall be stopped when the unit is indexed to economizer cycle based on outdoor air enthalpy conditions comparative to return/exhaust air conditions.

5. Discharge air temperature (DAT) control:
   a. The discharge air temperature and humidity shall be controlled based on a duct mounted combination temperature/humidity sensor and a daisy-chain of averaging space combination temperature/humidity sensors (refer to drawings).
      1) The unit controller shall index the economizer dampers, energy recovery wheel, cooling stages, and gas heating furnace as required to meet the DAT setpoints indicated below.
      2) Normal or Heating mode: DAT = 70°F.
      3) Cooling mode: DAT = 55°F.
      4) Dehumidification mode: DAT = 70°F.

6. Heating:
   a. The unit shall utilize a modulating control strategy to stage furnace burner firing rate in conjunction with ERV wheel modulation as required to maintain the discharge air temperature. The unit controller shall index the unit to heating mode whenever the averaging space sensors indicate heating is required (average space temperature is <70°F).
   b. Staging:
      1) The first stage of heating shall be the ERV wheel. The unit controller shall modulate the ERV wheel to maximize energy transfer to maintain the DAT setpoint.
      2) If the ERV wheel is at max. speed and the DAT continues to fall, the unit shall automatically stage the furnace on and modulate the firing rate to maintain the DAT setpoint.

7. Cooling:
   a. The unit shall utilize a staged cooling strategy by integrating all compressor cooling, economizer cooling, and ERV wheel energy transfer. The unit controller shall index the unit to cooling mode

whenever the averaging space sensors indicate cooling is required (average space temperature is >75°F).

b. Mechanical cooling (direct expansion compressor cooling) shall be locked out if the unit is in heating mode (furnace is energized).

c. When indexed to cooling mode by averaging space temperature sensors, the unit shall be commanded to cooling and shall reset the discharge air temperature to 55°F.

d. Staging:

1) The first stage of cooling shall be economizer cooling. Based on enthalpy conditions. If outdoor air enthalpy is less than return/exhaust air enthalpy, the unit shall bypass the ERV wheel to deliver outdoor air directly without subsequent staging as long as the DAT can be satisfied.

2) The second stage of cooling shall be economizer cooling integrated with the ERV wheel. If outdoor air enthalpy increases to the return air enthalpy reading, the ERV wheel shall energize and the system shall monitor the unit discharge air enthalpy to maintain the DAT setpoint.

3) The third stage of cooling shall be ERV wheel at 100% speed integrated with mechanical (direct expansion compressor) cooling. The unit shall stage on compressors as required to maintain the DAT setpoint.

e. Hot Gas Reheat Coil – Dehumidification Mode:

1) The unit controller shall modulate hot gas to the reheat coil from the refrigeration circuit as required to keep neutral DAT of 70°F under the following conditions:

a) Whenever the system averaging space temperatures are in disagreement as to the need for cooling (e.g. one sensor is >75°F and the other is less).

b) Whenever any of the space RH sensors registers a level >60% RH.

8. Alarms:

a. Fan failure (supply & exhaust).

b. ERV wheel motor failure.

c. Damper failure (intake & exhaust).

d. Low unit DAT (>5°F below setpoint).

e. High unit DAT (<5°F above setpoint).

f. Dirty filter (supply & exhaust).

g. Duct mounted smoke detector activated (supply & exhaust fans shall automatically de-energize).

D. Packaged Rooftop HVAC (RTU) Units:

1. General:

a. Each unit shall include a BACnet interface card for connection to the BMS sub-network such that the full functionality of the unit can be monitored and controlled from the BMS.

b. Units serving spaces with transient occupancy that could be considered “densely occupied” such as libraries, gymnasiums, etc. shall be furnished with demand controlled ventilation (DCV) sensors and controls. DCV sensing shall be return air mounted CO2 detection.

c. The operating mode of the unit shall be considered "Occupied" or "Unoccupied" in conjunction with the building programming schedule to be coordinated with the Owner's Project Manager.

d. Whenever a unit is off per the BMS, for any reason, all devices shall go to their fail-safe positions as follows:

1) Supply fan is de-energized.

2) Outside air damper is fully closed.

3) Compressor(s) are de-energized.

4) Furnace is locked out.

2. Supply Fan:

a. Occupied: On.

b. Unoccupied: Off, except on call for unoccupied heating or cooling.

3. Outdoor air damper:

a. Occupied: Open to minimum position except when in economizer mode.

b. Unoccupied: Closed, except on a call for economizer cooling or DCV sensor reads > 500 parts per million (PPM) of CO2.

c. DCV: Open, starting at minimum position and increasing toward full open based on dynamic feedback from return air CO2 sensor.

1) For CO2 measured < 750 PPM, damper shall stay at minimum position.

2) If C02 measured increases above 750 PPM, damper shall modulate toward full open and shall close toward minimum position if CO2 drops closer to 750 PPM.

4. Heating:

a. The unit controller shall index the unit to heating mode whenever the space sensor indicates heating is required (space temperature is <70°F).

b. Staging:

1) The unit shall command the furnace on and modulate (or stage/step) from low to high fire based on space temperature drift below setpoint.

2) The furnace shall modulate (or stage/step) from high to low fire as the space temperature approaches setpoint and then be off once setpoint is met.

5. Cooling:

a. The unit shall utilize a staged cooling strategy by integrating all compressor cooling with economizer cooling. The unit controller shall index the unit to cooling mode whenever the space sensor indicates cooling is required (space temperature is >75°F).

b. Mechanical cooling (direct expansion compressor cooling) shall be locked out if the unit is in heating mode (furnace is energized).

c. On a call for cooling the unit shall stage as needed to provide 55°F discharge air.

1) The first stage of cooling shall be economizer cooling. Based on enthalpy conditions. If

outdoor air enthalpy is less than return air enthalpy, the unit shall deliver outdoor air directly without subsequent staging as long as the DAT can be satisfied.

2) The second (and third, if applicable) stage of cooling shall be mechanical (direct expansion compressor) cooling. The unit shall stage on compressors as required to maintain the DAT setpoint.

6. Alarms:
   a. Fan failure.
   b. Damper failure.
   c. Low space temp (>5°F below setpoint).
   d. High space temp (>5°F above setpoint).
   e. Dirty filter.
   f. Duct mounted smoke detector activated (supply fan shall automatically de-energize).
   g. DCV high limit (CO_2 > 1000 PPM).

E. Heating Water Boiler Plant:

1. The boiler plant shall be enabled and disabled through the BMS based on ambient OAT:
   a. OAT above 60°F: Off.
   b. OAT below 50°F: On, and remain on until OAT rises above 60°F.

2. System supply water temperature:
   a. The boiler supply water temperature delivery for the system shall be reset based on an outdoor air temperature strategy:
      1) When ambient OAT <20°F, SWT shall be 160°F.
      2) When ambient OAT >50°F, SWT shall be 120°F.
      3) When ambient OAT is 21°F to 49°F, SWT shall reset inversely proportional from 160°F down to 120°F.

3. Each boiler has an primary boiler pump. Pumps shall be operated automatically from the boiler controller to provide supply water temperature to the secondary loop via system sensors. Supply water temperature shall be on a reset schedule as noted above.

4. Boiler staging:
   a. Boilers shall be setup in a lead and standby configuration and the lead boiler shall automatically switch weekly.
   b. When commanded to fire, the lead boilers shall stage on first and modulate up to 100% firing rate as required to maintain the system supply water temperature.
   c. If after 100% fire is reached on the lead boiler, the SWT cannot be met, the standby boiler shall fire and modulate up as required to achieve the SWT.
   d. When SWT is met, the reverse staging and modulation shall occur.

5. Secondary system pumps:
    a. Shall be enabled/disabled with the boiler plant On/Off setpoints listed above.
    b. Lead/lag operation:
        1) Pumps shall be automatically switched between lead and lag pump status through the BMS daily at 2 am.
        2) If lead pump fails to start, an alarm shall be generated and the BMS shall automatically index the lag pump to lead status.
    c. Speed Control:
        1) Pumps shall be self-sensing variable frequency drive technology and automatically vary system flow based on system differential pressure.
        2) Speed settings shall be set initially during test and balance procedure for "full flow" and "minimum flow" conditions:
            a) Full flow = all equipment calling for full heat demand, valves full open (HW coils, CUH, UH, FT).
            b) Minimum flow = "system bypass" flow through CUH and UH coils only.
6. Points:
    a. Boiler(s) status.
    b. Boiler pump status.
    c. Secondary (system) pump status.
    d. Secondary (system) supply water temperature setpoint.
    e. Secondary (system) supply water temperature active.
    f. Secondary (system) return water temperature active.
    g. Secondary (system) pump differential pressure active.
7. Alarms:
    a. Boiler(s): lockout condition.
    b. Boiler pump fail to start.
    c. Secondary (system) pump fail to start.
    d. Low secondary system supply water temperature (>10°F below setpoint).
    e. High secondary system supply water temperature (<10°F above setpoint).

F. Hot Water Coils (DOAS System – duct mounted coils):

1. Provide a space mounted adjustable temperature sensor meeting the constraints of "control devices" listed above.
2. Setpoints: shall be globally adjustable at the BMS, including global range adjustment for local user control and shall be individually adjustable at each sensor within the global range.

3. All HWC's on a respective system (DOAS) shall have their control valves mapped to the DOAS unit control logic. Whenever the respective DOAS unit is in cooling of dehumidification mode, all associated HWC control valves shall be held closed (no reheat allowed).

4. On a call for heat at the space sensor, the HW coil control valve shall modulate towards full open based on active space temperature deviation below setpoint.

5. As space temperature approaches the sensor setpoint, the control valve shall modulate closed until setpoint is met.

G. Cabinet Unit Heaters:

1. Provide a space mounted temperature sensor. The temperature sensor shall cycle the fan On/Off as well as actuate the 2-position control valve open/closed based on heating demand.

2. Setpoints: shall be globally adjustable at the BMS only (no user adjustability at the space level).
   a. Occupied: 70°F
   b. Unoccupied: 60°F

3. Points:
   a. Fan status.
   b. Control valve status (open/closed).
   c. Space temperature setpoint.
   d. Space temperature active.

4. Alarms:
   a. Low space temp. (>5°F below sensor setpoint)

H. Unit Heater:

1. Provide a space mounted temperature sensor. The temperature sensor shall cycle the fan On/Off based on heating demand.

2. Setpoints: shall be globally adjustable at the BMS only (no use adjustability at the space level).
   a. Permanent: 50°F

3. Points:
   a. Fan status.
   b. Space temperature setpoint.
   c. Space temperature active.

4. Alarms:
   a. Low space temp. (>5°F below sensor setpoint)

PART 3 – EXECUTION

3.1 COMMISSIONING OF EQUIPMENT AND SYSTEMS

A. Coordinate with the Owner's Commissioning Agent (CxA) for the commissioning of the work of this specification section. The Contractor(s) providing the work of this specification section shall be available before construction, during construction, and at the end of construction to assist the CxA in the commissioning process. Assistance shall include demonstrating proper operation, calibration, and adjustment of the work of this specification section, as necessary for the CxA to verify that the equipment and systems are working properly and in accordance to the Construction Documents.

B. Where the commissioning process reveals, as determined by the CxA, equipment and/or systems that are not operating properly or are not in accordance to the Construction Documents, such equipment and systems shall be repaired and/or adjusted until they are operating properly and are in accordance to the Construction Documents.

C. Prior to final commissioning, submit documentation indicating that the Contractor(s) providing work of this section have verified the following:

1. That equipment and systems of this specification section have been started up and tested in accordance to the manufacturer's installation manuals. Where either the manufacturer's installation manuals or the equipment submittals include manufacturer's start-up sheets, such documentation shall be completed, signed, and dated by the Contractor(s) performing the start-up.

2. That equipment and systems of this specification section have been tested and balanced by the testing and balancing agency.

3.2 SPECIAL RESPONSIBILITIES

A. Coordination: Cooperate and coordinate with work of other Sections in executing work of this Section.

1. Perform work such that progress of entire project including work of other Sections shall not be interfered with or delayed.

2. Provide information as requested on items furnished under this Section which shall be installed under other Sections.

3. Obtain detailed installation information from manufacturers of equipment provided under this Section.

4. Obtain final roughing dimensions or other information as needed for complete installation of items furnished under other Sections or by Owner.

5. Keep fully informed as to shape, size and position of openings required for material or equipment to be provided under this and other Sections. Give full information so that openings required by work of this Section may be coordinated with other work and other openings and may be provided for in advance. In case of failure to provide sufficient information in proper time, provide cutting and patching or have same done, at own expense and to full satisfaction of Architect.

6. Provide information as requested as to sizes, number and locations of concrete housekeeping pads necessary for floor-mounted vibrating and rotating equipment provided under this Section.

7. Notify Architect of location and extent of existing piping, ductwork and equipment that interferes with

new construction. In coordination with and with approval of Architect, relocate piping, ductwork and equipment to permit new work to be provided as required by Contract Documents. Remove non-functioning and abandoned piping, ductwork and equipment as directed by Architect. Dispose of or store items as requested by Architect.

B. Installation Only Items:

1. Where this Contractor is required to install items which it does not purchase, it shall coordinate their delivery and be responsible for this unloading from delivery vehicles and for their safe handling and field storage up to the time of installation. This trade shall be responsible for:

   a. Any necessary field assembly and internal connections, as well as mounting in place of the items, including the purchase and installation of all dunnage supporting members and fastenings necessary to adapt them to architectural and structural conditions.

   b. Their connection to building systems including the purchase and installation of all terminating fittings necessary to adapt and connect them to the building system.

2. This Contractor shall carefully examine such items upon delivery. Claims that any of these items have been received in such condition that their installation will require procedures beyond the reasonable scope of work of this Contractor will be considered only if presented in writing within one (1) week of their date of delivery. Unless such claims have been submitted this Contractor shall be fully responsible for the complete reconditioning or replacement of the damaged items.

C. Maintenance of equipment and Systems: Maintain HVAC equipment and systems until Final Acceptance. Ensure adequate protection of equipment and material during delivery, storage, installation and shutdown delays pending final test of systems and equipment because of seasonal conditions. Do not use boilers before providing water treatment where required; this includes use of boilers for temporary heat or for testing.

D. Use of Premises: Use of premises shall be restricted as directed by Architect and as required below:

1. Remove and dispose of dirt and debris, and keep premises reasonably clean. Upon completion of work, remove equipment and unused material. Put building and premises in neat and clean condition and do cleaning and washing required to provide acceptable appearance and operation of equipment, to satisfaction of Architect and as specified under CLEANING paragraph.

2. It shall be this trade's responsibility to store his material in a manner that will maintain an orderly clean appearance. If stored on-site in open or unprotected areas, all equipment and material shall be kept off the ground by means of pallets or racks, and covered with tarpaulins.

3. Do not interfere with functions of existing sewers and gas mains. Extreme care shall be observed to prevent debris from entering ductwork. Confer with Architect as to disruption of heating services or other utilities due to testing or connection of new work to existing. Interruption of heating services shall be performed at time of day or night deemed by Architect to provide minimum interference with normal operation. Obtain Architect's approval of the method proposed for minimizing service interruption.

E. Surveys and Measurements:

1. Base measurements, both horizontal and vertical, on reference points established by Contractor and be

responsible for correct laying out of work.

2. In event of discrepancy between actual measurements and those indicated, notify Architect in writing and do not proceed with work until written instructions have been issued by Architect.

F. Fireproofing:

1. Clips, hangers, clamps, supports and other attachments to surfaces to be fireproofed shall be installed, insofar as possible prior to start of spray fiber work.

2. Ducts, piping and other items, which would interfere with proper application of fireproofing, shall be installed after completion of spray fiber work.

3. Patching and repairing of spray fireproofing due to cutting or damaging to fireproofing during course of work specified under this Section shall be performed by installer of fireproofing and paid for by trade responsible for damage and shall not constitute grounds for an extra to Owner.

3.3 MATERIALS AND WORKMANSHIP

A. Work shall be neat and rectilinear. Ductwork and piping shall run concealed except in mechanical rooms and areas where no hung ceiling exists. Install material and equipment as required by manufacturers. Installation shall operate safely and without leakage, undue wear, noise, vibration, corrosion or water hammer. Work shall be properly and effectively protected, and pipe and duct openings shall be temporarily closed to prevent obstruction and damage before completion.

1. Except as specified otherwise, material and equipment shall be new. Provide supplies, appliances and connections necessary for complete and operational installation. Provide components required or recommended by OSHA and applicable NFPA documents.

2. References to manufacturers and to catalog designation are intended to establish standards of quality for materials and performance but imply no further limitation of competitive bidding.

3. Finish of materials, components and equipment shall be as approved by Architect and shall be resistant to corrosion and weather as necessary.

4. Owner will not be responsible for material and equipment before testing and acceptance.

3.4 CONTINUITY OF SERVICES

A. Do not interrupt existing service without Owner’s approval.

B. Schedule interruptions in advance, according to Owner’s instructions. Submit, in writing, with request for interruption, methods proposed to minimize length of interruption.

C. Interruptions shall be scheduled at such times of day and work so that they have minimal impact on Owner’s operations.

