

18-23 Green River School HVAC System Project
PERFORMANCE DESIGN/BUILD SPECIFICATIONS

Prepared by:
B2Q Associates, Inc.
Johnson Engineering & Design, Inc.
June 18, 2018

Section 11 0

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EXECUTION AND CLOSEOUT REQUIREMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Examination, preparation, and general installation procedures.
- B. Mass CEC Rebate Program Compliance
- C. Requirements for alterations work, including selective demolition, except removal, disposal, and/or remediation of hazardous materials and toxic substances.
- D. Pre-installation meetings.
- E. Cutting and patching.
- F. Surveying for laying out the work.
- G. Cleaning and protection.
- H. Starting of systems and equipment.
- I. Demonstration and instruction of Owner personnel.
- J. Closeout procedures, including Contractor's Correction Punch List, except payment procedures.
- K. General requirements for maintenance service.

1.02 RELATED REQUIREMENTS

- A. Contract with the City of Greenfield, MA

1.03 REFERENCE STANDARDS

- A. NFPA 241 - Standard for Safeguarding Construction, Alteration, and Demolition Operations; 2013.

1.04 SUBMITTALS

- A. Cutting and Patching: Submit written request in advance of cutting or alteration that affects:
 - 1. Structural integrity of any element of Project.
 - 2. Integrity of weather exposed or moisture resistant element.
 - 3. Efficiency, maintenance, or safety of any operational element.
 - 4. Visual qualities of sight exposed elements.
 - 5. Work of Owner or separate Contractor.
- B. Project Record Documents: Accurately record actual locations of all equipment, piping, and ductwork installed under this contract.

1.05 QUALIFICATIONS

- A. For demolition work, employ a firm specializing in the type of work required.
 - 1. Minimum of 3 years of documented experience.
- B. Work shall be performed by tradesman holding a valid license for their associated trade. Electricians shall only perform electrical work; sheet metal works shall only install sheet metal etc.

1.06 MASS CEC REBATE PROGRAM COMPLIANCE

- A. Contractor and Engineer of Record must be listed as a participating installer and designer, respectively, in the Massachusetts Clean Energy Center Air-Source Heat

Pump and Variable Refrigerant Flow program.

- B. The system final system Designer and Contractor shall be responsible for submitting the application and all paperwork required to received the rebate from the Mass CEC.

1.07 PROJECT CONDITIONS

- A. Use of explosives is not permitted.
- B. Ventilate enclosed areas to assist cure of materials, to dissipate humidity, and to prevent accumulation of dust, fumes, vapors, or gases.
- C. Dust Control: Execute work by methods to minimize raising dust from construction operations. Provide positive means to prevent air-borne dust from dispersing into atmosphere and over adjacent property.
 - 1. Provide dust-proof barriers between construction areas and areas continuing to be occupied by Owner.
- D. Noise Control: Provide methods, means, and facilities to minimize noise produced by construction operations.
- E. Pollution Control: Provide methods, means, and facilities to prevent contamination of soil, water, and atmosphere from discharge of noxious, toxic substances, and pollutants produced by construction operations. Comply with federal, state, and local regulations.

1.08 COORDINATION

- A. Coordinate scheduling, submittals, and work of the various sections of the Project Manual to ensure efficient and orderly sequence of installation of interdependent construction elements, with provisions for accommodating items installed later.
- B. Verify that utility requirements and characteristics of new operating equipment are compatible with building utilities. Coordinate work of various sections having interdependent responsibilities for installing, connecting to, and placing in service, such equipment.
- C. Coordinate space requirements, supports, and installation of mechanical and electrical work that are indicated diagrammatically on drawings. Follow routing indicated for pipes, ducts, and conduit, as closely as practicable; place runs parallel with lines of building. Utilize spaces efficiently to maximize accessibility for other installations, for maintenance, and for repairs.
- D. In finished areas except as otherwise indicated, conceal pipes, ducts, and wiring within the construction. Coordinate locations of fixtures and outlets with finish elements.
- E. Coordinate completion and clean-up of work of separate sections.
- F. After Owner occupancy of premises, coordinate access to site for correction of defective work and work not in accordance with Contract Documents, to minimize disruption of Owner's activities.

PART 2 PRODUCTS

201 PATCHING MATERIALS

- A. New Materials: As specified in product sections; match existing products and work for patching and extending work.
- B. Type and Quality of Existing Products: Determine by inspecting and testing products where necessary, referring to existing work as a standard.