3.5 TAGS

A. Upon completion of work, attach engraved laminated tags to all valves (listed in the valve directory called for in the "Bulletins, Manuals and Instructions" paragraph of these Specifications) and all pieces of HVAC equipment (including but not limited to pumps, fans, air handlers, coils and all other equipment listed in the HVAC Schedules). Valve tags shall have black characters on white face, consecutively numbered and prefixed by letter "V". Equipment tags shall have black characters on white face with labels corresponding to drawing schedule numbers.

B. Embossed or engraved aluminum or brass tags may be substituted if desired. Tags shall be at least 1/8" thick.

C. Valve tags shall be at least 1" in diameter with numerals at least 3/8" high and attached by "S" hooks or chains. Equipment tags shall be at least 2" diameter securely attached to apparatus.

D. Provide manufacturers equipment nameplates, catalog numbers and rating identification securely attached to electrical and mechanical equipment with screws or rivets. Adhesives or cements will not be permitted.

3.6 PIPE AND DUCT IDENTIFICATION

A. Ductwork shall be stenciled at each junction or branch takeoff, at least once in each room, and at intervals not longer than 20 feet. Stencil shall clearly identify duct service ("S" for supply air; "R" for return air, "O" for outdoor air, "E" for exhaust air), area served by branch, and arrow indicating direction of flow.

B. Provide color-coded pipe identification markers on piping installed under this Section. Pipe markers shall be snap-on laminated plastic protected by clear acrylic coating. Pipe markers shall be applied after architectural painting where such is required.

C. Provide arrow marker with each pipe content marker to indicate direction of flow. If flow can be in either direction, use double-headed arrow marker.

D. Mains shall be labeled at points of entrance and exit from mechanical room, adjacent to each valve, on each riser, at each tee fitting, at points of entrance and exit from building, at least once in each room and at intervals no longer than 20 feet.

E. Size of legend letters on markers and length of color field shall be per the latest edition of ANSI A13.1.

F. Markers shall be "Setmark" by Seton Name Plate Corp., or approved equal.

G. Following color-coding shall be used with names in black letters on background and while letters on green background:

Service	Legend	Background Color
Suction Gas Refrigerant	SGR	Green
Discharge Gas Refrigerant	DGR	Green
Liquid Refrigerant	LR	Green
Condensate	CON	Yellow

H. Color banding shall meet latest edition of ANSI A13.1 and OSHA.

3.7 ACCESS AND ACCESS PANELS

A. Provide proper access to materials and equipment that require inspection, replacement, repair or service and coordinate their delivery with the installing Trade. If proper access cannot be provided, confer with Architect as to best method of approach for minimizing effect of reduced access which may result.

B. Coordinate and prepare a location, size and function schedule of access panels required to fully service equipment and deliver to a representative of the installing Trade. Furnish and install distinctively colored buttons (color as selected by Architect) in finished ceiling to identify all access panels.

C. Furnish access panels for installation under other Sections where fire dampers, volume dampers, controls, shut-off valves, control valves, check valves or other items installed under this Section require access and are concealed in floor, wall, furred space or above ceiling. Access panels shall be by Milcor, Knapp, Nystrom or Inland Steel; coordinate selection with other Sections supplying similar access panels.

D. Ceilings consisting of lay-in or removable splined tiles do not require access panels and dampers, splitters or test hole openings above ceiling shall have location marked with thumb tack on finished ceiling panel. Location shall be noted on record Drawings.

E. Access panels shall have same fire-rating classification as surface penetrated.

F. Panels shall be at least 12” x 12”; access panels at equipment shall be 18” x 18”.

3.8 PENETRATIONS AND SLEEVES

A. General:

1. Provide pipe and duct sleeves and packing materials as specified and as shown on Drawings at penetrations of foundations, walls, slabs (except on-grade), partitions and floors. Sleeves shall meet NFPA-101 requirements and materials requirements of PART 2 or this Section.

2. Coordinate work carefully with architectural and structural work. Set sleeves in forms before concrete is poured. Provide core drilling as necessary if walls are poured, or otherwise constructed, without sleeves and a wall penetration is required. Provide core drilling as required for penetrations of existing construction. Do not penetrate structural members without Architect's approval.

3. Sleeves for insulated pipe and duct in non-fire rated construction shall accommodate continuous insulation without compression. Sleeves and/or penetrations in fire-rated construction shall be packed with fire-rated material which shall maintain the fire rating of the wall. Seal ends of penetrations to provide continuous vapor barrier where insulation is interrupted. See "PART 2" of these Specifications for requirements for packing materials.

4. Sleeves through floor shall be water-tight and shall extend 2" above floor surface.

B. Pipe Sleeves:

1. Annular space between pipe and sleeve shall be at least 1/4".

2. Sleeves are not required for slabs-on-grade unless specified otherwise.

3. Sleeves and packing materials, through rated fire walls and smoke partitions shall maintain fire rating of construction penetrated.

4. Do not support piping risers on sleeves.

C. Duct Sleeves and Prepared Openings:

1. Provide duct sleeves for round ducts 15" and smaller; provide prepared, framed openings for round ducts larger than 15" and for square, rectangular and flat oval ducts, except as specified otherwise. Sleeves shall met SMACNA requirements.

2. Provide sleeves for ducts through 1, 2, or 3-hour fire-rated construction and smoke partitions, regardless of size and shape of ducts. Sleeves shall maintain fire rating of construction penetrated. Sleeve and seal materials, construction and clearances shall meet requirements of SMACNA Fire Damper and Heat Stop Guide for Air Handling Systems.

3. Prepared openings shall be framed to provide 1" clearance between framing and duct or duct insulation.

D. Installation Testing, Listings and Approvals:

1. Installation shall meet material manufacturer's recommendations exactly, particularly as regarding safety, ventilation, removal of foreign materials and other details of installation. Dam openings as recommended. Remove flammable materials used for damming and forming seals in fire-rated construction.

2. Sleeve penetration methods shall be water and gas-tight and shall meet requirements of ASTM E-119 Standard Methods of Fire Tests of Building Construction and Materials.

3. Fire-stop penetration seal methods and materials shall be FM-approved and UL-listed as applicable.

4. Inspect foamed sealants to ensure manufacturer's optimum cell structure and color ranges.

3.9 ANCHORS AND INSERTS

A. Inserts shall be iron or steel of type to receive machine bolt head or nut after installation. Inserts shall permit adjustment of bolt in one (1) horizontal direction and shall develop strength of bolt when installed in properly cured concrete.

B. Provide anchors as necessary for attachment of equipment supports and hangers.

3.10 INSTALLATION OF EQUIPMENT

A. Avoid interference with structure and with work of other trades, preserving adequate headroom and clearing doors and passageways to satisfaction of Architect and in accordance with code requirements. Installation shall permit clearance for access to equipment for repair, servicing and replacement.

B. Install equipment so as to properly distribute equipment loads on building structural members provided for equipment support under other Sections. Roof-mounted equipment shall be installed and supported on structural steel provided under other Sections.

C. Provide suspended platforms, strap hangers, brackets, shelves, stands or legs as necessary for floor, wall or ceiling mounting of equipment provided under this Section (e.g. heating and ventilating units, fans, ducts and piping) as indicated on Drawings and in Specifications.

D. Provide steel supports and hardware for proper installation of hangers, anchors, guides, etc.

E. Provide cuts, weight and other pertinent data required for proper coordination of equipment support provisions and installation.

F. Structural steel and hardware shall conform to Standard Specifications of ASTM; use of steel and hardware shall conform to requirements of Section 5 of Code of Practice of American Institute of Steel Construction.

G. Verify site conditions and dimensions of equipment to ensure access for proper installation of equipment without disassembly which will void warrantee. Report in writing to Architect, prior to purchase or shipment of equipment involved, on conditions which may prevent proper installation.

3.11 INSTALLATION OF BOILERS

A. General:

1. Installation shall be performed by the contractor in accordance with the requirements of the applicable codes. Contractor shall review the boiler and installation for compliance with requirements and/or issues that may affect boiler performance. Installation should not proceed until unsatisfactory conditions have been corrected.

2. The contractor shall mount the equipment as described below:

   a. Install boilers on cast-in-place concrete equipment base in compliance with the requirements for equipment bases and foundation specified in Section 03 30 00 “Cast-in-Place Concrete.”

   b. If required by the local code, install vibration isolation devices in compliance with Section 23 05 48 “Vibration and Seismic Controls for HVAC Piping and Equipment.”

3. The contractor shall install gas-fired boilers in accordance with NFPA 54/ANSI Z223.1 (United States), or CAN/CSA B/149.1 (Canada).

4. The contractor shall install gas-fired boilers in accordance with NBIC – Part 1 (Installation), or another installation code having local jurisdiction.

5. The contractor shall assemble and install any external boiler safety/trim devices.

6. The contractor shall install any electrical devices furnished with the boiler, but not specified to be factory-mounted.

7. The contractor shall install control wiring to field mounted electrical devices in accordance with the requirements of NFPA 70.

8. The contractor shall install electrical (power) wiring to the boiler in accordance with the requirements of NFPA 70.

B. Connections:

1. Gas Piping:
   a. Each boiler shall be provided with all necessary gas connections. Refer to the boiler's specification sheet or manual for connection sizes.
   b. Install gas piping in accordance with NFPA 54/ANSI Z223.1 (United States), or CAN/CSA B/149.1 (Canada).
   c. For boilers configured for Natural Gas or Dual Fuel, refer to the requirements of Section 23 11 23 "Facility Natural-Gas Piping".
   d. For boilers configured for Propane Gas or Dual Fuel, refer to the requirements of Section 23 11 26 "Facility Liquefied-Petroleum Gas Piping".

2. Hydronic Piping:
   a. Each boiler shall be provided with all necessary inlet (supply) and outlet (return) connections. Refer to the boiler's specification sheet or manual for connection sizes.
   b. Check manufacturer's installation manual for clearance dimensions and install piping that will allow for service and ease of maintenance.
   c. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection and adhere to proper codes for neutralization.
   d. The hydronic piping and related components shall comply with the requirements of 23 21 00 "Hydronic Piping and Pumps".
   e. All meters and gages in the hydronic piping shall comply with the requirements of Section 23 05 19 "Meters and Gages for HVAC Piping".
   f. All instrumentation and controls in the hydronic piping shall comply with the requirements of Section 23 09 13 "Instrumentation and Control Devices for HVAC".
   g. All valves in the hydronic piping shall comply with the requirements of Section 23 05 23 "General-Duty Valves for HVAC Piping".

h. All expansion fittings shall comply with the requirements of Section 23 05 16 “Expansion Fittings and Loops for HVAC Piping”.

i. Any pipe hangers or supports shall comply with the requirements of Section 23 05 29 “Hangers and Supports for HVAC Piping and Equipment”.

j. Any vibration isolation devices on the hydronic piping shall comply with the requirements of Section 23 05 48 “Vibration and Seismic Controls for HVAC Piping and Equipment.”

k. The feedwater piping shall comply with the requirements of Section 23 53 00 “Heating Boiler Feedwater Equipment”.

l. The hydronic piping shall be insulated in accordance with the requirements of Section 23 07 19 “HVAC Piping Insulation”.

m. After insulation, all hydronic piping shall be identified in accordance with the requirements of Section 23 05 53 “Identification for HVAC Piping and Equipment”.

n. Any water treatment of the hydronic system shall be in accordance with the boiler manufacturer’s requirements and/or Section 23 25 13 “Water Treatment for Closed-Loop Hydronic Systems”.

3. Exhaust Venting:

   a. The boilers shall be dual certified as Category II or IV appliances and are capable of operating with slightly negative to slightly positive exhaust vent pressure, and the vent gas temperature is likely to cause condensate production in the vent.

   b. Install the exhaust/flue venting system in accordance with NFPA 54/ANSI Z223.1 (United States), or CAN/CSA B/149.1 (Canada) and per the manufacturer’s recommendations in the installation manual.

   c. All exhaust venting components shall comply with the requirements of Section 23 51 00 “Breechings, Chimneys and Stacks.”

4. Air Inlet:

   a. The boilers shall be certified for Direct Vent / Sealed Combustion installations where the combustion air is supplied directly to the boiler through ductwork.

   b. Install the air inlet system in accordance with NFPA 54/ANSI Z223.1 (United States), or CAN/CSA B/149.1 (Canada) and per the manufacturer’s recommendations in the installation manual.

   c. All air inlet components shall comply with the requirements of Section 23 37 00 “Air Outlets and Inlets”.

5. Electrical:

   a. Install an external disconnect and overload protection for each boiler in accordance with the requirements of NFPA 70.

   b. The voltage requirements for each boiler model is described below:

   c. The boilers shall be configured for 110-120VAC, Single Phase (w/ Neutral), 60 Hz.

   d. The amperage requirements for each boiler shall be as scheduled.

3.12 PAINTING

A. Equipment installed under this Section shall have shop coat of non-lead gray paint. Hangers and supports shall have one (1) coat of non-lead red primer. Machinery such as pumps, fans, etc., shall be stenciled with equipment name. Stencil shall be at least 6" high for large equipment, 2" high for small equipment. Finish painting, including painting of various piping and duct systems, shall be done under other Sections.

B. Note requirements for Architect's approval invoked under paragraph 3.03 MATERIALS AND WORKMANSHIP regarding finish of material and equipment which are visible or subject to corrosive or atmospheric conditions.

3.13 CLEANING

A. Ductwork:

1. New ductwork shall be shipped from the shop to the job site with the ends of the ducts sealed tight with heavy duty plastic to prevent dirt, water or other elements from entering the ducts while in transport to the job site.

2. At the end of each working day all open ends of ducts that have been hung in place shall be re-covered with the plastic material to prevent the entry of foreign objects, dirt or debris into the ducts.

3. All ducts shall be cleaned of dirt and any other foreign matter if it should accumulate on or in the ducts prior to start-up and testing of the new HVAC systems. If the ducts do need to be blown clean, cheesecloth shall be placed over the outlet air openings, and the rooftop unit(s) serving the ducts shall be provided with temporary filters.

3.14 STARTUP, TESTING, ADJUSTING AND BALANCING FOR HVAC

A. General:

1. References:

a. AABC – National Standards for Total System Balance.

b. ADC – Test Code for Grilles, Registers, and Diffusers.

c. ASHRAE 111 – Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilating, Air Conditioning and Refrigeration Systems.

d. NEBB – Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

e. SMACNA – HVAC Systems Testing, Adjusting, and Balancing.

2. Qualifications:

a. Agency: Company specializing in the testing, adjusting, and balancing of systems specified in this section with minimum three years documented experience certified by AABC.

b. Perform work under supervision of AABC Certified Test and Balance Engineer or NEBB Certified Testing, Balancing and Adjusting Supervisor.

B. Examination:

1. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
   a. Systems are started and operating in a safe and normal condition.
   b. Control systems are installed complete and operable.
   c. Proper thermal overload protection is in place for electrical equipment.
   d. Ductwork systems:
      1) Final filters are clean and in place. If required, install temporary media in addition to final filters.
      2) Duct systems are clean of debris.
      3) Fans are rotating correctly.
      4) Dampers are in place and open.
      5) Air coil fins are cleaned and combed.
      6) Access doors are closed and duct end caps are in place.
      7) Air inlets and outlets are installed and connected.
      8) Duct system leakage is minimized.
2. Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.
3. Beginning of work means acceptance of existing conditions.

C. Preparation:

1. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Owner to facilitate spot checks during testing.
2. Provide additional balancing devices as required.

D. Installation Tolerances:

1. HVAC Systems: Adjust to within plus or minus 10 percent of design for supply and return systems and plus or minus 10 percent of design for exhaust systems.
2. Air Outlets and Inlets: Adjust outlets and inlets in space to within plus or minus 10 percent of design.

E. Adjusting:

1. Ensure recorded data represents actual measured or observed conditions.
2. Permanently mark settings of balancing devices allowing settings to be restored. Set and lock memory stops.
3. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

4. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

F. Sequencing:

1. All systems providing both heating and cooling shall be balanced in both modes of operation.

2. For all systems provide initial balancing to tolerances indicated in this section. After initial balancing readjust systems as directed by engineer and owner as necessary to achieve uniform space temperatures free from objectionable drafts and noises.

G. Air System Procedure:

1. Adjust equipment and distribution systems to provide required or design air quantities.

2. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

3. Measure and record air quantities at air inlets and outlets.

4. Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Adjust air volume by adjusting duct internal devices such as dampers and splatters. Do not utilized opposed blade dampers at air inlets and outlets.

5. Vary total system air quantities by adjusting sheave position or replacing fixed sheaves with larger or smaller diameter sheaves at each fan. Provide replacement fixed ratio sheaves and belts after final balancing selected to achieve design airflows. Vary branch air quantities by damper regulation.

6. Measure and record static air pressure conditions at air supply and exhaust units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

7. Adjust settings and minimum setpoints for motorized and backdraft dampers to design conditions.

8. Measure and record temperature conditions across dampers to check leakage.

9. Where modulating dampers are provided, take measurements and balance at extreme conditions.

10. Measure and record building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches (12.5 Pa) positive static pressure near the building entries.

11. Measure and record inlet and outlet temperatures at each air supply unit at full cooling and heating capacity.

12. Prepare system pressure profiles: On schematic fan system diagrams, show STATIC pressure readings taken at following points.
    a. Fan discharge
    b. Fan discharge plenum or main duct in fan room
    c. Fan inlet plenum

d. Inlet and outlet plenum space on each side of each heating coil, cooling coil and filter
e. Return air/outside air mixing plenum
f. Duct or plenum immediately behind outside air louver
g. Return/exhaust fan inlet
h. Return/exhaust fan outlet
i. Each main branch duct takeoff at each floor
j. Within 3 feet of last supply air outlet connection in most remote duct.

H. Schedules:

1. Equipment requiring Testing, Adjusting, and Balancing including but not limited to:
   a. Pumps
   b. Unit Air Conditioners
   c. Air Coils
   d. Air Handling Units
   e. Fans
   f. Generators
   g. Electric Heaters
   h. Gas Detection System
   i. Intake Ventilators
   j. Exhaust Fans
   k. Energy Recovery Unit
   l. Variable Refrigerant Flow System

I. Report Forms:

1. Forms shall include the following:
   a. Title Page:
      1) Name of Testing, Adjusting, and Balancing Agency
      2) Address of Testing, Adjusting, and Balancing Agency
      3) Telephone number of Testing, Adjusting, and Balancing Agency
      4) Project name
      5) Project location
      6) Project Architect
      7) Project Engineer
      8) Project Contractor
      9) Project altitude

10) Report date

b. All equipment shall include:
   1) Manufacturer
   2) Model/Size
   3) Identification/Number
   4) Serial Number

c. Summary Comments:
   1) Design versus final performance
   2) Notable characteristics of system
   3) Description of systems operation sequence
   4) Summary of outdoor and exhaust flows to indicated amount of building pressurization
   5) Nomenclature used throughout report
   6) Test conditions

d. Instrument List:
   1) Instrument
   2) Manufacturer
   3) Model number
   4) Serial number
   5) Range
   6) Calibration date

e. Electric Motors: (data for single and multispeed motors)
   1) Manufacturer
   2) Model/Frame
   3) HP/BHP/efficiency
   4) Phase, voltage, amperage; nameplate, actual, no load
   5) RPM
   6) Service factor
   7) Starter size, rating, heater elements
   8) Sheave Make/Size/Bore

f. V-Belt Drive:
   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

g. Pump Data:
1) Impeller
2) Service
3) Design flow rate, pressure drop, BHP
4) Actual flow rate, pressure drop, BHP
5) Discharge pressure
6) Suction pressure
7) Total operating head pressure
8) Shut off, discharge and suction pressures
9) Shut off, total head pressure

h. Combustion Test:
1) Manufacturer
2) Model number
3) Firing rate
4) Over-fire draft
5) Gas meter timing dial size
6) Gas meter time per revolution
7) Gas pressure at meter outlet
8) Gas flow rate
9) Heat input
10) Oil flow rate
11) Burner manifold gas pressure
12) Percent carbon monoxide (CO)
13) Percent carbon dioxide (CO2)
14) Percent oxygen (O2)
15) Percent excess air
16) Flue gas temperature at outlet
17) Ambient temperature
18) Net stack temperature
19) Percent stack loss
20) Percent combustion efficiency
21) Heat output

i. Air Cooled Condensing Unit:
   1) Location
   2) Serial number
   3) Entering DB air temperature, design and actual
   4) Leaving DB air temperature, design and actual
   5) Number of compressors

j. Coil Data:
   1) Location
   2) Service
   3) Air flow, design and actual
   4) Entering air DB temperature, design and actual
   5) Entering air WB temperature, design and actual
   6) Leaving air DB temperature, design and actual
   7) Leaving air WB temperature, design and actual
   8) Water flow, design and actual
   9) Water pressure drop, design and actual
   10) Entering water temperature, design and actual
   11) Leaving water temperature, design and actual
   12) Saturated suction temperature, design and actual
   13) Air pressure drop, design and actual

k. Air Handling Units/ Rooftop Units:
   1) Location
   2) Arrangement/Class/Discharge
   3) Air flow, specified and actual
   4) Return air flow, specified and actual
   5) Outside air flow, specified and actual
   6) Total static pressure (total external), specified and actual
   7) Inlet pressure
   8) Discharge pressure
   9) Sheave Make/Size/Bore
   10) Number of Belts/Make/Size
   11) Fan RPM

l. Return Air/Outside Air Data:
   1) Identification/location

2) Design air flow
3) Actual air flow
4) Design return air flow
5) Actual return air flow
6) Design outside air flow
7) Actual outside air flow
8) Return air temperature
9) Outside air temperature
10) Required mixed air temperature
11) Actual mixed air temperature
12) Design outside/return air ratio
13) Actual outside/return air ratio

m. Exhaust/Supply Fan Data:
1) Location
2) Air flow, specified and actual
3) External static pressure, specified and actual
4) Inlet pressure
5) Discharge pressure
6) Fan RPM

n. Duct Traverse:
1) System zone/branch
2) Duct size
3) Area
4) Design velocity
5) Design air flow
6) Test velocity
7) Test air flow
8) Duct static pressure
9) Air temperature
10) Air correction factor

o. Duct Leak Test:
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

p. Terminal Unit Data:
1) Type, constant, variable, single, dual duct
2) Location
3) Size
4) Minimum static pressure
5) Minimum design air flow
6) Maximum design air flow

END OF SECTION

PACKAGED ROOFTOP HVAC UNIT SCHEDULE

GENERAL			PERFORMANCE																		ELECTRICAL				PHYSICAL			REMARKS			
			COOLING				SENSIBLE RECOVERY EFFICIENCY (%)		SUPPLY FAN					EXHAUST FAN					HEATING													
TAG	SERVICE	NOMINAL TONS	TOTAL MBH	SENSIBLE MBH	EER	IEER(I)/ SEER(S)	HEATING	COOLING	CFM	ESP (IN WG)	RPM	BHP	HP	CFM	ESP (IN WG)	RPM	BHP	HP/ WATTS	INPUT (MBH)	OUTPUT (MBH)	THERMAL EFF. (%)	OUTDOOR SOUND dBA	MCA	MOP	VOLTAGE	PHASE	WEIGHT (LBS)	# OF COMP.	MANUFACTURER MODEL	TYPE	RATINGS	FEATURES	INSTALL
DOAS-1	MAIN SCHOOL SOUTH & EAST	15.0	182.4	129.3	14.8	–	65.3	68.5	4325	2.0	2334	3.50	5.0	4000	1.5	1732	2.43	3.0	200	160	80	93.1	95.0	110	208	3	4159	2	TRANE 0ADG015C1	①	①	1 2 3 4 6	①②
DOAS-2	MAIN SCHOOL WEST	12.0	142.9	104.2	14.7	–	66.7	69.9	3600	2.0	2221	2.61	5.0	3240	1.5	1985	1.88	3.0	200	160	80	93.1	80.1	100	208	3	4071	2	TRANE 0ADG012C1	①	①	1 2 3 4 6	①②
DOAS-3	MAIN SCHOOL NORTH	15.0	183.6	130.8	14.8	–	63.2	66.5	4410	2.0	1999	3.62	5.0	3920	1.5	1716	2.37	3.0	200	160	80	93.1	95.0	110	208	3	4159	2	TRANE 0ADG015C1	①	①	2 3 4 6 8	①②
RTU-1	ALL PURPOSE / GYM	25	284.7	219.7	10.8	16.0(I)	67.3	67.3	10,000	1.0	1709	6.35	(2)@ 4.6	10,000	1.78	1573	–	(2)@ 4065W	320	260	80	–	151	200	208	3	4355	2	TRANE YHK300A	③	②	2 3 4 5 7 9	①②
RTU-2	LIBRARY	6	83.1	62.5	12.2	17.7(I)	–	–	2,400	1.5	1267	1.38	3.0	–	–	–	–	–	150	121.5	80	–	38	50	208	3	1241	1	TRANE YHK072A	②	②	1 2 5 7	①②
RTU-3	LIBRARY OFFICES/STOR.	5	60.0	39.0	12.9	17.1(S)	–	–	1610	1.0	1083	0.77	3.0	–	–	–	–	–	100	81	80	–	34	45	208	3	1142	1	TRANE YHK060A	②	②	1 2 5 7	①②
RTU-4	FRONT OFFICES	4	46.6	36.5	12.9	17.1(S)	–	–	1600	1.0	918	0.49	3.0	–	–	–	–	–	100	81	80	–	32	45	208	3	1114	1	TRANE YHK048A	②	②	1 2 5 7	①②

⚠1

① PACKAGED DEDICATED OUTDOOR AIR UNIT, NATURAL GAS FIRED, DIRECT EXPANSION COOLING HORIZONTAL SUPPLY & RETURN, R-454BA, ROTARY WHEEL ENERGY RECOVERY EXCHANGER
② PACKAGED ROOFTOP HVAC UNIT, NATURAL GAS FIRED, DIRECT EXPANSION COOLING DOWNFLOW SUPPLY & RETURN, R-454BA, UNIT SHALL CONTROL SPACE TEMPERATURE
③ PACKAGED ROOFTOP HVAC UNIT, NATURAL GAS FIRED, DIRECT EXPANSION COOLING HORIZONTAL SUPPLY & RETURN, R-454BA, UNIT SHALL CONTROL SPACE TEMPERATURE

① COOLING: 81°F EDB/68°F EWB, 95°F ODB, 78°F OWB
HEATING: 7°F ODB, 70°F EDB
② COOLING (ARI): 80°F EDB/67°F EWB, 95°F ODB
HEATING (ARI): 7°F ODB, 70°F EDB

1 FULL PERIMETER, SEISMIC ISOLATION ROOF CURB, NOVIA OR EQUAL W/ MIN 2" DEFLECTION
2 MODULATING HOT GAS REHEAT COIL
3 ERV WHEEL SECTION, POLYMER CONSTRUCTION
4 POWERED EXHAUST, DIRECT DRIVE W/VFD & ISOLATION DAMPERS
5 COMPARATIVE ENTHALPY ECONOMIZER W/BAROMETRIC RELIEF DAMPER
6 UC600 MICROPROCESSOR CONTROLLER W/BACNET IP COMM. CARD
7 MICROPROCESSOR CONTROLLER W/BACNET IP COMM. CARD
8 PROVIDE WITH VIBRATION ISOLATION SPRING RAILS WITH MIN 2" DEFLECTION ON STEEL DUNNAGE PROVIDED BY OTHERS. COORDINATE EXACT EQUIPMENT SIZING AND LOCATION WITH STRUCTURAL.
9 30" FULL PERIMETER PLENUM CURB, SEISMIC ISOLATION ROOF CURB, NOVIA OR EQUAL W/ MIN 2" DEFLECTION

① SUPPLY AIR DUCT SMOKE DETECTOR, FURNISHED AND INSTALLED BY M.C., WIRING AND FIRE ALARM SYSTEM INTERLOCK BY E.C.
② ADHERE TO ALL MANUFACTURER'S INSTALLATION DETAILS AND REFERENCE DETAILS ON SHEET M0.3

DIFFUSER AND GRILLE SCHEDULE

GENERAL	PHYSICAL				REMARKS		
TAG	SIZE (IN)	BLOW PATTERN	BRANCH DUCT (IN)	MANUFACTURER MODEL	TYPE	FEATURES	INSTALL
A6	9x9	A4-L	6ø	PRICE SMD	①	1	①②
A8	9x9	A4-L	8ø	PRICE SMD	①	1	①②
A10	12x12	A4-L	10ø	PRICE SMD	①	1	①②
A15	15x15	A4-L	12ø	PRICE SMD	①	1	①②
B8	8x8	B4A-S	8x8	PRICE 520	②	2	①②③
B14	14x10	B4A-S	14x10	PRICE 520	②	2	①②③
Y6	6x6	Y1-S	6x6	PRICE 530	③	2	①②③
Y48	48x28	Y1-S	48x28	PRICE 530	③	2	①②③
Z12	24x12	Z1-L	22x10	PRICE 530	③	1	①②③
Z24	24x24	Z1-L	22x22	PRICE 530	③	1	①②③

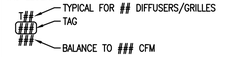
① SQUARE PLAQUE SUPPLY DIFFUSER, FLUSH FACE, 24"X24" MODULE, ROUND NECK, STEEL, WHITE
② SUPPLY GRILLE, DOUBLE DEFLECTION BLADES ON 3/4" CENTERS, FRONT BLADES PARALLEL TO LONG DIMENSION, STEEL, WHITE
③ RETURN/EXHAUST GRILLE, 45° FIXED BLADES ON 3/4" CENTERS, BLADES PARALLEL TO LONG DIMENSION, STEEL, WHITE

1 LAY-IN T-BAR CEILING MOUNT
2 SURFACE MOUNT
3 INTEGRAL VOLUME DAMPER
4 INTEGRAL RADIATION DAMPER

① WHERE NO BRANCH DUCT SIZE IS INDICATED ON PLAN, USE BRANCH DUCT SIZE INDICATED HEREIN
② PROVIDE A DUCT MOUNTED VOLUME DAMPER WHETHER OR NOT A DUCT MOUNTED VOLUME DAMPER IS INDICATED ON PLAN. EXCEPTIONS:
- TRANSFER AIR APPLICATIONS (GRILLE IS NOT CONNECTED BY A DUCTWORK SYSTEM TO A FAN)
- EXHAUST AND RETURN GRILLES WHERE ONLY ONE GRILLE SERVES THE FAN/AIR HANDLING SYSTEM
③ PROVIDE A 1" THICK ACOUSTICALLY LINED PLENUM, SAME SIZE AS DIFFUSER/GRILLE X HEIGHT/DEPTH NECESSARY TO CONNECT BRANCH DUCT INDICATED

PATTERN

TAG LEGEND



PUMP SCHEDULE

GENERAL		PERFORMANCE			ELECTRICAL			PHYSICAL		REMARKS			
TAG	SERVICE	GPM	TDH (FT WG)	RPM	WATTS/HP	VOLTAGE	PHASE	PIPE CONNECTION (IN)	MANUFACTURER MODEL	TYPE	RATINGS	FEATURES	INSTALL
P-B1,B2	BOILER PUMP	18.6	10	2800	480 W	120	1	1-1/2	TACO VR15M	①	①	1 2	①②
P-1,2	SYSTEM PUMPS	~56	45	–	2 HP	208	3	1-1/2	TACO SKS1507D	②	①	1 3	①③

① CARTRIDGE CIRCULATOR
② VERTICAL INLINE PUMP WITH INTEGRAL VFD

① WATER AT 160°F

1 ALL IRON, ECM MOTOR
2 ANSI B16.1 CLASS 125 (175 PSIG AT 250°F)
3 ALL IRON, MOTOR WITH VFD

① SEE DETAIL 1, 2, & 3/MA1.3
② PUMP ENABLE/DISABLE BASED ON BOILER CONTROLLER
③ LEAD/LAG CONFIGURED, WITH AUTOMATIC CHANGEOVER DAILY

DUCT SILENCER SCHEDULE

GENERAL		PERFORMANCE													PHYSICAL					REMARKS			
		AIRFLOW					DYNAMIC INSERTION LOSS (dB) OCTAVE BAND (HZ)								DIMENSIONS								
TAG	SERVICE	CFM	FACE AREA (SQ FT)	FPM	APD (IN WG)	DIRECTION	63	125	250	500	1000	2000	4000	8000	ROUND DIAMETER (IN)	RECTANGULAR WIDTH (IN)	RECTANGULAR HEIGHT (IN)	LENGTH (IN)	MANUFACTURER MODEL	TYPE	RATINGS	FEATURES	INSTALL
DS-1	RTU-1 SUPPLY AIR	10,000	10.2	978	0.22	SUPPLY	7	9	14	14	7	7	7	3	–	46	32	36	KINETICS 46 KCRS-F/1.5	①	①	1	①

① RECTANGULAR, GLASS FIBER MEDIA

① AIR PRESSURE DROP (APD) AND ACOUSTICAL DATA ARE IN ACCORDANCE TO ASTM E477

1 22 GAUGE GALVANIZED STEEL CASING, 2" SLIP CONNECTIONS

① PROVIDE MIN. 18" LONG TRANSITION FITTINGS FROM NOMINAL DUCT DIMENSION TO ATTENUATOR DIMENSION AS INDICATED ON PLANS

CABINET UNIT HEATER SCHEDULE

GENERAL		PERFORMANCE						ELECTRICAL				PHYSICAL	REMARKS			
TAG	LOCATION	MBH	GPM	WPD (FT WG)	LAT (°F)	CFM	FAN SPEED	WATTS	HP	VOLTAGE	PHASE	MANUFACTURER MODEL	TYPE	RATINGS	FEATURES	INSTALL
CUH-A	SEE DWG	11.3	1.13	0.38	105.7	230	HIGH	–	1/15	120	1	STERLING RC-1200	①	①	1 2	①②
UH-B	SEE DWG	12.4	1.24	0.1	86	450	H	16	–	115	1	STERLING HS-24	②	①	1 2	①②