PART 3 EXECUTION

301 EXAMINATION

- A. Verify that existing site conditions and substrate surfaces are acceptable for subsequent work. Start of work means acceptance of existing conditions.
- B. Verify that existing substrate is capable of structural support or attachment of new work being applied or attached.
- C. Examine and verify specific conditions described in individual specification sections.
- D. Take field measurements before confirming product orders or beginning fabrication, to minimize waste due to over-ordering or misfabrication.
- E. Verify that utility services are available, of the correct characteristics, and in the correct locations.
- F. Prior to Cutting: Examine existing conditions prior to commencing work, including elements subject to damage or movement during cutting and patching. After uncovering existing work, assess conditions affecting performance of work. Beginning of cutting or patching means acceptance of existing conditions.

302 PREPARATION

- A. Clean substrate surfaces prior to applying next material or substance.
- B. Seal cracks or openings of substrate prior to applying next material or substance.
- C. Apply manufacturer required or recommended substrate primer, sealer, or conditioner prior to applying any new material or substance in contact or bond.

303 PREINSTALLATION MEETINGS

- A. When required in individual specification sections, convene a pre-installation meeting at the site prior to commencing work of the section.
- B. Require attendance of parties directly affecting, or affected by, work of the specific section.

304 GENERAL INSTALLATION REQUIREMENTS

- A. In addition to compliance with regulatory requirements, conduct construction operations in compliance with NFPA 241, including applicable recommendations in Appendix A.
- B. Install products as specified in individual sections, in accordance with manufacturer's instructions and recommendations, and so as to avoid waste due to necessity for replacement.
- C. Make vertical elements plumb and horizontal elements level, unless otherwise indicated.
- D. Install equipment and fittings plumb and level, neatly aligned with adjacent vertical and horizontal lines, unless otherwise indicated.

- E. Make consistent texture on surfaces, with seamless transitions, unless otherwise indicated.
- F. Make neat transitions between different surfaces, maintaining texture and appearance.

305 ALTERATIONS

- A. Drawings showing existing construction and utilities are based on casual field observation and existing record documents only.
 - 1. Verify that construction and utility arrangements are as indicated.
 - 2. Beginning of alterations work constitutes acceptance of existing conditions.
- B. Maintain weatherproof exterior building enclosure except for interruptions required for replacement or modifications; take care to prevent water and humidity damage.
 - 1. Where openings in exterior enclosure exist, provide construction to make exterior enclosure weatherproof.
 - 2. Insulate existing ducts or pipes that are exposed to outdoor ambient temperatures by alterations work.
- C. Remove existing work as indicated and as required to accomplish new work.
 - 1. Remove items indicated on drawings.
 - 2. Where new surface finishes are to be applied to existing work, perform removals, patch, and prepare existing surfaces as required to receive new finish; remove existing finish if necessary for successful application of new finish.
 - 3. Where new surface finishes are not specified or indicated, patch holes and damaged surfaces to match adjacent finished surfaces as closely as possible.
- D. Services (Including but not limited to HVAC, Plumbing, and Electrical): Remove, relocate, and extend existing systems to accommodate new construction.
 - 1. Maintain existing active systems that are to remain in operation; maintain access to equipment and operational components; if necessary, modify installation to allow access or provide access panel.
 - 2. Where existing systems or equipment are not active and Contract Documents require reactivation, put back into operational condition; repair supply, distribution, and equipment as required.
 - 3. Where existing active systems serve occupied facilities but are to be replaced with new services, maintain existing systems in service until new systems are complete and ready for service.
 - a. Disable existing systems only to make switchovers and connections; minimize duration of outages.
 - b. Provide temporary connections as required to maintain existing systems in service.
 - 4. Verify that abandoned services serve only abandoned facilities.
 - 5. Remove abandoned pipe as, ducts, conduits, and equipment, including those above accessible ceilings; remove back to source of supply where possible, otherwise cap stub and tag with identification; patch holes left by removal using materials specified for new construction.

- E. Protect existing work to remain.
 - 1. Perform cutting to accomplish removals neatly and as specified for cutting new work.
 - 2. Repair adjacent construction and finishes damaged during removal work.
- F. Adapt existing work to fit new work: Make as neat and smooth transition as possible.
 - 1. When existing finished surfaces are cut so that a smooth transition with new work is not possible, terminate existing surface along a straight line at a natural line of division and make recommendation to Engineer.
- G. Patching: Where the existing surface is not indicated to be refinished, patch to match the surface finish that existed prior to cutting. Where the surface is indicated to be refinished, patch so that the substrate is ready for the new finish.
- H. Refinish existing surfaces as indicated:
 - 1. Where rooms or spaces are indicated to be refinished, refinish all visible existing surfaces to remain to the specified condition for each material, with a neat transition to adjacent finishes.
 - 2. If mechanical or electrical work is exposed accidentally during the work, recover and refinish to match.
- I. Clean existing systems and equipment.
- J. Remove demolition debris and abandoned items from alterations areas and dispose of off-site; do not burn or bury.
- K. Do not begin new construction in alterations areas before demolition is complete.
- L. Comply with all other applicable requirements of this section.