① RECESSED CEILING MOUNT, BOTTOM/FRONT SUPPLY & RETURN
② HORIZONTAL HOT WATER UNIT HEATER

① 160°F EWT, 140°F LWT, 60°F EAT

1 BAKED ENAMEL FINISH, COLOR SELECTABLE BY OWNER
2 SINGLE ROW COIL W/ ¾" HWS&R CONNECTIONS

① SEE DETAIL 5/MA1.3
② SELECT AUTOMATIC BALANCING VALVE FOR GPM INDICATED

DUCT MOUNTED HOT WATER COIL SCHEDULE

GENERAL		PERFORMANCE									PHYSICAL					REMARKS			
		AIR SIDE						WATER SIDE											
TAG	LOCATION	MBH	CFM	FPM	APD (IN WG)	EAT (°F)	LAT (°F)	GPM	WPD (FT WG)	LWT (°F)	DUCT WIDTH (IN)	DUCT HEIGHT (IN)	ROWS	FINS PER INCH	MANUFACTURER MODEL	TYPE	RATINGS	FEATURES	INSTALL
HWC-A1	SEE DWG	9.5	250	600	0.151	70	105.2	1.3	0.30	145	12	6	1	12.5	TRANE DTOB06010	①	①②③	1 2	①②
HWC-A2	SEE DWG	7.5	225	540	0.108	70	97.8	1.0	0.30	145	12	6	1	9.2	TRANE DTOB06010	①	①②③	1 2	①②
HWC-B1	SEE DWG	19.5	500	500	0.095	70	106.1	1.95	0.65	140	14	12	1	9.2	TRANE DTOB12012	①	①②③	1 2	①②
HWC-C1	SEE DWG	20.5	550	550	0.130	70	104.5	2.1	0.65	140	14	12	1	12.5	TRANE DTOB12012	①	①②③	1 2	①②
HWC-D1	SEE DWG	20.0	600	600	0.152	70	100.9	2.0	0.65	140	14	12	1	12.5	TRANE DTOB12012	①	①②③	1 2	①②
HWC-E1	SEE DWG	24.0	650	557	0.133	70	104.2	1.8	0.71	140	16	12	1	12.5	TRANE DTOB12014	①	①②③	1 2	①②
HWC-F1	SEE DWG	10.8	400	576	0.143	70	95	1.08	0.30	140	12	10	1	9.2	TRANE DTOB09010	①	①②③	1 2	①②

① SINGLE OR TWO ROW SERPENTINE, SAME END CONNECTIONS

① PERFORMANCE CERTIFIED IN ACCORDANCE TO ARI 410
② 160.0°F EWT, 0.00025 FOULING FACTOR
③ HEATING COILS ARE SIZED FOR PEAK DEMAND WHICH OCCURS DURING UNNOCUPIED HOURS. LAT TO BE 95°F MAX DURING OCCUPIED HOURS

1 COPPER HEADER, 0.020" THICK COPPER TUBES, ALUMINUM FINS
2 ¾" HWS & RETURN CONNECTIONS

① SEE DETAIL 4/MA1.3
② SELECT AUTOMATIC BALANCING VALVE FOR GPM INDICATED

BOILER SCHEDULE

GENERAL		PERFORMANCE									ELECTRICAL			PHYSICAL		REMARKS			
		MAXIMUM FIRE					MINIMUM FIRE		WATER SIDE										
TAG	LOCATION	INPUT MBH	GROSS IBR OUTPUT MBH	NET IBR RATING MBH	THERMAL EFFICIENCY (%)	AFUE (%)	INPUT MBH	OUTPUT MBH	GPM	LWT (°F)	AMPS	VOLTAGE	PHASE	WEIGHT (LBS)	MANUFACTURER MODEL	TYPE	RATINGS	FEATURES	INSTALL
B-1,2	BOILER ROOM 105	399	371	–	93	–	39.9	38.7	30	160	10	120	1	402	P-K MACH CM-399	①	①	1 2 3 4	①

① NATURAL GAS FIRED, CONDENSING, DIRECT VENT AND COMBUSTION AIR

① WATER SIDE AT 135°F EWT, MAXIMUM FIRE

1 SIDEWALL CONCENTRIC VENT ASSEMBLY
2 CONDENSATE NEUTRALIZATION KIT
3 FLOOR MOUNTING STAND
4 CSD-1 SAFETY CONTROL

① SEE DETAIL 1/MA1.3

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Revision Schedule	
Revision Number	Revision Date
3	03-10-2026

SHEET TITLE

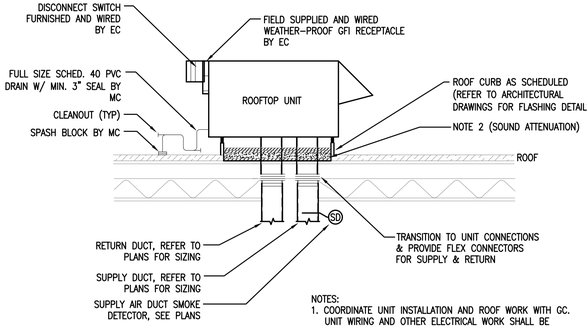
MECHANICAL SCHEDULES

DRAWN BY: AR	JOB NUMBER: 25040
CHECKED BY: DK	DATE: 02-09-2026

M0.2

SHEET: 18 OF: 44

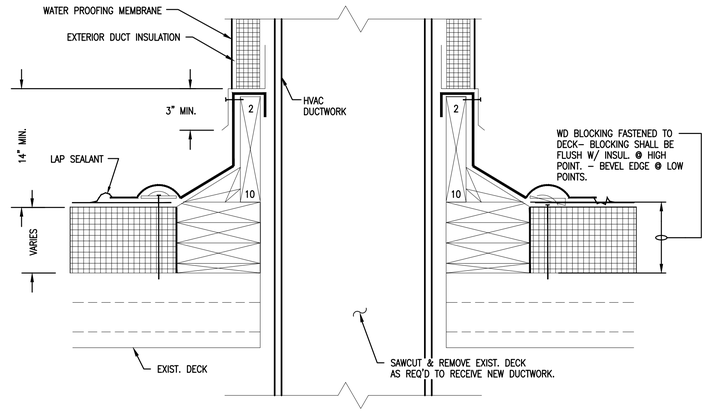
BER# 21228



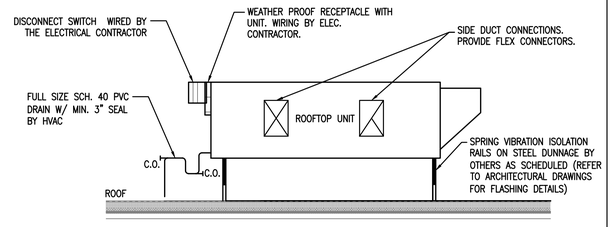
NOTES:
1. COORDINATE UNIT INSTALLATION AND ROOF WORK WITH GC. UNIT WIRING AND OTHER ELECTRICAL WORK SHALL BE COORDINATED WITH ELECTRICAL PLANS AND E.C.
2. SOUND ATTENUATION: (FIELD PROVIDED AND INSTALLED). PROVIDE ONE LAYER OF 1/2" CEMENT BOARD, 5" RIGID INSULATION AND TWO LAYERS OF 1/2" CEMENT BOARD ON TOP. SEAL AROUND DUCT AND STAGGER JOINTS OF TOP LAYERS OF CEMENT BOARD. PROVIDE SUPPORTS FOR THE ABOVE WORK INSIDE THE CURB.

DETAIL TYPICAL FOR RTU-2, RTU-3, & RTU-4

PACKAGED ROOFTOP UNIT BOTTOM DISCHARGE DETAIL | NTS



DUCT THROUGH ROOF DETAIL | NTS

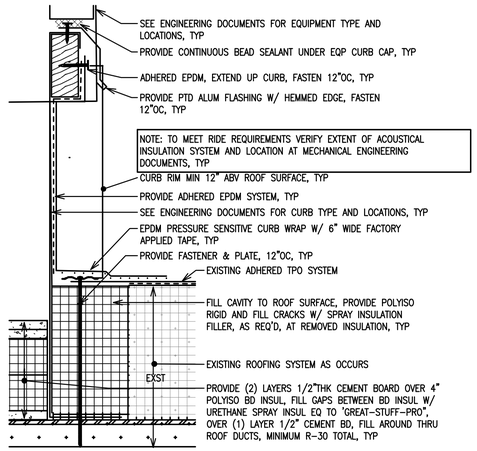


DETAIL TYPICAL FOR DOAS-3

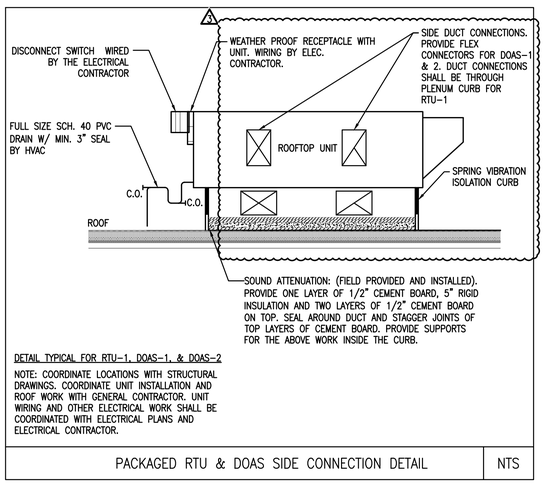
NOTE: COORDINATE LOCATIONS WITH STRUCTURAL DRAWINGS. COORDINATE UNIT INSTALLATION AND ROOF WORK WITH GENERAL CONTRACTOR. UNIT WIRING AND OTHER ELECTRICAL WORK SHALL BE COORDINATED WITH ELECTRICAL PLANS AND ELECTRICAL CONTRACTOR.

ROOF MOUNTED EQUIPMENT SPRING RAIL ISOLATION DETAIL | NTS

NOTE: 1. ROOF MEMBRANE SYSTEM DETAIL IS LIKE CARLISLE SYNTEC "PRESSURE-SENSITIVE CURB WRAP", NUMBER: U-5B, AND PROVIDE "OUTSIDE CORNER W/ PRE-CUT PRESSURE-SENSITIVE CORNER", NUMBER: U-15E. TO RETAIN WARRANTY, ANY MODIFICATIONS TO THE ROOF SHALL BE DONE BE QUALIFIED ROOF CONTRACTOR THAT IS APPROVED BY THE MANUFACTURER.



ROOFTOP UNIT CURB FLASHING SECTION DETAIL

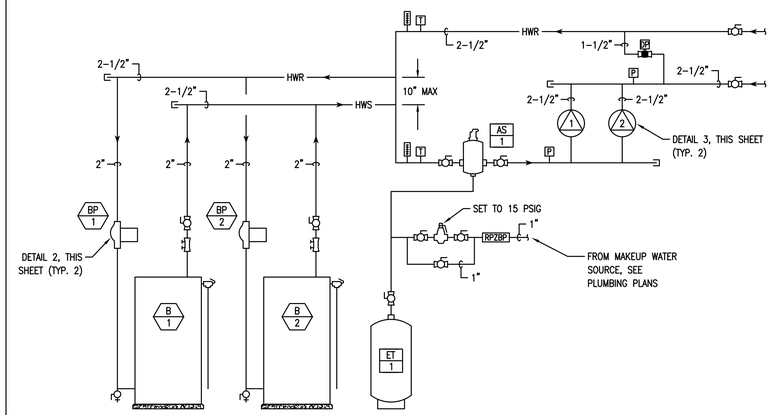


DETAIL TYPICAL FOR RTU-1, DOAS-1, & DOAS-2

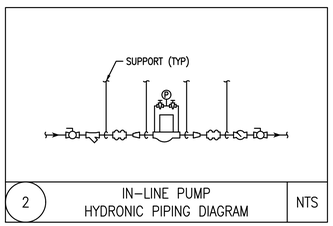
NOTE: COORDINATE LOCATIONS WITH STRUCTURAL DRAWINGS. COORDINATE UNIT INSTALLATION AND ROOF WORK WITH GENERAL CONTRACTOR. UNIT WIRING AND OTHER ELECTRICAL WORK SHALL BE COORDINATED WITH ELECTRICAL PLANS AND ELECTRICAL CONTRACTOR.

PACKAGED RTU & DOAS SIDE CONNECTION DETAIL | NTS

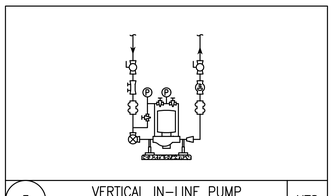
BOILER HYDRONIC PIPING ACCESSORIES	
TAG	DESCRIPTION
AS-1	MAGNETIC AIR & DIRT SEPARATOR, CALEFFI NA546M, 2-1/2" INLET AND OUTLET, 55 GPM AT 0.4 FT WPD
ET-1	EXPANSION TANK, TACO CA140-125, 37 GALLON TANK VOLUME, 37 GALLON ACCEPTANCE VOLUME



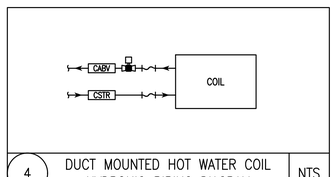
1 BOILER PLANT HYDRONIC PIPING DIAGRAM | NTS



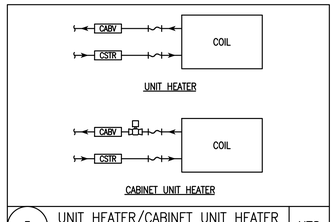
2 IN-LINE PUMP HYDRONIC PIPING DIAGRAM | NTS



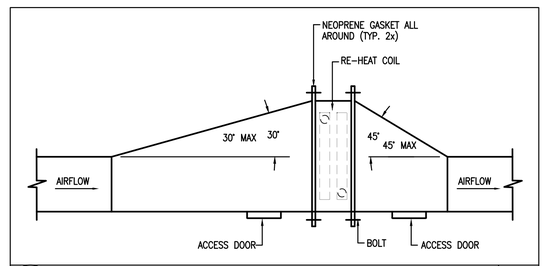
3 VERTICAL IN-LINE PUMP HYDRONIC PIPING DIAGRAM | NTS



4 DUCT MOUNTED HOT WATER COIL HYDRONIC PIPING DIAGRAM | NTS



5 UNIT HEATER/CABINET UNIT HEATER HYDRONIC PIPING DIAGRAM | NTS



6 REHEAT COIL DIAGRAM | NTS

HYDRONIC PIPING DIAGRAM LEGEND	
SYMBOL	DESCRIPTION
	PUMP, ## REPRESENTS PUMP P-##
FPSUPP	PUMP & PUMP ACCESSORY FLOOR SUPPORT
	REINFORCED CONCRETE HOUSEKEEPING PAD
	FLOW DIRECTION
	NON-SLAM CHECK VALVE, GLOBE STYLE
	SWING CHECK VALVE
	WYE STRAINER
	WYE STRAINER WITH BLOWDOWN VALVE
	MULTI-PURPOSE/TRIPLE DUTY VALVE
	SUCTION DIFFUSER
	TWO WAY CONTROL VALVE, TWO POSITION
	TWO WAY CONTROL VALVE, MODULATING
	THREE WAY CONTROL VALVE, TWO POSITION
	THREE WAY CONTROL VALVE, MODULATING
	ASME RELIEF VALVE
	PRESSURE REGULATING/REDUCING VALVE
	QUARTER TURN SHUT-OFF VALVE
	MANUAL BALANCING VALVE
	AUTOMATIC BALANCING VALVE
	FLEXIBLE CONNECTION
	HOSE CONNECTION
	GAUGE COCK (NEEDLE VALVE)
	COIN VENT - TACO 417
	AUTOMATIC AIR VENT - TACO HY-VENT/414
	AUTOMATIC AIR VENT - TACO 409
	REDUCER
P	PRESSURE GAUGE
P T	THERMOMETER
P	CONTROL SYSTEM PRESSURE SENSOR
T	CONTROL SYSTEM TEMPERATURE SENSOR
P T	PRESSURE & TEMPERATURE TEST PORT
	3/4" BALL DRAIN VALVE WITH HOSE THREAD
CABV	COMBINATION AUTOMATIC BALANCING VALVE
CSTR	COMBINATION STRAINER
RP7BP	REDUCED PRESSURE ZONE BACKFLOW PREVENTOR
DP	MECHANICAL DIFFERENTIAL PRESSURE BYPASS VALVE

HYDRONIC PIPING DIAGRAM NOTES

- APPLICATION: THESE NOTES APPLY TO ALL OF THE HYDRONIC PIPING DIAGRAMS, AS APPLICABLE
- AIR VENTS, AUTOMATIC & MANUAL: LOCATE AT THE HIGHEST POINT OF PIPING. LOCATION INDICATED ON PIPING DIAGRAM MAY NOT NECESSARILY BE THE HIGHEST POINT OF ACTUAL PIPING.
- AIR VENTS, AUTOMATIC, TACO HY-VENT/414: PIPE INDEPENDENTLY TO FLOOR DRAIN.
- AUTOMATIC BALANCING VALVES: SHALL INCLUDE AUTOMATIC FLOW CONTROL MECHANISM AND TWO PRESSURE AND TEMPERATURE TEST PORTS. NEXUS VALVE MODEL ND (DYNAMIC).
- COMBINATION AUTOMATIC BALANCING VALVES: SHALL INCLUDE SHUT-OFF BALL VALVE, AUTOMATIC FLOW CONTROL MECHANISM, AND TWO PRESSURE AND TEMPERATURE TEST PORTS. PROVIDE WITH MANUAL AIR VENT IF AT TOP COIL CONNECTION. NEXUS VALVE MODEL UM (ULTRAMATIC).
- COMBINATION STRAINER: SHALL INCLUDE SHUT-OFF BALL VALVE, STRAINER, AND TWO PRESSURE AND TEMPERATURE TEST PORTS. PROVIDE WITH MANUAL AIR VENT IF AT TOP COIL CONNECTION. NEXUS VALVE MODEL UY (ULTRAY).
- DRAIN VALVES: LOCATE AT THE LOWEST POINT OF PIPING. LOCATION INDICATED ON PIPING DIAGRAM MAY NOT NECESSARILY BE THE LOWEST POINT OF ACTUAL PIPING.
- FLANGES & UNIONS: FLANGES AND UNIONS ARE NOT SHOWN ON THE HYDRONIC PIPING DIAGRAMS. PROVIDE FLANGES AND UNIONS SUCH THAT THE FOLLOWING CAN BE REPLACED BY THE USE OF WRENCHES ONLY: COILS, CONTROL VALVES, CABINET UNIT HEATERS, WATER SOURCE HEAT PUMPS, FAN COIL UNITS, UNIT VENTILATORS, FIN TUBE BASEBOARD, RADIATORS, CONVECTORS, VAV TERMINAL UNITS, HEAT EXCHANGER TUBE BUNDLES, HEAT EXCHANGERS.
- HOSE CONNECTIONS: STAINLESS STEEL BRAIDED, 18" LONG, UNION ENDS
- HOUSEKEEPING PADS: SHALL BE MINIMUM 4" THICK REINFORCED CONCRETE WITH 3/4" CHAMFERED EDGES, AND SHALL BE SIZED FOR MINIMUM CLEARANCE OF 4" FROM EQUIPMENT BASE TO EDGE OF PAD.
- PRESSURE GAUGES: PROVIDE WITH GAUGE COCKS (NEEDLE VALVES), PRESSURE SNUBBERS, AND SIPHONS
- PUMP & PUMP ACCESSORY FLOOR SUPPORTS: PROVIDE PAD, MASON INDUSTRIES MODEL BBNR, AT BASE
- REDUCED PRESSURE ZONE BACKFLOW PREVENTERS: PROVIDE WITH AIR GAP FITTING PIPE INDEPENDENTLY TO FLOOR DRAIN OR JANITOR'S SINK
- REDUCERS: ALL REDUCERS REQUIRED ARE NOT SHOWN ON THE PIPING DIAGRAMS. PROVIDE REDUCERS WHERE INDICATED AND REQUIRED.
- RELIEF VALVES: SHALL BE ASME RATED FOR MINIMUM 150% OF THE CAPACITY OF THE EQUIPMENT SERVED. PIPE DISCHARGE FULL SIZE TO FLOOR DRAIN.
- SUCTION DIFFUSERS: WHERE THE PUMP INLET IS SMALLER THAN THE INLET PIPE SIZE, PROVIDE A REDUCING TYPE SUCTION DIFFUSER. PROVIDE SUCTION DIFFUSERS WITH BLOWDOWN VALVES.
- THERMOMETERS: PROVIDE WITH THERMOWELLS
- UOI, BRANCH PIPES TO EQUIPMENT SHALL BE AS FOLLOWS:

GPM	BRANCH PIPES
0.0 TO 3.0	3/4"
3.1 TO 7.0	1"
7.1 TO 12.0	1-1/4"
12.1 TO 19.0	1-1/2"
19.1 TO 40.0	2"

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Revision Schedule	
Revision Number	Revision Date
3	03-10-2026

SHEET TITLE

MECHANICAL DETAILS

DRAWN BY:	AR	JOB NUMBER:	25040
CHECKED BY:	DK	DATE:	02-09-2026

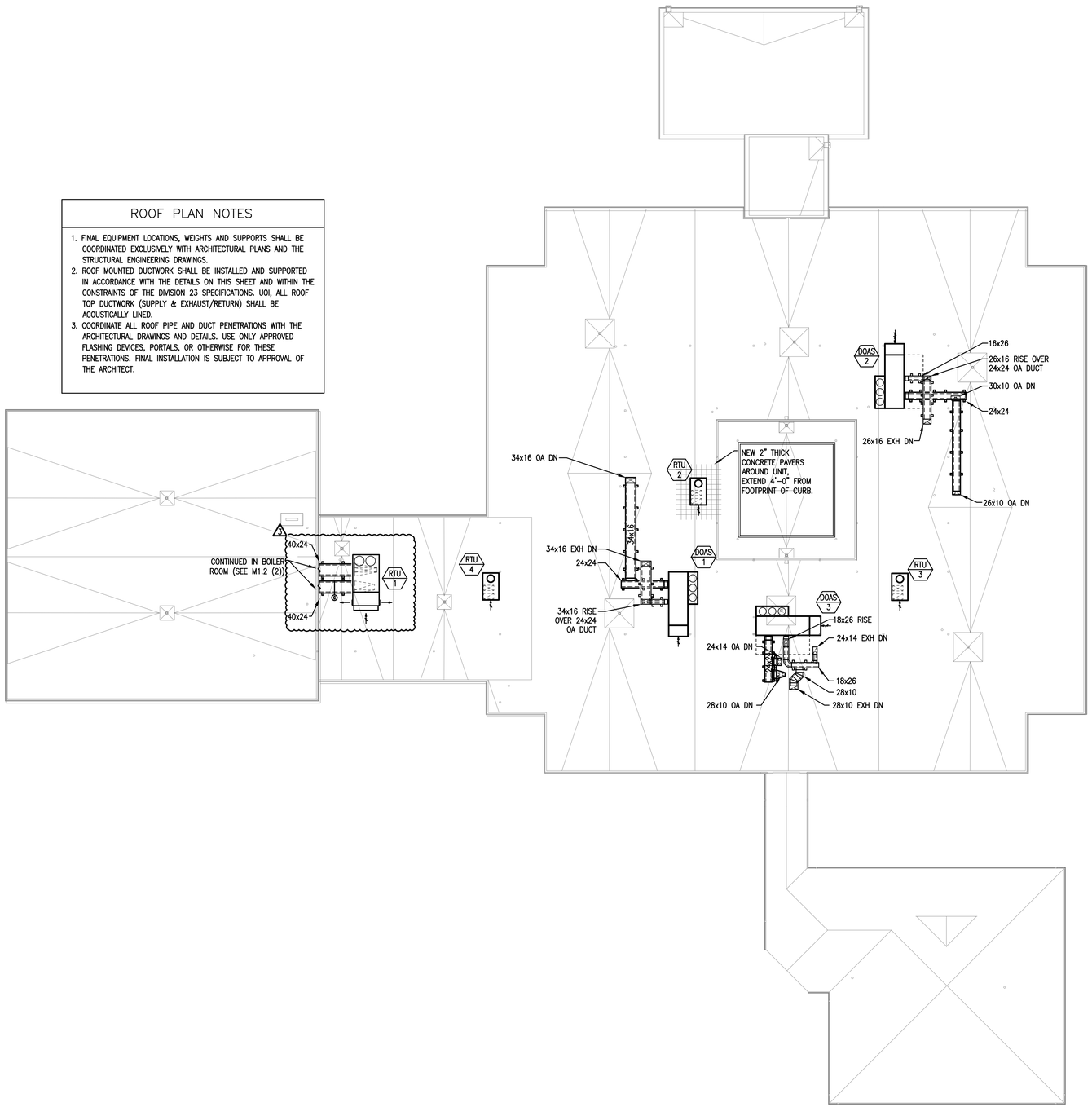
M0.3

SHEET: 19 OF: 44

BER# 21228

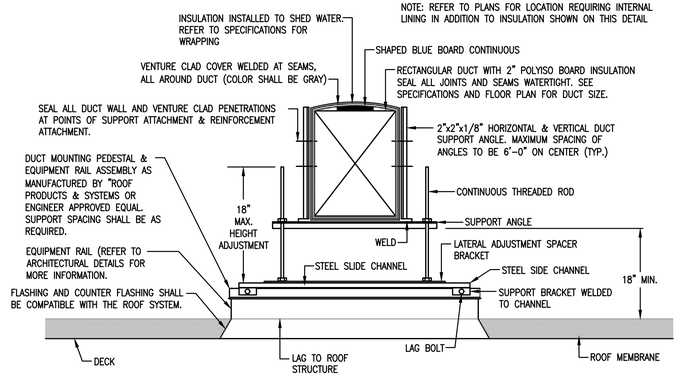
ROOF PLAN NOTES

1. FINAL EQUIPMENT LOCATIONS, WEIGHTS AND SUPPORTS SHALL BE COORDINATED EXCLUSIVELY WITH ARCHITECTURAL PLANS AND THE STRUCTURAL ENGINEERING DRAWINGS.
2. ROOF MOUNTED DUCTWORK SHALL BE INSTALLED AND SUPPORTED IN ACCORDANCE WITH THE DETAILS ON THIS SHEET AND WITHIN THE CONSTRAINTS OF THE DIVISION 23 SPECIFICATIONS. UOI, ALL ROOF TOP DUCTWORK (SUPPLY & EXHAUST/RETURN) SHALL BE ACOUSTICALLY LINED.
3. COORDINATE ALL ROOF PIPE AND DUCT PENETRATIONS WITH THE ARCHITECTURAL DRAWINGS AND DETAILS. USE ONLY APPROVED FLASHING DEVICES, PORTALS, OR OTHERWISE FOR THESE PENETRATIONS. FINAL INSTALLATION IS SUBJECT TO APPROVAL OF THE ARCHITECT.

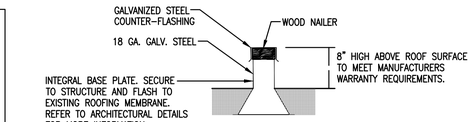


1 MECHANICAL ROOF PLAN
1/16" = 1'-0"

NOTE: REFER TO PLANS FOR LOCATION REQUIRING INTERNAL LINING IN ADDITION TO INSULATION SHOWN ON THIS DETAIL



- DUCT MOUNTING PEDASTAL AND EQUIPMENT RAIL ASSEMBLY AS MANUFACTURED BY "ROOF PRODUCTS & SYSTEMS" OR APPROVED EQUAL.
- PROVIDE DUCT SUPPORT AT EVERY 8'-0" AND EVERY CHANGE OF DIRECTION.



EQUIPMENT RAIL

ROOF DUCT MOUNTING PEDESTAL DETAIL | NTS

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MECHANICAL
ROOF PLAN & DETAILS

DRAWN BY:	AR	JOB NUMBER:	25040
CHECKED BY:	DK	DATE:	02-09-2026

M3.1

SHEET: 27 OF: 44

BER# 21228

LEGEND

- MOUNTING HEIGHTS SHALL BE AS INDICATED UNLESS SHOWN OTHERWISE ON ELECTRICAL DRAWINGS OR ARCHITECTURAL ELEVATIONS
- ALL SYMBOLS MAY NOT BE SHOWN ON PLANS

RACEWAYS AND WIRING

P4–1,3,5 — SINGLE PHASE HOMERUNS TO PANELBOARD. "P4" DENOTES PANEL, "1,3,5" DENOTES CIRCUIT NUMBERS, [(3) 20A, 1P CIRCUITS] NUMBER OF SLASH MARKS DENOTES NUMBER OF #12AWG CONDUCTORS IN MINIMUM 3/4"C. NO SLASH MARKS INDICATE 2#12 & 1#12G–3/4"C UNLESS INDICATED OTHERWISE.

P4–2 / 20/3 — MULTI–POLE HOMERUN TO PANELBOARD. "P4" DENOTES PANEL, "2" DENOTES CIRCUIT NUMBER, 20 AMP 3 POLE C/B.

NOTES:
1. GREEN GROUND CONDUCTOR NOT INDICATED BUT SHALL BE INCLUDED IN EACH RACEWAY. SIZE SHALL BE #12AWG UNLESS INDICATED OTHERWISE.

—— E —— 2#10,#10G EMERGENCY ONLY WIRING
—— CT —— CABLE TRAY – REFER TO SPECIFICATIONS FOR REQUIREMENTS
—— J —— J HOOKS 3'–0" ON CENTER
—— P —— PRIMARY CONDUIT DUCT BANK
—— S —— SECONDARY CONDUIT DUCT BANK
—— T —— TELEPHONE SERVICE CONDUIT DUCT BANK
—— CATV —— CABLE TELEVISION CONDUIT DUCT BANK

LIGHTING FIXTURES (REFER TO LIGHTING FIXTURE SCHEDULE FOR EXACT FIXTURE TYPE)

A 2a — LIGHTING FIXTURE CEILING OR RECESSED MOUNTED. "A" DENOTES FIXTURE TYPE, "2" DENOTES CIRCUIT NUMBER, "a" DENOTES SWITCH CONTROL,
LIGHT FIXTURE WIRED TO CONSTANT–ON OR NORMAL EMERGENCY CIRCUIT
STRIP LIGHTING FIXTURE
ROUND RECESSED LIGHTING FIXTURE
WALL MOUNTED LIGHTING FIXTURE
WALL WASH OR DIRECTIONAL LIGHTING FIXTURE
CEILING MOUNTED ILLUMINATED EXIT SIGN. SINGLE OR DOUBLE FACE, WITH OR WITHOUT ARROWS AS INDICATED ON DRAWINGS
WALL MOUNTED ILLUMINATED EXIT SIGN – SHADING INDICATES FACE PLATE(S)
EB — SELF–CONTAINED EMERGENCY LIGHTING UNIT
WP — REMOTE EMERGENCY LIGHTING HEADS – SINGLE OR DOUBLE AS SHOWN. "WP" DENOTES WEATHERPROOF

LIGHTING CONTROL DEVICES

Soc / ob — SINGLE POLE TOGGLE SWITCH. "o" DENOTES FIXTURE CONTROL. "oc" DENOTES INTEGRAL OCCUPANCY SENSOR. EQUAL TO WATTSTOPPER DSW–301–X
S3 — THREE WAY TOGGLE SWITCH
S4 — FOUR WAY TOGGLE SWITCH
SK — KEY OPERATED SWITCH
SP — SINGLE POLE TOGGLE SWITCH WITH RED PILOT LIGHT
SD — DIMMER SWITCH
OC — CEILING MOUNTED OCCUPANCY SENSOR FOR LIGHTING CONTROL. EQUAL TO WATTSTOPPER DT–355–CA–1

RECEPTACLES (MOUNTED 18" AFF OR AS INDICATED ON ARCHITECTURAL PLANS)

IG GFI 2 WP — DUPLEX RECEPTACLE, "2" DENOTES CIRCUIT NUMBER, "GFI" DENOTES GROUND FAULT CIRCUIT INTERRUPTER TYPE DEVICE, "IG" DENOTES ISOLATED GROUND TYPE DEVICE, "WP" DENOTES WEATHER PROOF COVER
DUPLEX RECEPTACLE MOUNTED 6" ABOVE COUNTER TOP OR AS INDICATED ON ARCHITECTURAL PLANS
DOUBLE DUPLEX RECEPTACLE MOUNTED 6" ABOVE COUNTER TOP OR AS INDICATED ON THE ARCHITECTURAL PLANS
DOUBLE DUPLEX RECEPTACLE
DUPLEX RECEPTACLE ONE HALF SWITCH CONTROLLED
EWC — DUPLEX RECEPTACLE FOR ELECTRIC WATER COOLER. PROVIDE DEDICATED 20A/1P GFCI CIRCUIT BREAKER UNLESS NOTED OTHERWISE.