3.06 CUTTING AND PATCHING

- A. Whenever possible, execute the work by methods that avoid cutting or patching.
- B. See Alterations article above for additional requirements.
- C. Perform whatever cutting and patching is necessary to:
 - 1. Complete the work.
 - 2. Fit products together to integrate with other work.
 - 3. Provide openings for penetration of mechanical, electrical, and other services.
 - 4. Match work that has been cut to adjacent work.
 - 5. Repair areas adjacent to cuts to required condition.
 - 6. Repair new work damaged by subsequent work.
 - 7. Remove samples of installed work for testing when requested.
 - 8. Remove and replace defective and non-conforming work.
- D. Execute work by methods that avoid damage to other work and that will provide appropriate surfaces to receive patching and finishing. In existing work, minimize damage and restore to original condition.
- E. Employ original installer to perform cutting for weather exposed and moisture resistant elements, and sight exposed surfaces.

- F. Cut rigid materials using masonry saw or core drill. Pneumatic tools not allowed without prior approval.
- G. Restore work with new products in accordance with requirements of Contract Documents.
- H. Fit work air tight to pipes, sleeves, ducts, conduit, and other penetrations through surfaces.
- I. Patching:
 1. Finish patched surfaces to match finish that existed prior to patching. On continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.
 2. Match color, texture, and appearance.
 3. Repair patched surfaces that are damaged, lifted, discolored, or showing other imperfections due to patching work. If defects are due to condition of substrate, repair substrate prior to repairing finish.

3.07 PROGRESS CLEANING

- A. Maintain areas free of waste materials, debris, and rubbish. Maintain site in a clean and orderly condition.
- B. Remove debris and rubbish from pipe chases, plenums, attics, crawl spaces, and other closed or remote spaces, prior to enclosing the space.
- C. Broom and vacuum clean interior areas prior to start of surface finishing, and continue cleaning to eliminate dust.
- D. Collect and remove waste materials, debris, and trash/rubbish from site daily and dispose off-site; do not burn or bury. Areas shall be broom swept at the end of each workday.

3.08 PROTECTION OF INSTALLED WORK

- A. Protect installed work from damage by construction operations.
- B. Provide special protection where specified in individual specification sections.
- C. Provide temporary and removable protection for installed products. Control activity in immediate work area to prevent damage.
- D. Provide protective coverings at walls, projections, jambs, sills, and soffits of openings.
- E. Protect finished floors, stairs, and other surfaces from traffic, dirt, wear, damage, or movement of heavy objects, by protecting with durable sheet materials.
- F. Prohibit traffic or storage upon waterproofed or roofed surfaces. If traffic or activity is necessary, obtain recommendations for protection from waterproofing or roofing material manufacturer.
- G. Remove protective coverings when no longer needed; reuse or recycle coverings if possible.

3.09 SYSTEM STARTUP

- A. Coordinate schedule for manufacturer start-up of various equipment and systems.
- B. Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, and for conditions that may cause damage.

- C. Verify tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer.
- D. Verify that wiring and support components for equipment are complete and tested.
- E. Execute start-up under supervision of applicable Contractor personnel and manufacturer's representative in accordance with manufacturers' instructions.
- F. All new powered mechanical equipment require manufacturer to provide authorized representative to be present at site to inspect, check, and approve equipment or system installation prior to start-up, and to supervise placing equipment or system in operation.
- G. Submit a written report that equipment or system has been properly installed and is functioning correctly.

3.10 DEMONSTRATION AND INSTRUCTION

- A. Demonstrate operation and maintenance of products to Owner's personnel five days prior to date of Substantial Completion.
- B. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment at scheduled time, at equipment location.
- C. For equipment or systems requiring seasonal operation, perform demonstration for other season within six months.
- D. Provide a qualified person who is knowledgeable about the Project to perform demonstration and instruction of Owner's personnel.
- E. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with Owner's personnel in detail to explain all aspects of operation and maintenance.
- F. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

3.11 ADJUSTING

- A. Adjust operating products and equipment to ensure smooth and unhindered operation.
- B. Testing, adjusting, and balancing HVAC systems: See Section 23 0593 - Testing, Adjusting, and Balancing for HVAC.

3.12 FINAL CLEANING

- A. Execute final cleaning prior to final project assessment.
 - 1. Clean areas to be occupied by Owner prior to final completion before Owner occupancy.
- B. Use cleaning materials that are nonhazardous.
- C. Clean interior and exterior glass, surfaces exposed to view; remove temporary labels, stains and foreign substances, polish transparent and glossy surfaces, vacuum carpeted and soft surfaces.
- D. Remove all labels that are not permanent. Do not paint or otherwise cover fire test labels or nameplates on mechanical and electrical equipment.

- E. Clean equipment and fixtures to a sanitary condition with cleaning materials appropriate to the surface and material being cleaned.
- F. Clean filters of operating equipment.
- G. Clean site; sweep paved areas, rake clean landscaped surfaces.
- H. Remove waste, surplus materials, trash/rubbish, and construction facilities from the site; dispose of in legal manner; do not burn or bury.

3.13 CLOSEOUT PROCEDURES

- A. Make submittals that are required by governing or other authorities.
 - 1. Provide copies to Owner.
- B. Accompany Project Coordinator on preliminary inspection to determine items to be listed for completion or correction in the Contractor's Correction Punch List for Contractor's Notice of Substantial Completion.
- C. Notify Engineer when work is considered ready for Engineer's Substantial Completion inspection.
- D. Submit written certification containing Contractor's Correction Punch List, that Contract Documents have been reviewed, work has been inspected, and that work is complete in accordance with Contract Documents and ready for Engineer's Substantial Completion inspection.
- E. Conduct Substantial Completion inspection and create Final Correction Punch List containing Engineer's and Contractor's comprehensive list of items identified to be completed or corrected and submit to Engineer.
- F. Correct items of work listed in Final Correction Punch List and comply with requirements for access to Owner-occupied areas.
- G. Notify Engineer when work is considered finally complete and ready for Engineer's Substantial Completion final inspection.
- H. Complete items of work determined by Engineer listed in executed Certificate of Substantial Completion.

3.14 MAINTENANCE

- A. Provide service and maintenance of components indicated in specification sections.
- B. Maintenance Period: As indicated in specification sections or, if not indicated, not less than one year from the Date of Substantial Completion or the length of the specified warranty, whichever is longer.
- C. Examine system components at a frequency consistent with reliable operation. Clean, adjust, and lubricate as required.
- D. Include systematic examination, adjustment, and lubrication of components. Repair or replace parts whenever required. Use parts produced by the manufacturer of the original component.
- E. Maintenance service shall not be assigned or transferred to any agent or subcontractor without prior written consent of the Owner.

END OF SECTION

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Adhesive-backed duct markers.

1.02 REFERENCE STANDARDS

- A. ASTM D709 - Standard Specification for Laminated Thermosetting Materials; 2017.

1.03 SUBMITTALS

- A. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- B. Manufacturer's Installation Instructions: Indicate special procedures, and installation.

PART 2 PRODUCTS

2.01 IDENTIFICATION APPLICATIONS

- A. Energy Recovery Units: Nameplates.
- B. Ductwork: Nameplates.
- C. Piping: Tags.

2.02 NAMEPLATES

- A. Manufacturers:
 - 1. Advanced Graphic Engraving, LLC: www.advancedgraphicengraving.com.
 - 2. Brimar Industries, Inc: www.pipemarker.com/#sle.
 - 3. Kolbi Pipe Marker Co: www.kolbipipemarkers.com.
 - 4. Seton Identification Products, a Tricor Direct Company: www.seton.com.
- B. Letter Color: White.
- C. Letter Height: 1/4 inch (6 mm).
- D. Background Color: Black.
- E. Plastic: Conform to ASTM D709.

2.03 TAGS

- A. Manufacturers:
 - 1. Advanced Graphic Engraving: www.advancedgraphicengraving.com.
 - 2. Brady Corporation: www.bradycorp.com.
 - 3. Brimar Industries, Inc: www.pipemarker.com/#sle.
 - 4. Kolbi Pipe Marker Co: www.kolbipipemarkers.com.
- B. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch (40 mm) diameter.
- C. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch (40 mm) diameter with smooth edges.

204 ADHESIVE-BACKED DUCT MARKERS

- A. Manufacturers:
 - 1. Brimar Industries, Inc: www.pipemarker.com/#sle.
- B. Material: High gloss acrylic adhesive-backed vinyl film 0.0032 inch (0.76 mm); printed with UV and chemical resistant inks.
- C. Style: Individual Label.
- D. Color: Yellow/Black.

PART 3 EXECUTION

301 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.

302 INSTALLATION

- A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Install plastic pipe markers in accordance with manufacturer's instructions.
- D. Use tags on piping 3/4 inch (20 mm) diameter and smaller.
- E. Install ductwork with plastic nameplates. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.

END OF SECTION

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Testing, adjustment, and balancing of air systems.
- B. Testing, adjustment, and balancing of refrigerating systems.
- C. Measurement of final operating condition of HVAC systems.

1.02 REFERENCE STANDARDS

- A. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems; 2008.
- B. NEBB (TAB) - Procedural Standards for Testing Adjusting and Balancing of Environmental Systems; 2015, with Errata (2017).
- C. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing; 2002.