FIRE ALARM SYSTEM

F — MANUAL PULL STATION MOUNTED 48" AFF
DH — MAGNETIC DOOR HOLD OPEN DEVICE
FAA — FIRE ALARM ANNUNCIATOR
FAC — FIRE ALARM COMMUNICATOR
FPC — FIRE PUMP CONTROLLER
BATT — BATTERY CABINET
FACP — FIRE ALARM CONTROL PANEL
FATC — FIRE ALARM TERMINAL CABINET
AIM — ADDRESSABLE INPUT MONITOR MODULE
AOM — ADDRESSABLE OUTPUT CONTROL MODULE
ROTATING BEACON
ACCESS FEATURE–FIRE DEPARTMENT KEYBOX
PS — NOTIFICATION APPLIANCE CIRCUIT POWER SUPPLY SIZE PER MANUFACTURERS SYSTEM CALCULATIONS.
CO_2 — CARBON DIOXIDE DETECTOR
CO — CARBON MONOXIDE DETECTOR
HEAT DETECTOR/SENSOR
MB — FIRE ALARM MASTER BOX
S — SMOKE DETECTOR/SENSOR
S ID — IN DUCT
S R CO — SMOKE/HEAT DETECTOR/CARBON MONOXIDE DETECTOR
S R — SMOKE/HEAT DETECTOR/SENSOR COMBINATION
S — SMOKE DETECTOR/SENSOR FOR DUCT S–SUPPLY R–RETURN
S SB — SOUNDER BASE
CD — COMBINATION HORN/VISIBLE CD= CANDELA RATING/SETTING
CD 1W — COMBINATION SPEAKER/VISIBLE W=WATTAGE CD= CANDELA RATING/SETTING
H — HORN ONLY
M — MINI–HORN
5W — SPEAKER ONLY, WALL MOUNT– DENOTE WATTAGE TAP
CD — VISIBLE ONLY (STROBE) – CEILING MOUNT CD=CANDELA RATING/SETTING
CD — VISIBLE ONLY (STROBE) – WALL MOUNT CD=CANDELA RATING/SETTING
RTS — REMOTE ALARM INDICATING TEST STATION
RI — REMOTE ALARM INDICATOR LAMP
FS — FLOW SWITCH (WATER), FURNISHED AND INSTALLED BY FIRE PROTECTION SUBCONTRACTOR, WIRED BY THE ELECTRICAL SUBCONTRACTOR.
TS — TAMPER SWITCH, FURNISHED AND INSTALLED BY FIRE PROTECTION SUBCONTRACTOR, WIRED BY THE ELECTRICAL SUBCONTRACTOR.

SECURITY SYSTEM

CCTV — CLOSED CIRCUIT SECURITY CAMERA

POWER DISTRIBUTION EQUIPMENT

DISTRIBUTION PANEL
PANELBOARD, SURFACE MOUNTED
PANELBOARD, FLUSH MOUNTED
J — JUNCTION BOX, SIZED PER NEC
2 — MOTOR, "2" DENOTES HORSEPOWER
MAGNETIC MOTOR STARTER WITH ENCLOSURE, MINIMUM SIZE NEMA 1
P — MANUAL MOTOR STARTER WITH THERMAL OVERLOAD. "P" DENOTES PILOT LIGHT
30/3 — NON–FUSED DISCONNECT SWITCH: "30/3" DENOTES 30 AMP/3 POLE SWITCH
30/20/3 — FUSED DISCONNECT SWITCH: "30/20/3" DENOTES 30 AMP/3 POLE SWITCH, 20 AMP FUSES
COMBINATION MAGNETIC STARTER AND FUSED DISCONNECT SWITCH. SIZE OF STARTER, SWITCH AND FUSE AS REQUIRED
T — PAD MOUNTED TRANSFORMER
GROUND

MISCELLANEOUS

JUNCTION BOX WITH FLEXIBLE CONNECTION TO EQUIPMENT
EF — EXHAUST FAN
CP — CONTROL PANEL
PB — PULL BOX – SIZED PER NEC FOR CONDUITS ENTERING AND LEAVING
PC — PHOTO–CELL
TC — TIME CLOCK
KP — KEY PAD
TS — TEST SWITCH (EMERGENCY LIGHTING)

MECHANICAL EQUIPMENT TAG ABBREVIATIONS

AH 1 — DENOTES EQUIPMENT TYPE / DENOTES UNIT NUMBER

ACC	AIR–COOLED CONDENSER
AHU	AIR HANDLING UNIT
B	BOILER
CH	CHILLER
CUH	CABINET UNIT HEATER
EBB	ELECTRIC BASEBOARD
EF	EXHAUST FAN
EH	EXHAUST HOOD
EWH	ELECTRIC WALL HEATER
FC	FAN COIL
HP	HEAT PUMP
MAU	MAKE–UP AIR UNIT
P	PUMP
RTU	ROOF TOP UNIT
UH	UNIT HEATER
VAV	VARIABLE AIR VOLUME BOX
WH	ELECTRIC WATER HEATER

ABBREVIATIONS

3R	NEMA 3R RATING
4X	NEMA 4X RATING
A	AMPERES
AFF	ABOVE FINISHED FLOOR
AFG	ABOVE FINISHED GRADE
AIC	AMPERE INTERRUPTING CAPACITY
ARCH	ARCHITECT
ATS	AUTOMATIC TRANSFER SWITCH
AWG	AMERICAN WIRE GAUGE
C	CONDUIT
C/B	CIRCUIT BREAKER
C.T.	CURRENT TRANSFORMER
CAT	CATALOG
CKT	CIRCUIT
CU	COPPER
DWG	DRAWING
E	WIRED ON EMERGENCY CIRCUIT
EC	ELECTRICAL CONTRACTOR
EM	EMERGENCY
ETD	EXISTING TO BE DEMOLISHED
ETR	EXISTING TO REMAIN
ETRL	EXISTING TO BE RELOCATED
ETRP	EXISTING TO BE REPLACED
G	GROUND
GC	GENERAL CONTRACTOR
GFI	GROUND FAULT INTERRUPTER
HVAC	HEATING, VENTILATION, AIR CONDITIONING CONTRACTOR
IG	ISOLATED GROUND
KCMIL	ONE THOUSAND CIRCULAR MILS
KVA	KILOVOLT–AMPERES
KVAR	KILOVOLT–AMPERES REACTIVE
KW	KILOWATTS
MCB	MAIN CIRCUIT BREAKER
MCC	MOTOR CONTROL CENTER
MD	MOTORIZED DAMPER
MLO	MAIN LUGS ONLY
NC	NORMALLY CLOSED
NEC	NATIONAL ELECTRICAL CODE
NL	NIGHT LIGHT
NO	NORMALLY OPEN
NTS	NOT TO SCALE
ø	PHASE
P	POLE
PC	PLUMBING CONTRACTOR
P.T.	POTENTIAL TRANSFORMER
PVC	POLYVINYL CHLORIDE
RL	NEW LOCATION OF RELOCATED DEVICE
SM	SURFACE MOUNT
ST	SHUNT TRIP
T/D	TEL/DATA
TEL	TELEPHONE
UG	UNDERGROUND
UNO	UNLESS NOTED OTHERWISE
V	VOLT
VIF	VERIFY IN FIELD
W	WATT
WP	WEATHERPROOF
XFMR	TRANSFORMER

LIGHTING FIXTURE SCHEDULE

TYPE	DESCRIPTION	MANUFACTURER & CATALOG NUMBER	LAMPS NUMBER	LAMPS TYPE	LAMPS VOLTS	LAMPS WATTS	REMARKS
F1	RECESSED 2'x4' LED FLAT PANEL	ORACLE LIGHTING 24–FPL1–LED–4000/5000/6000L/ DIM10–MVOLT–35K/40K/50K	–	LED	120	53	INITIAL FIXTURE SETTING SHALL BE 5000 LUMENS AND 40K COLOR TEMP
F2	RECESSED 2'x2' LED FLAT PANEL	ORACLE LIGHTING 22–FPL1–LED–2000/3000/4000L/ DIM10–MVOLT–35K/40K/50K	–	LED	120	42	INITIAL FIXTURE SETTING SHALL BE 4000 LUMENS AND 40K COLOR TEMP
F3	DUAL–HEAD SPOT LIGHT FIXTURE	BETA CALCO MRDF1P01/LMAO250/LMBO250/ CR90/CTA30/BA30/BB30/V1/DAO1/ FAO2/NT1/NU1/EO/CS1	–	LED	120	38	FINISH SELECTED BY ARCHITECT

LIGHTING FIXTURE NOTES:

1. PROVIDE ACCESSORIES AND MOUNTING HARDWARE FOR ALL FIXTURES.
2. COLORS SHALL BE AS SELECTED BY ARCHITECT.
3. COORDINATE EXACT LOCATION WITH ARCHITECT'S REFLECTED CEILING PLAN PRIOR TO ROUGH–IN.
4. E.C. SHALL ENSURE THAT ALL PROPOSED SWITCHES AND DIMMER SWITCHES ARE COMPATIBLE WITH THE LIGHT FIXTURE(S) INDICATED TO BE CONTROLLED. INSTALL ALL SWITCHES AND DIMMER SWITCHES PER MANUFACTURER'S RECOMMENDATIONS AND REQUIREMENTS.

DEMOLITION AND REMOVAL WORK

A. REMOVE ALL ELECTRICAL EQUIPMENT, WIRING, AND OTHER ELECTRICAL WORK AS REQUIRED. DISCONNECT LOAD AND LINE END OF CONDUCTORS FEEDING DEVICES WHICH ARE TO BE REMOVED OR ABANDONED, REMOVE CONDUCTORS NO LONGER IN USE. CUT BACK TO FLOOR, WALL, OR CEILING AND PLUG BOTH ENDS OF CONCEALED CONDUITS MADE OBSOLETE BY THIS ALTERATION. REMOVE EXPOSED OR ABANDONED CIRCUITS AND OUTLETS. REMOVE MATERIAL AND EQUIPMENT AND DISPOSE OF AS DIRECTED.

B. WHEREVER IT IS REQUIRED TO DISCONNECT OR REMOVE ANY PART OF AN EXISTING CIRCUIT, IMMEDIATELY RECONNECT THAT CIRCUIT OR REESTABLISH SERVICE IN THE REMAINING PORTION OF THE CIRCUIT.

C. THE WORK SHALL ALSO INCLUDE THE REMOVAL OF MATERIALS AS DIRECTED. PRIOR TO REMOVING EQUIPMENT AND MATERIAL FROM PROJECT SITE, THE BUILDING MANAGER OR OWNER WILL INSPECT AND ADVISE WHICH ITEMS WILL BE STORED.

D. WHERE EXISTING RECEPTACLES AND/OR SWITCHES ARE LOCATED IN COLUMNS AND/OR EXTERIOR WALLS, AND ARE NOT TO BE REUSED, REMOVE RECEPTACLE AND CAP OUTLET BOX. RECEPTACLES SHOWN ON PARTITIONS TO BE REMOVED SHALL HAVE ALL WIRING AND CONDUIT REMOVED AS WELL.

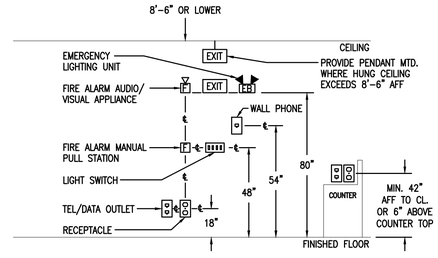
E. WHERE PRESENT WORK IS DAMAGED IN THE EXECUTION OF THIS CONTRACT, OR WHERE OPENINGS ARE LEFT DUE TO THE REMOVAL OF CONDUITS, EQUIPMENT, OR APPARATUS, THE SAME SHALL BE REPAIRED OR CLOSED UP TO CORRESPOND IN MATERIAL, QUALITY, SHAPE, AND FINISH WITH THAT OR SIMILAR AND ADJOINING WORK, UNLESS OTHERWISE CALLED FOR.

F. SHOULD ANY DAMAGE DUE TO THE EXECUTION OF THIS CONTRACT OCCUR TO THE FURNITURE, FIXTURES, OR ANY OTHER EQUIPMENT OR APPARATUS, SUCH DAMAGES SHALL BE PROPERLY REPAIRED WITH THE SUPPLY OF NEW ARTICLES AND MADE GOOD WITHOUT EXTRA CHARGE.

G. WHERE REMOVAL OF EXISTING ELECTRICAL EQUIPMENT WILL RESULT IN OUTAGES IN AREA NOT TO BE DEMOLISHED, THIS CONTRACTOR SHALL COORDINATE IN ADVANCE AND OBTAIN THE APPROVAL OF THE BUILDING MANAGER OR OWNER.

BRANCH CIRCUIT WIRING NOTES:

1. WIRING IS SHOWN ON DRAWINGS ONLY FOR SPECIFIC ROUTES OR SPECIAL CONDITIONS.
2. WIRING AND CONDUIT SHALL BE REQUIRED BETWEEN ALL OUTLETS INDICATED WITH CIRCUIT NUMBERS AND PANEL DESIGNATIONS.
3. ALL SWITCH CONTROLS SHALL BE PROVIDED WITH WIRING AND CONDUIT AS REQUIRED.
4. ALTHOUGH ALL BRANCH CIRCUIT WIRING AND CONDUIT IS NOT SHOWN, IT IS THE INTENT OF THESE DOCUMENTS THAT A COMPLETE BRANCH CIRCUIT WIRING SYSTEM BE INSTALLED.
5. A GREEN GROUNDING CONDUCTOR SHALL BE RUN WITH ALL CIRCUITS. VERIFY CONDUIT SIZE TO ENSURE IT CAN ACCOMMODATE ALL PHASE, NEUTRAL AND GROUND CONDUCTORS.
6. PROVIDE A NEUTRAL CONDUCTOR TO ALL NEW LIGHTING SWITCH BOXES PER NEC ARTICLE 404.2.
7. IN ALL NON–DWELLING TYPE OCCUPANCIES, ALL 125–VOLT THROUGH 250–VOLT RECEPTACLES SUPPLIED BY SINGLE–PHASE BRANCH CIRCUITS RATED 150 VOLTS OR LESS TO GROUND, 50 AMPERES OR LESS, AND ALL RECEPTACLES SUPPLIED BY THREE–PHASE BRANCH CIRCUITS RATED 150 VOLTS OR LESS TO GROUND, 100 AMPERES OR LESS, SHALL HAVE GROUND–FAULT CIRCUIT–INTERRUPTER PROTECTION FOR PERSONNEL PER NEC ARTICLE 210.8(B)(2).
8. PROVIDE TAMPER RESISTANT RECEPTACLES IN ALL AREAS REQUIRED BY NEC ARTICLE 406.12.
9. WHERE EXISTING SWITCHES AND RECEPTACLES ARE INDICATED TO REMAIN, THIS CONTRACTOR SHALL REPLACE SAID DEVICE(S) AND DEVICE PLATE(S) WITH NEW TO MATCH THE NEW CONSTRUCTION. WHERE THEY ARE INDICATED AS RELOCATED, EXTEND BRANCH CIRCUIT WIRING TO NEW LOCATION AND PROVIDE NEW DEVICE AND DEVICE PLATE TO MATCH NEW CONSTRUCTION.
10. ALL SELF CONTAINED EMERGENCY LIGHTING UNITS AND EXIT LIGHTING IN THE BUILDING SHALL BE CONNECTED TO THE NEAREST UNSWITCHED LIGHTING CIRCUIT IN THE AREA WITH 2#12, #12G, 3/4" CONDUIT UNLESS OTHERWISE NOTED.



NOTES:
1. INSTALL DEVICES ON ONE COMMON VERTICAL CENTERLINE.
2. INSTALL DEVICES AT THIS HEIGHT WHEREVER APPLICABLE.

DETAIL OF TYPICAL DEVICE MOUNTING HEIGHTS — NTS

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HVAC UPGRADES
at
Hoxsie Elementary School
55 Glenwood Drive, Warwick, RI 02889
for
Warwick School Department