1.03 SUBMITTALS

- A. Installer Qualifications: Submit name of adjusting and balancing agency and TAB supervisor for approval within 30 days after award of Contract.
- B. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
 - 1. Submit to Engineer.
 - 2. Include at least the following in the plan:
 - a. Preface: An explanation of the intended use of the control system.
 - b. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
 - c. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
 - d. Identification and types of measurement instruments to be used and their most recent calibration date.
 - e. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
 - f. Final test report forms to be used.
 - g. Detailed step-by-step procedures for TAB work for each system and issue, including:
 - 1) Terminal flow calibration (for each terminal type).
 - 2) Branch/submain proportioning.
 - 3) Total flow calculations.
 - 4) Rechecking.
 - 5) Diversity issues.

- h. Expected problems and solutions, etc.
 - i. Confirmation of understanding of the outside air ventilation criteria under all conditions.
 - j. Procedures for field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
 - k. Procedures for formal progress reports, including scope and frequency.
 - l. Procedures for formal deficiency reports, including scope, frequency and distribution.
- C. Control System Coordination Reports: Communicate in writing to the controls installer all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect, or could affect, the control system setup and operation.
- D. Progress Reports.
- E. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
- 1. Submit to the the Commissioning Authority and HVAC controls contractor within two weeks after completion of testing, adjusting, and balancing.
 - 2. Revise TAB plan to reflect actual procedures and submit as part of final report.
 - 3. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Engineer and for inclusion in operating and maintenance manuals.
 - 4. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
 - 5. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
 - 6. Units of Measure: Report data in I-P (inch-pound) units only.
 - 7. Include the following on the title page of each report:
 - a. Name of Testing, Adjusting, and Balancing Agency.
 - b. Address of Testing, Adjusting, and Balancing Agency.
 - c. Telephone number of Testing, Adjusting, and Balancing Agency.
 - d. Project name.
 - e. Project location.
 - f. Project Engineer.
 - g. Project Contractor.
 - h. Project altitude.
 - i. Report date.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

301 GENERAL REQUIREMENTS

- A. Perform total system balance in accordance with one of the following:
 - 1. NEBB Procedural Standards for Testing Adjusting Balancing of Environmental Systems.
 - 2. SMACNA (TAB).
 - 3. Maintain at least one copy of the standard to be used at project site at all times.
- B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.
- C. TAB Agency Qualifications:
 - 1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
 - 2. Having minimum of three years documented experience.
 - 3. Certified by one of the following:
 - a. AABC, Associated Air Balance Council: www.aabc.com; upon completion submit AABC National Performance Guaranty.
 - b. NEBB, National Environmental Balancing Bureau: www.nebb.org.
 - c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: www.tabbcertified.org.
- D. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

302 EXAMINATION

- A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
 - 1. Systems are started and operating in a safe and normal condition.
 - 2. Temperature control systems are installed complete and operable.
 - 3. Proper thermal overload protection is in place for electrical equipment.
 - 4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 - 5. Duct systems are clean of debris.
 - 6. Fans are rotating correctly.
 - 7. Air coil fins are cleaned and combed.
 - 8. Access doors are closed and duct end caps are in place.
 - 9. Air outlets are installed and connected.
 - 10. Duct system leakage is minimized.
- B. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.
- C. Beginning of work means acceptance of existing conditions.

303 ADJUSTMENT TOLERANCES

- A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.

304 RECORDING AND ADJUSTING

- A. Field Logs: Maintain written logs including:
 - 1. Running log of events and issues.
 - 2. Discrepancies, deficient or uncompleted work by others.
 - 3. Contract interpretation requests.
 - 4. Lists of completed tests.
- B. Ensure recorded data represents actual measured or observed conditions.
- C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- D. Mark on the drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.
- E. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
- G. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

305 AIR SYSTEM PROCEDURE

- A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.
- B. Measure air quantities at air inlets and outlets.
- C. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
- D. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- E. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- F. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

306 SCOPE

- A. Test, adjust, and balance the following:
 - 1. Energy Recovery Unit ERV-1
 - 2. Heat Pump Refrigerant Systems
 - 3. Air Terminal Units.

END OF SECTION

23 0713
DUCK INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Duct insulation.

1.02 RELATED REQUIREMENTS

- A. Section 23 0553 - Identification for HVAC Piping and Equipment.
- B. Section 23 3100 - HVAC Ducts and Casings:

1.03 REFERENCE STANDARDS

- A. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2017.
- B. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2013.
- C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2017.
- D. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials; 2016.
- E. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

202 GLASS FIBER, FLEXIBLE

- A. Manufacturer:
 - 1. Johns Manville: www.jm.com.
 - 2. Knauf Insulation; Atmosphere Duct Wrap: www.knaufinsulation.com/#sle.
 - 3. Owens Corning Corporation: www.ocbuildingspec.com.
 - 4. CertainTeed Corporation: www.certainteed.com.
- B. Insulation: ASTM C553; flexible, noncombustible blanket.
 - 1. 'K' ('Ksi') value: 0.36 at 75 degrees F (0.052 at 24 degrees C), when tested in accordance with ASTM C518.
 - 2. Maximum Service Temperature: 1200 degrees F (649 degrees C).
 - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
- C. Vapor Barrier Jacket:
 - 1. Kraft paper with glass fiber yarn and bonded to aluminized film.
 - 2. Moisture Vapor Permeability: 0.02 perm inch (0.029 ng/Pa s m), when tested in accordance with ASTM E96/E96M.
 - 3. Secure with pressure sensitive tape.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that ducts have been tested before applying insulation materials.
- B. Verify that surfaces are clean, foreign material removed, and dry.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Insulated ducts conveying air below ambient temperature:
 - 1. Provide insulation with vapor barrier jackets.
 - 2. Finish with tape and vapor barrier jacket.
 - 3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 - 4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- D. Ducts Exposed in Mechanical Equipment Rooms or Finished Spaces (below 10 feet above finished floor) ((below 3 meters above finished floor)): Finish with canvas jacket sized for finish painting.

3.03 SCHEDULES

- A. Exhaust Ducts Exposed to Outdoor Air: Refer to ASHRAE 90.1.
- B. Outside Air Intake Ducts: Refer to ASHRAE 90.1.
- C. Supply Ducts: Refer to ASHRAE 90.1.

END OF SECTION

HVAC PIPING INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Piping insulation.
- B. Engineered wall outlet seals and refrigerant piping insulation protection.

1.02 RELATED REQUIREMENTS

- A. Section 23 2300 - Refrigerant Piping: Placement of inserts.

1.03 REFERENCE STANDARDS

- A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus; 2013.
- B. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation; 2017.
- C. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel; 2008 (Reapproved 2013).
- D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2017.
- E. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials; 2016.
- F. ASTM E331 - Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference; 2000 (Reapproved 2016).
- G. ASTM E2178 - Standard Test Method for Air Permeance of Building Materials; 2013.
- H. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- B. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

1.06 FIELD CONDITIONS

- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 PRODUCTS

201 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

202 GLASS FIBER

- A. Manufacturers:
 - 1. CertainTeed Corporation: www.certainteed.com.
 - 2. Johns Manville Corporation: www.jm.com.
 - 3. Knauf Insulation; Earthwool 1000 Degree Pipe Insulation: www.knaufinsulation.com/#sle.
 - 4. Owens Corning Corporation; Fiberglas Pipe Insulation ASJ: www.ocbuildingspec.com/#sle.
- B. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible.
 - 1. 'K' ('Ksi') Value: ASTM C177, 0.24 at 75 degrees F (0.035 at 24 degrees C).
 - 2. Maximum Service Temperature: 850 degrees F (454 degrees C).
 - 3. Maximum Moisture Absorption: 0.2 percent by volume.
- C. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible, with wicking material to transport condensed water to the outside of the system for evaporation to the atmosphere.
 - 1. 'K' ('Ksi') Value: ASTM C177, 0.23 at 75 degrees F (0.034 at 24 degrees C).
 - 2. Maximum Service Temperature: 220 degrees F (104 degrees C).
 - 3. Maximum Moisture Absorption: 0.2 percent by volume.
- D. Insulation: ASTM C547 and ASTM C795; semi-rigid, noncombustible, end grain adhered to jacket.
 - 1. Maximum Service Temperature: 650 degrees F (343 degrees C).
 - 2. Maximum Moisture Absorption: 0.2 percent by volume.
- E. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches (0.029 ng/Pa s m).
- F. Tie Wire: 0.048 inch (1.22 mm) stainless steel with twisted ends on maximum 12 inch (300 mm) centers.
- G. Lagging: Utilized embossed aluminum at building exterior and PVC at interior.

203 ENGINEERED WALL OUTLET SEALS AND REFRIGERANT PIPING INSULATION PROTECTION

- A. Manufacturers:
 - 1. Airex Manufacturing, Inc: www.airexmfg.com/#sle.
- B. Basis of Design: Airex Manufacturing, Inc; www.airexmfg.com/#sle.
 - 1. Pipe Penetration Wall Seal: Airex Titan Outlet.
 - 2. Refrigeration Pipe Insulation Protection System: Airex E-Flex Guard.
 - 3. Pipe Penetration Wall Seal and Insulation Protection System: Airex Pro-System Kit.
- C. Pipe Penetration Wall Seal: Seals HVAC piping wall penetrations with compression gasket wall mounted rigid plastic outlet cover.
 - 1. Wall Outlet Size, Stucco and Masonry Applications: 7-1/2 inch wide by 10 inch high (190.5 mm wide by 254 mm high).
 - a. Elastomeric Sleeve Diameter: 1-11/16 inch (43 mm).