Revision Schedule	
Revision Number	Revision Date
3	03-10-2026

SHEET TITLE

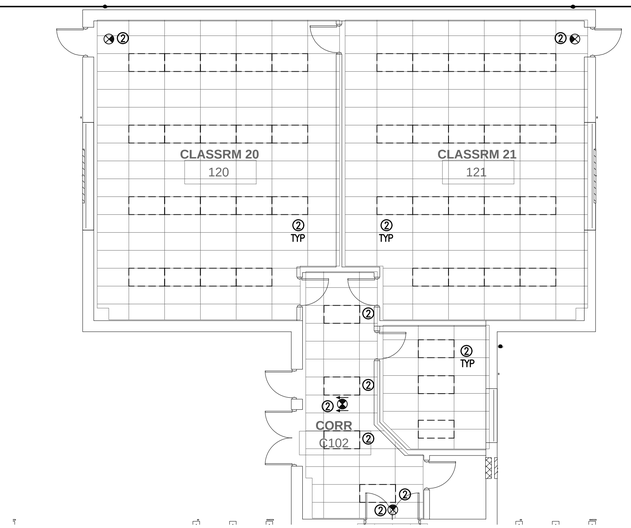
ELECTRICAL LEGEND, LIGHTING FIXTURE SCHEDULE AND NOTES

DRAWN BY: RJ	JOB NUMBER: 25040
CHECKED BY: RF	DATE: 02-09-2026

E1.0

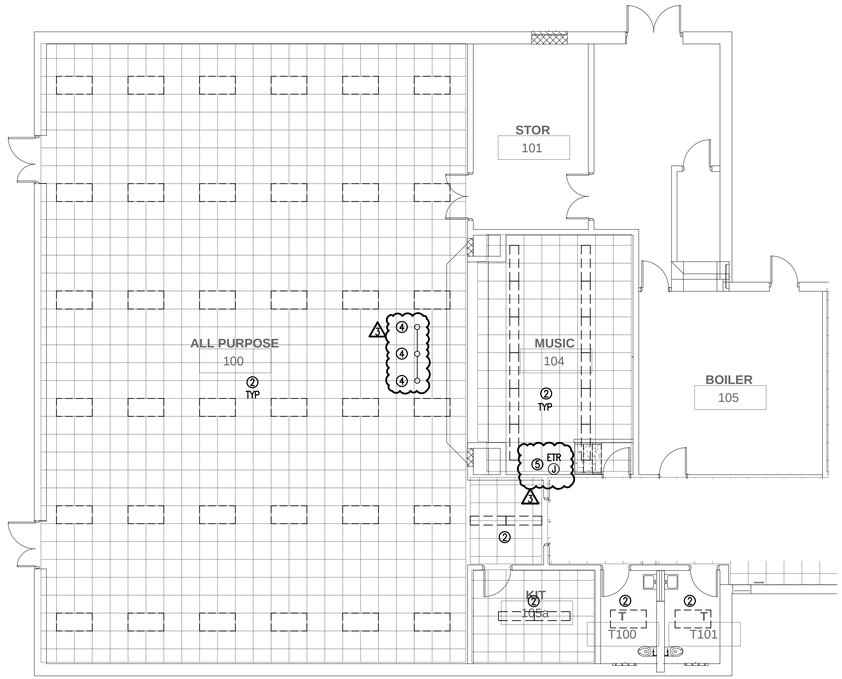
SHEET: 28 OF: 44

BER# 21228



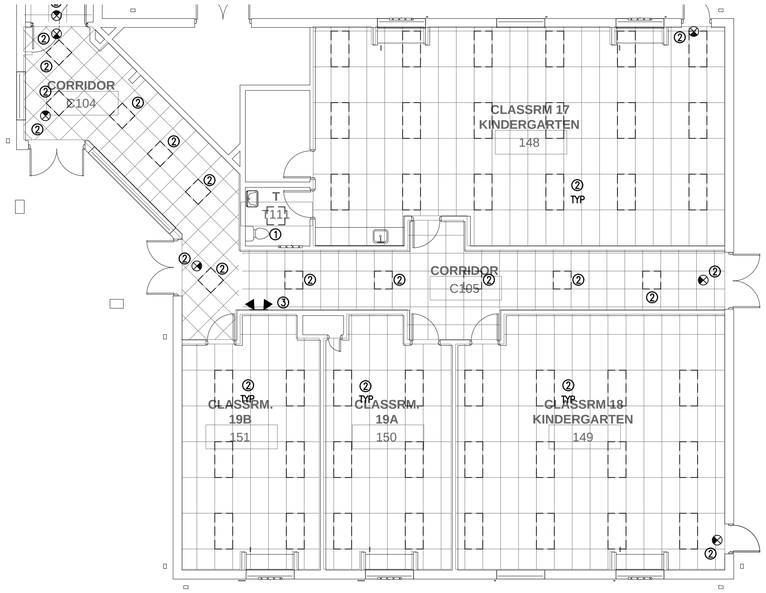
1 ELECTRICAL PLAN - AREA B - DEMOLITION

1/8" = 1'-0"



2 ELECTRICAL PLAN - AREA C - DEMOLITION

1/8" = 1'-0"



3 ELECTRICAL PLAN - AREA D - DEMOLITION

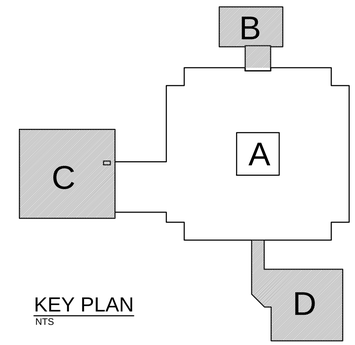
1/8" = 1'-0"

GENERAL NOTE:

PRIOR TO CONSTRUCTION BEGINNING, THE CONTRACTOR SHALL PERFORM A WALK-THRU TO REVIEW THE EXISTING CONDITION OF ALL ELECTRICAL EQUIPMENT AFFECTED BY THIS PROJECT. ANY EQUIPMENT FOUND TO BE DEFECTIVE SHALL BE RECORDED. ONCE ALL EQUIPMENT HAS BEEN INSPECTED, THE CONTRACTOR SHALL NOTIFY THE OWNER/ARCHITECT/ENGINEER OF ANY DEFECTIVE EQUIPMENT. FAILURE TO PERFORM THIS WORK WILL FORFEIT ANY ADDITIONAL MONIES TO REPLACE/REPAIR DAMAGED EQUIPMENT.

KEYED NOTES – **APPLIES TO ED1.2 DETAIL 1, 2, & 3 ONLY**:

1. EXISTING LIGHT FIXTURE TO BE DEMOLISHED. MAINTAIN EXISTING BRANCH CIRCUIT WIRING FOR RE-USE WITH NEW RECESSED L.E.D. FIXTURES.
2. EXISTING LIGHT FIXTURE SHALL BE DISCONNECT, REMOVED, AND STORED PRIOR TO EXISTING CEILING BEING REMOVED. FIXTURES TO BE PROPERLY RE-INSTALLED AFTER NEW CEILING IS INSTALLED. REFER TO DRAWING E1.2.
3. EXISTING LIGHT FIXTURE TO REMAIN THROUGH-OUT CEILING REMOVAL/ CONSTRUCTION. PROPERLY SUPPORT AND PROTECT ALL EQUIPMENT DURING CEILING REMOVAL/CONSTRUCTION. ALL ASSOCIATED CABLING SHALL BE SUPPORTED AND PROTECTED DURING CEILING REMOVAL/CONSTRUCTION. ANY EQUIPMENT DAMAGED DURING CONSTRUCTION SHALL BE REPLACED AT NO COST TO THE PROJECT.
4. EXISTING LIGHT FIXTURES, OUTLET BOXES, AND EXPOSED CONDUITS SHALL BE DEMOLISHED. DISCONNECT EXISTING BRANCH CIRCUIT WIRING AND SWITCH LEG. DISCONNECT AND REMOVE EXISTING CONTROL SWITCH.
5. EXISTING ABANDONED WALL BOX SHALL REMAIN AND BE REUSED FOR NEW DIMMING WALL SWITCH. DISCONNECT AND REMOVE ANY EXISTING WIRING WITHIN BOX BACK TO SOURCE.



KEY PLAN
NTS

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at

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55 Glenwood Drive, Warwick, RI 02889

for

Warwick School Department

Revision Schedule	
Revision Number	Revision Date
3	03-10-2026

SHEET TITLE

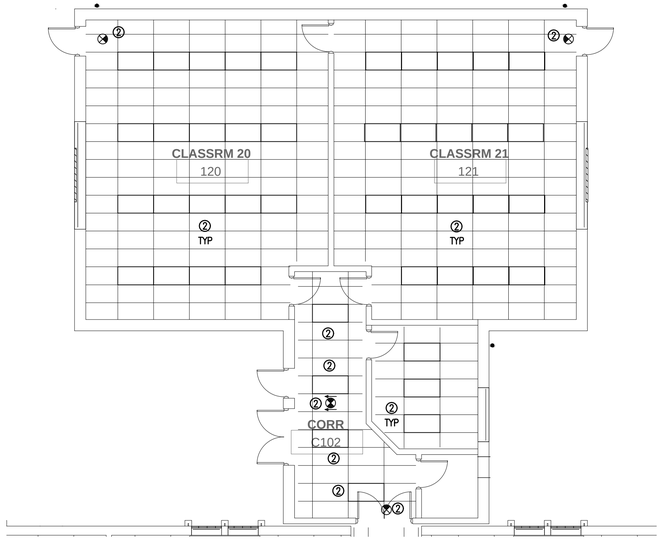
ELECTRICAL PLANS - AREAS B, C & D - LIGHTING DEMOLITION

DRAWN BY:	RJ	JOB NUMBER:	25040
CHECKED BY:	RF	DATE:	02-09-2026

ED1.2

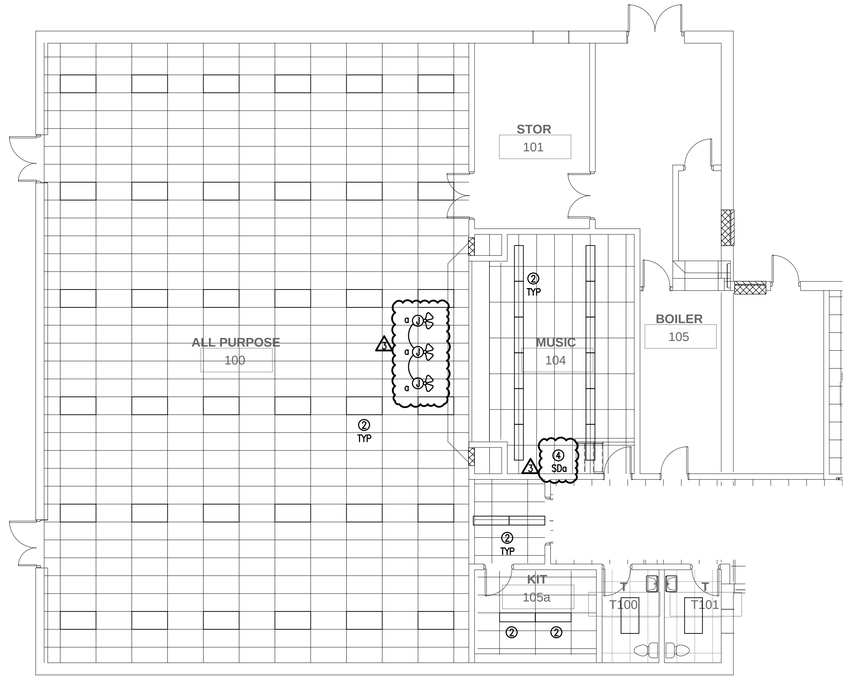
SHEET: 31 OF: 44

BER# 21228



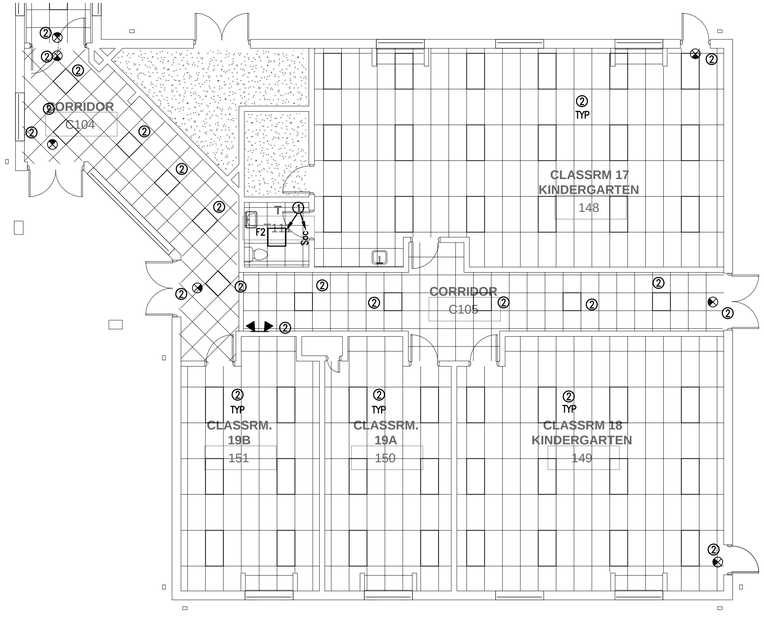
1 ELECTRICAL PLAN - AREA B

1/8" = 1'-0"



2 ELECTRICAL PLAN - AREA C

1/8" = 1'-0"

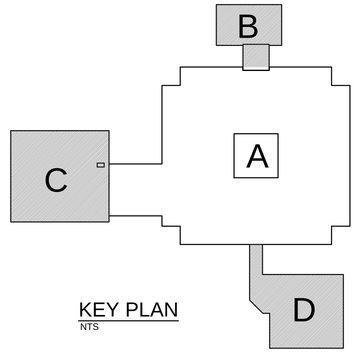


3 ELECTRICAL PLAN - AREA D

1/8" = 1'-0"

KEYED NOTES:

1. PROVIDE NEW LIGHT FIXTURE AND OCCUPANCY SENSOR AS INDICATED. PROVIDE CONNECTION TO EXISTING BRANCH CIRCUIT AND PROVIDE NEW SWITCH LEG.
2. RE-INSTALL EXISTING LIGHT FIXTURE AND PROVIDE CONNECTION TO EXISTING BRANCH CIRCUIT. EXTEND EXISTING BRANCH CIRCUIT WIRING AS REQUIRED. PROPERLY SUPPORT IN ACCORDANCE WITH RHODE ISLAND STATE ELECTRIC CODE. ALL FIXTURES SHALL BE TESTED AT PROJECT COMPLETION TO ENSURE PROPER WORKING CONDITION. ANY FIXTURE DAMAGED DURING CONSTRUCTION SHALL BE REPLACED AT NO COST TO THE PROJECT.
3. PROVIDE NEW RECESSED OUTLET BOXES AT CEILING FOR INSTALLATION OF NEW SURFACE MOUNTED, DUAL-HEAD MONOPOINT FIXTURES. UTILIZE EXISTING BRANCH CIRCUIT MADE AVAILABLE BY DEMOLITION OF EXISTING LIGHT FIXTURES IN THIS AREA FOR CONNECTION TO NEW FIXTURES. PROVIDE NEW SWITCH LEG AND NEW 0-10V DIMMING WALL SWITCH. PROPERLY SUPPORT ALL OUTLET BOXES AND LIGHT FIXTURES IN ACCORDANCE WITH RHODE ISLAND STATE ELECTRIC CODE. FIXTURES SHALL BE AIMED AS DIRECTED BY FACILITIES PERSONNEL.
4. PROVIDE NEW 0-10V DIMMING WALL SWITCH IN EXISTING WALL BOX FOR CONTROL OF NEW STAGE SPOT LIGHTS. VERIFY SWITCH COMPATIBILITY WITH LIGHT FIXTURE SPECIFICATIONS.



KEY PLAN

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SHEET TITLE

ELECTRICAL PLANS - AREAS B, C & D - LIGHTING

DRAWN BY:	RJ	JOB NUMBER:	25040
CHECKED BY:	RF	DATE:	02-09-2026

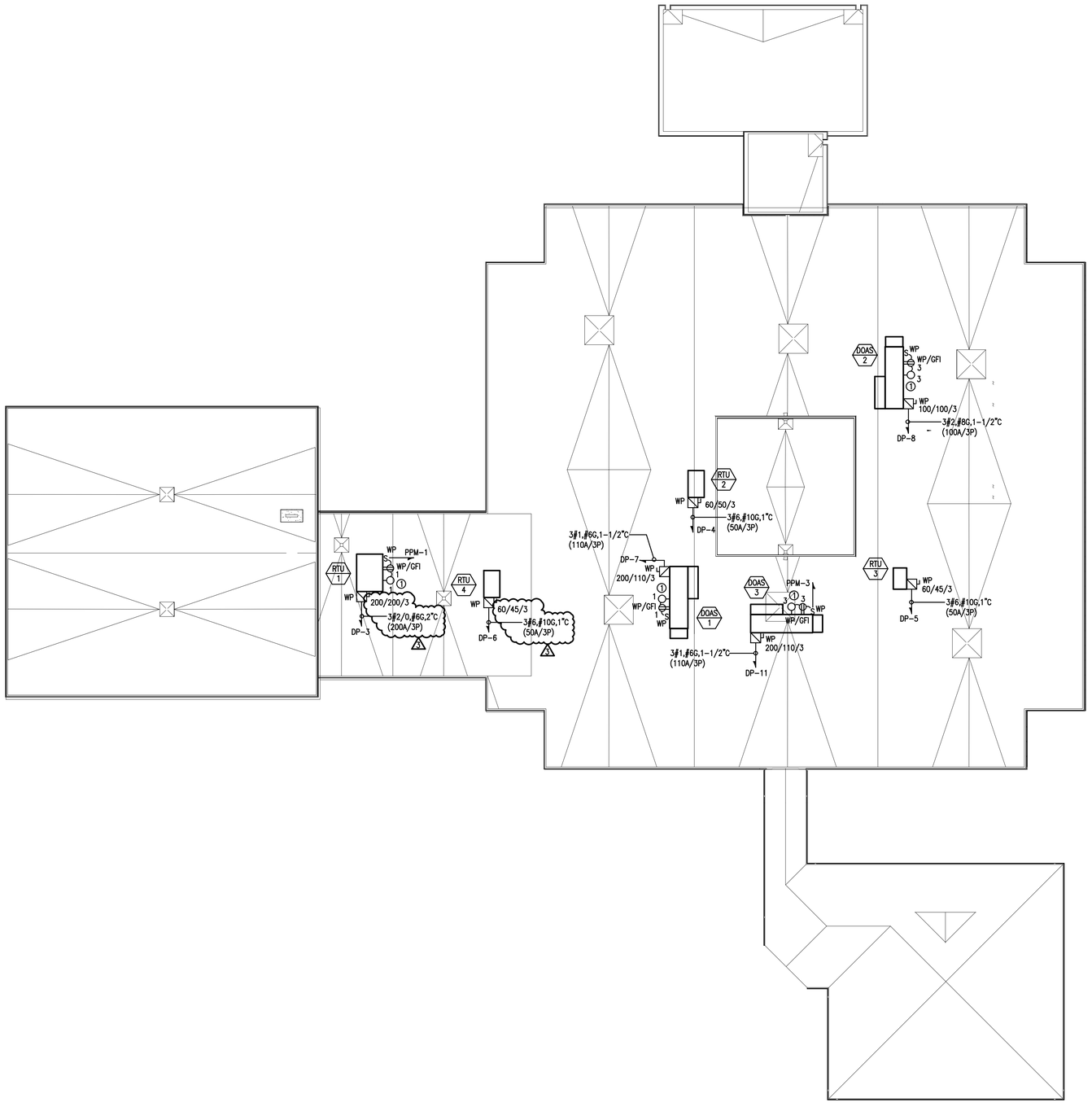
E1.2

SHEET: 36 OF: 44

BER# 21228

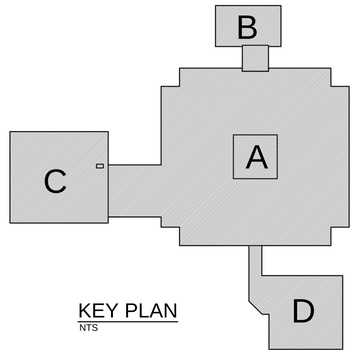
KEYED NOTES:

① PROVIDE FIXTURE EQUAL TO LITONIA CAT.#OLVTWM.