2. Outlet Cover Color: Gray.
 3. Water Penetration: Comply with ASTM E331.
 4. Air Permeance: Comply with ASTM E2178.
- D. Insulation Protection System: Refrigerant piping insulation PVC protective cover.
1. PVC Insulation Cover Color: Black with full-length velcro fastener.
 2. Flame Spread and Smoke Development Rating of 24/450: Comply with ASTM E84 or UL 723.

PART 3 EXECUTION

301 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Exposed Piping: Locate insulation and cover seams in least visible locations.
- D. Insulated pipes conveying fluids below ambient temperature; insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.
- E. Glass fiber insulated pipes conveying fluids below ambient temperature:
 1. Provide vapor barrier jackets, factory-applied or field-applied; secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.

2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor barrier adhesive or PVC fitting covers.
- F. Glass fiber insulated pipes conveying fluids above ambient temperature.
1. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
- G. Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping. Provide two coats of UV resistant finish for flexible elastomeric cellular insulation without jacketing.

302 SCHEDULE

- A. Cooling Systems:
1. Refrigerant Suction: Refer to IECC-2012.
 2. Refrigerant Hot Gas: Refer to IECC-2012.

END OF SECTION

REFRIGERANT PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Piping.
- B. Refrigerant.
- C. Moisture and liquid indicators.
- D. Valves.

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS

- A. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2013.
- B. ASME B31.5 - Refrigeration Piping and Heat Transfer Components; 2016.
- C. ASME B31.9 - Building Services Piping; 2014.
- D. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.
- E. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service; 2016.
- F. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2011 (Amended 2012).
- G. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2009.

1.04 SUBMITTALS

- A. Product Data: Provide general assembly of specialties, including manufacturers catalogue information. Provide manufacturers catalog data including load capacity.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum five years of documented experience.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store piping and specialties in shipping containers with labeling in place.
- B. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.
- C. Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 for installation of piping system.

202 PIPING

- A. Copper Tube: ASTM B280, H58 hard drawn or O60 soft annealed.
 - 1. Fittings: ASME B16.22 wrought copper.
 - 2. Joints: Braze, AWS A5.8M/A5.8 BCuP silver/phosphorus/copper alloy.
- B. Pipe Supports and Anchors:
 - 1. Provide hangers and supports that comply with MSS SP-58.
 - a. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
 - 2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch (13 to 38 mm): Malleable iron adjustable swivel, split ring.
 - 3. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 - 4. Wall Support for Pipe Sizes to 3 Inches (75 mm): Cast iron hook.
 - 5. Vertical Support: Steel riser clamp.
 - 6. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
 - 7. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
 - 8. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.
 - 9. Rooftop Supports for Low-Slope Roofs: Steel pedestals with bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified; and as follows:
 - a. Bases: High density, UV tolerant, polypropylene or reinforced PVC.
 - b. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
 - c. Steel Components: Stainless steel, or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
 - d. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.
 - e. Height: Provide minimum clearance of 6 inches (150 mm) under pipe to top of roofing.

203 REFRIGERANT

- A. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 50.

204 VALVES

- A. Ball Valves:
 - 1. Two piece bolted forged brass body with teflon ball seals and copper tube extensions, brass bonnet and seal cap, chrome plated ball, stem with neoprene ring stem seals; for maximum working pressure of 500 psi (3450 kPa) and maximum temperature of 300 degrees F (149 degrees C).

PART 3 EXECUTION

301 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

302 INSTALLATION

- A. Install refrigeration specialties in accordance with manufacturer's instructions.
- B. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.
- C. Install piping to conserve building space and avoid interference with use of space.
- D. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- E. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.5.
 - 2. Support horizontal piping as indicated.
 - 3. Install hangers to provide minimum 1/2 inch (13 mm) space between finished covering and adjacent work.
 - 4. Place hangers within 12 inches (300 mm) of each horizontal elbow.
 - 5. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - 6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 - 7. Provide copper plated hangers and supports for copper piping.
- F. Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow.
- G. Provide clearance for installation of insulation and access to valves and fittings.
- H. Provide factory furnished ball valves at each indoor unit for isolation and maintenance.
- I. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.
- J. Fully charge completed system with refrigerant after testing.

303 FIELD QUALITY CONTROL

- A. Test refrigeration system in accordance with ASME B31.5.