1 ELECTRICAL OVERALL ROOF PLAN

1/16" = 1'-0"



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ELECTRICAL OVERALL ROOF PLAN

DRAWN BY:	RJ	JOB NUMBER:	25040
CHECKED BY:	RF	DATE:	02-09-2026

E2.3

SHEET: 39 OF: 44

BER# 21228

MAIN DISTRIBUTION PANEL "DP"

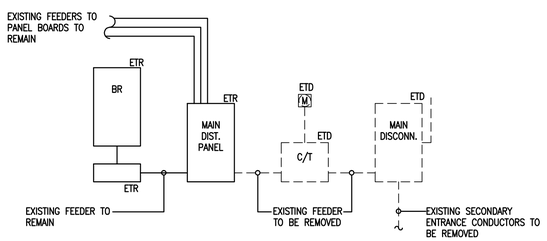
VOLTAGE: 120/208V — PHASE: 3
BUS RATING (CU): 1200 AMPS — WIRE: 4
MAINS: 1200A MAIN CIRCUIT BREAKER — AIC: 100K

CKT NO	OVERCURRENT DEVICE (AMP) FRAME	TRIP	POLES	DESCRIPTION OF LOAD	REMARKS
1	125A	80A	3	TVSS UNIT	–
2	125A	100A	3	PANEL "PP1"	–
3	225A	200A (A)	3	RTU–1	–
4	125A	50A	3	RTU–2	–
5	125A	50A	3	RTU–3	–
6	125A	50A (A)	3	RTU–4	–
7	125A	110A	3	DOAS–1	–
8	125A	100A	3	DOAS–2	–
9	400A	400A	3	EXISTING PANEL "MDP"	–
10	125A	100A	3	PANEL "PPM"	–
11	125A	110A	3	DOAS–3	–
12	–	–	–	SPACE ONLY	PROVIDE BUSING AND PROVISIONS
13	125A	100A	3	SPARE	
14	125A	100A	3	SPARE	

PANELBOARD SCHEDULE

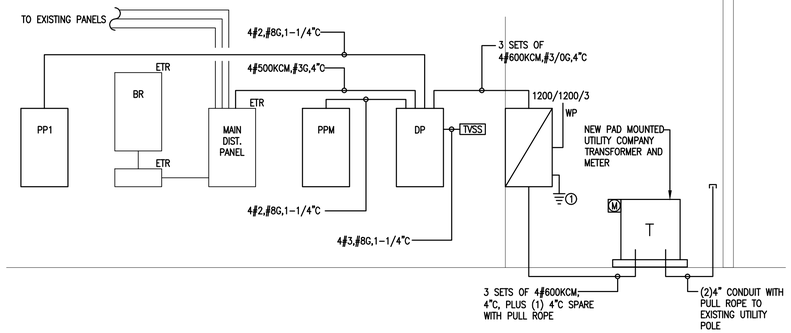
PANEL DESIGNATION	VOLTS	PHASE	WIRES	MAINS MLO: MAIN LUGS ONLY MCB: MAIN CKT. BKR. BUS SIZE	OVERCURRENT DEVICE FRAME AMPS	TRIP AMPS	BKR. POLES	BRANCH DEVICES BREAKER AMPS 15	20	25	30	40	50	60	70	* TOTAL POLES	MOUNTING S: SURFACE F: FLUSH	GROUND BUS	ADDITIONAL BRANCH C.B.'S	REMARKS
PP1	120/208	3	4	100A	MLO	MLO	1		24							30	S	P		
							2													
							3													
PPM	120/208	3	4	100A	MLO	MLO	1		20							42	S	P		
							2					2								
							3													

* INCLUDES SPACES



1 EXISTING ELECTRIC RISER DIAGRAM

NOT TO SCALE

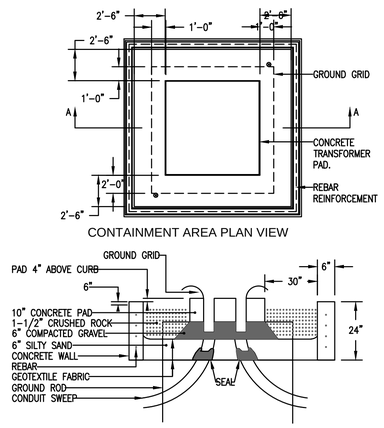


2 NEW ELECTRIC RISER DIAGRAM

NOT TO SCALE

KEYED NOTES:

1. PROVIDE #3/0 AWG GROUND IN 1–1/4" CONDUIT TO BUILDING STEEL TO STREET SIDE OF WATER SERVICE AND TO 3/4" x 10'–0" COPPER–CLAD GROUND ROD PER NEC ART. 250.



CONTAINMENT AREA PLAN VIEW

TYPICAL CROSS SECTION OF CONTAINMENT PAD A-A

3 TRANSFORMER PAD OIL CONTAINMENT DETAIL

NOT TO SCALE

TRANSFORMER PAD OIL CONTAINMENT DETAIL NOTES

1. BUILD OIL CURB, THIS SHOULD BE INSTALLED WITH CONCRETE IN ACCORDANCE WITH MIX #4 LOCAL UTILITY COMPANY PER CONCRETE SPECIFICATIONS. REINFORCEMENT TO BE #4, GRADE 60 ROD MINIMUM, 6 INCHES ON CENTER, BEND RODS AROUND CORNERS. CURB TO BE 24" DEEP WITH MINIMUM THICKNESS OF 6".
2. INSTALL GEOTEXTILE LINER FROM TOP OF WALLS AND AROUND BOTTOM OF CONTAINMENT AREA. AREA WHERE CONDUIT CROSSES OVERLAP LINER AROUND CONDUIT AND SEAL WITH EXPANDING FOAM.
3. INSTALL 6" OF SILTY SAND ON TOP OF LINER.
4. INSTALL SECOND LAYER OF GEOTEXTILE LINER AS NOTED IN STEP 2.
5. BUILD UP AREA FOR TRANSFORMER PAD WITH 6" OF COMPACTED GRAVEL AND LEVEL.
6. INSTALL GROUND GRID.
7. SET/BUILD TRANSFORMER PAD.
8. FILL IN CONDUIT OPENINGS WITH SILTY OR EXPANDING FOAM UP TO THE LAST TWO INCHES OF THE PAD.
9. FILL REST OF CONDUIT OPENING WITH CONCRETE GROUT OR EXPANDING FOAM.
10. FILL AREA BETWEEN SLAB AND CURB WITH 1–1/2 INCHES UNIFORMLY GRADED CRUSHED ROCK.
11. ALL CONCRETE WORK, EXCAVATION AND OIL CONTAINMENT LINER SHALL BE FURNISHED AND INSTALLED BY THE GENERAL CONTRACTOR.

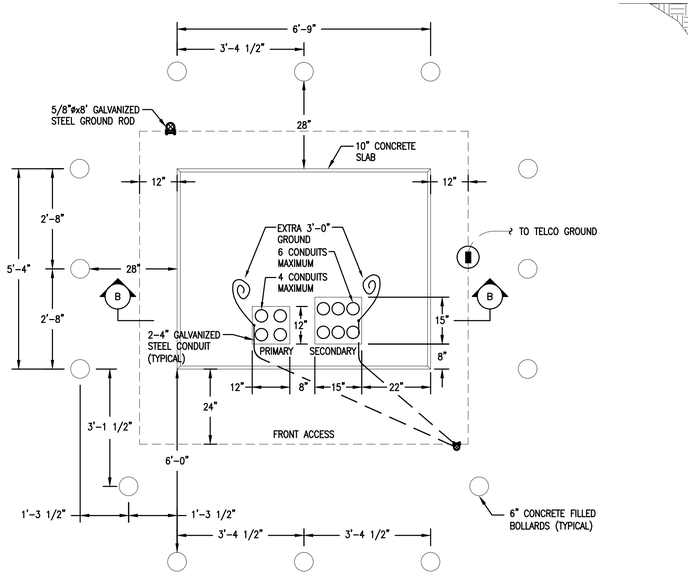
GEO–TEXTILE LINER

GENERIC NAME IS: 16oz POLYPROPYLENE GEOTEXTILE ALSO CALLED FILTER FABRIC WEIGHING 16oz/Square YARD.

BRAND NAME/SUPPLIERS ARE:
AME1680 AVAILABLE FROM AMERICAN ENGINEERING FABRICS (AEF), Inc. (EMPHASIZE POLYPROPYLENE NOT POLYESTER) NEW BEDFORD, MA @ 1–617–965–0007 / 1–800–770–2666 OR FROM VELLANO BROS. LANCASTER NY 1–716–684–7222, SEVERAL OTHER LOCATIONS IN NY, MA, RI AND NH, GO TO WWW.VELLANO.COM

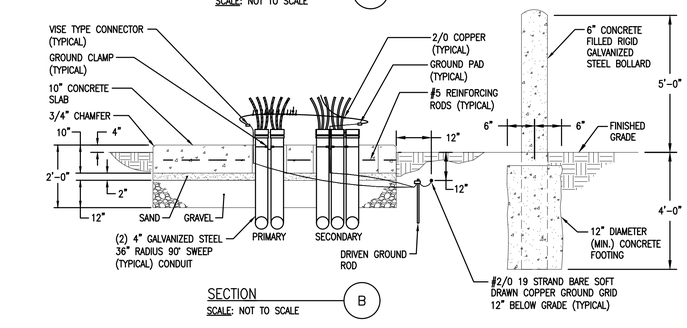
SYNTHETIC INDUSTRIES ST 160 AVAILABLE FROM SPARTAN MILLS Inc's, SPARTANBURG, NC 1–803–576–2353

CARTHAGE MILLS FX–160HS / US CONSTRUCTION FABRICS LLC 90 RANGE Rd, WINDHAM NH 03087 1–603–898–0532



PLAN VIEW DETAIL A

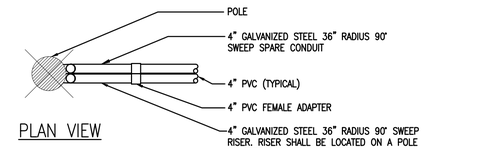
SCALE: NOT TO SCALE



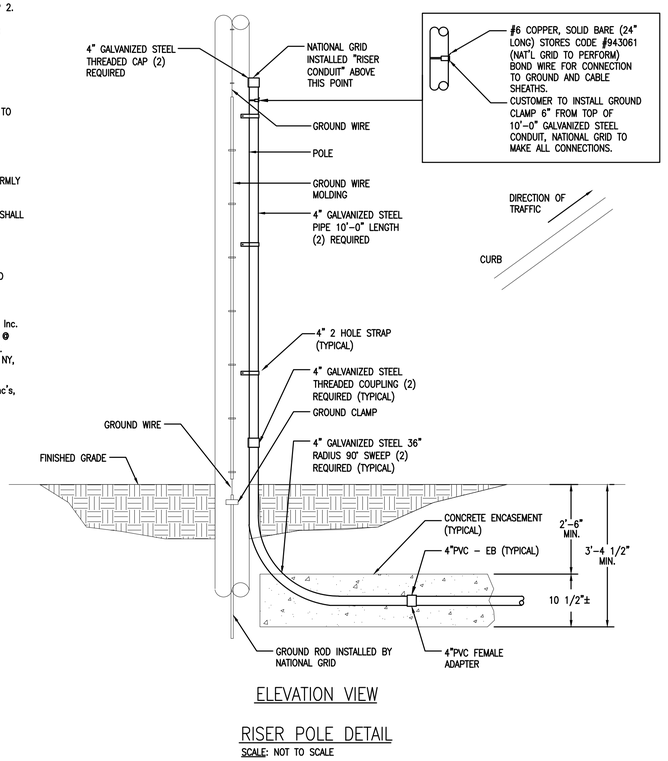
SECTION B

SCALE: NOT TO SCALE

STANDARD THREE PHASE TRANSFORMER 75–500KVA MAXIMUM PAD DETAIL



PLAN VIEW



ELEVATION VIEW

RISER POLE DETAIL

SCALE: NOT TO SCALE

TRANSFORMER PAD NOTES:

1. INSTALL CONDUITS AS SHOWN IN DETAILS "A" AND "B" ON DRAWING #ES1.0 BEFORE SLAB IS POURED. USE 36" RADIUS BENDS, WITH COUPLINGS, NIPPLES AND BUSHINGS AS REQUIRED. BENDS FOR PRIMARY CABLES SHALL BE GALVANIZED STEEL. TERMINATIONS AND BUSHINGS SHALL BE INSTALLED AFTER THE TRANSFORMER IS PLACED, AND BEFORE THE CABLES ARE PULLED.
2. INSTALL #1/0 7 STRAND BARE SOFT DRAWN COPPER WIRE LOOP 21" BELOW GRADE. BOND TO ALL EXPOSED METALLIC CONDUIT AND LEAVE 3'–0" OF WIRE ABOVE PAD FOR GROUNDING TRANSFORMER AT TWO OPPOSITE POINTS IN THE CABLE CONDUIT OPENINGS. INSTALL TWO 8" GALVANIZED STEEL (3/4") GROUND RODS AND APPROVED CONNECTORS BELOW GROUND. LEAVE GROUND GRID EXPOSED UNTIL INSPECTED BY THE UTILITY COMPANY. CONNECTIONS TO GROUND GRID TO BE MADE AS SHOWN IN DETAILS "C", "D" AND "G" ON DRAWING #, EXCEPT THAT EXOTHERMIC WELDING ("CALDWELD") SHALL BE AN ACCEPTABLE ALTERNATE TO COMPRESSION BOLTED CONNECTIONS.
3. CRUSHED ROCK, GRAVEL AND SAND SHALL BE PLACED AS SHOWN IN DETAIL "B" ON DRAWING #; THE GRAVEL, BEING THOROUGHLY COMPACTED, AND THE SAND THOROUGHLY WETTED, JUST BEFORE PLACING THE CONCRETE.
4. INSTALL CONCRETE SLAB IN ACCORDANCE WITH MIX #5– (N.E.E.S STD.GS 0211) UNLESS OTHERWISE SPECIFIED. ALL EXPOSED EDGES TO HAVE A 3/4" CHAMFER.
5. REINFORCING RODS TO BE #4 GRADE 60 AND SHALL CONFORM TO ASTM. STANDARD A–615 OF LATEST DATE. REINFORCING RODS TO BE LOCATED IN CENTER OF THE SLAB, WITH A MINIMUM OF 2" CLEARANCE FROM FACE OF CONCRETE.
6. UPON COMPLETION OF THE SLAB, AND THE INSTALLATION OF CONDUIT, FILL THE OPEN AREA AROUND THE CONDUITS WITH CONCRETE AND GROUT AROUND THE CONDUIT TO SEAL THIS AREA.
7. TRANSFORMER TO BE INSTALLED BY THE CUSTOMER (SEE DETAIL "A").
8. INSTALL CONCRETE OIL CURB IN ACCORDANCE WITH MIX #4 – GS 0211. REINFORCE WITH (4) 1/2" RODS, SIX INCHES ON CENTER AS SHOWN. BEND RODS AROUND CORNERS. FILL AREA BETWEEN SLAB AND CURB WITH A 1–1/2" UNIFORMLY GRADED CRUSHED ROCK AND LINE WITH 2 LAYERS OF GEOTEXTILE LINER AS SHOWN. GEOTEXTILE LINERS TO BE SEPARATED BY A 6" LAYER OF WELL COMPACTED, SILTY SAND AND GRAVEL MIX. GEOTEXTILE LINE SHALL BE 16 OZ. POLYPROPYLENE GEOTEXTILE – ALL SEAMS TO OVERLAP 12" MINIMUM.

ISSUED FOR PERMIT AND CONSTRUCTION

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HVAC UPGRADES

at

Hoxsie Elementary School

55 Glenwood Drive, Warwick, RI 02889

for

Warwick School Department

Revision Schedule	
Revision Number	Revision Date
3	03-10-2026

SHEET TITLE

ELECTRICAL SCHEDULES, RISER DIAGRAMS AND DETAILS

DRAWN BY: RJ	JOB NUMBER: 25040
CHECKED BY: RF	DATE: 02-09-2026

E3.0

SHEET: 40 OF: 44

BER# 21228