304 SCHEDULES

- A. Hanger Spacing for Copper Tubing.
 - 1. 1/2 inch (13 mm), 5/8 inch (16 mm), and 7/8 inch (22 mm) OD: Maximum span, 5 feet (1500 mm); minimum rod size, 1/4 inch (6.3 mm).
 - 2. 1-1/8 inch (29 mm) OD: Maximum span, 6 feet (1800 mm); minimum rod size, 1/4 inch (6.3 mm).
 - 3. 1-3/8 inch (35 mm) OD: Maximum span, 7 feet (2100 mm); minimum rod size, 3/8 inch (9.5 mm).
 - 4. 1-5/8 inch (41 mm) OD: Maximum span, 8 feet (2400 mm); minimum rod size, 3/8 inch (9.5 mm).

END OF SECTION

23 3100

HVAC DUCTS AND CASTINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Metal ductwork.
- B. Duct cleaning.

1.02 RELATED REQUIREMENTS

- A. Section 23 0593 - Testing, Adjusting, and Balancing for HVAC.
- B. Section 23 0713 - Duct Insulation: External insulation and duct liner.
- C. Section 23 3300 - Air Duct Accessories.

1.03 REFERENCE STANDARDS

- A. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2014.
- B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2017.
- C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2017.
- D. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2018.
- E. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2005 (Revised 2009).

1.04 SUBMITTALS

- A. Product Data: Provide data for duct materials.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience, and approved by manufacturer.
- B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum five years of documented experience.

1.06 FIELD CONDITIONS

- A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- B. Maintain temperatures within acceptable range during and after installation of duct sealants.

PART 2 PRODUCTS

201 DUCT ASSEMBLIES

- A. Regulatory Requirements: Construct ductwork to NFPA 90A standards.
- B. Ducts: Galvanized steel, unless otherwise indicated.
- C. Low Pressure Supply: 1/2 inch w.g. (125 Pa) pressure class, galvanized steel.
- D. Return and Relief: 1/2 inch w.g. (125 Pa) pressure class, galvanized steel.
- E. General Exhaust: 1/2 inch w.g. (125 Pa) pressure class, galvanized steel.

202 MATERIALS

- A. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G60/Z180 coating.
- B. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
 - 1. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
 - 2. Surface Burning Characteristics: Flame spread index of zero and smoke developed index of zero, when tested in accordance with ASTM E84.
- C. Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

203 DUCTWORK FABRICATION

- A. Fabricate and support in accordance with SMACNA (DCS) and as indicated.
- B. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- C. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide air foil turning vanes of perforated metal with glass fiber insulation.
- D. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- E. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.

204 MANUFACTURED DUCTWORK AND FITTINGS PART 3 EXECUTION

301 INSTALLATION

- A. Install, support, and seal ducts in accordance with SMACNA (DCS).
- B. Install in accordance with manufacturer's instructions.
- C. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- D. Flexible Ducts: Connect to metal ducts with adhesive.
- E. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- F. Locate ducts with sufficient space around equipment to allow normal

operating and maintenance activities.

G. Use double nuts and lock washers on threaded rod supports.

H. At exterior wall louvers, seal duct to louver frame and install blank-out panels.

302 CLEANING

A. Clean duct systems with high power vacuum machines. Protect equipment that could be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes.

END OF SECTION

23 3300
AIR DUCT ACCESSORIES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Air turning devices/extractors.
- B. Backdraft dampers - metal.
- C. Duct access doors.
- D. Duct test holes.
- E. Flexible duct connections.
- F. Volume control dampers.

1.02 RELATED REQUIREMENTS

- A. Section 23 3100 - HVAC Ducts and Casings.

1.03 REFERENCE STANDARDS

- A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2018.
- B. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations; 2017.
- C. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2005 (Revised 2009).

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Protect dampers from damage to operating linkages and blades.

PART 2 PRODUCTS

201 AIR TURNING DEVICES/EXTRACTORS

- A. Manufacturers:
 - 1. Carlisle HVAC Products; Dynair Hollow Vane and Rail (Double Wall Vane): www.carlislehvac.com/#sle.
 - 2. Krueger-HVAC, Division of Air System Components: www.krueger-hvac.com.
 - 3. Ruskin Company, a brand of Johnson Controls: www.ruskin.com.
 - 4. Titus HVAC, a brand of Johnson Controls: www.titus-hvac.com.
- B. Multi-blade device with radius blades attached to pivoting frame and bracket, steel construction, with push-pull operator strap.

202 BACKDRAFT DAMPERS - METAL

- A. Manufacturers:
 - 1. Louvers & Dampers, Inc, a brand of Mestek, Inc: www.louvers-dampers.com.
 - 2. Nailor Industries, Inc: www.nailor.com.

3. Ruskin Company, a brand of Johnson Controls: www.ruskin.com.
- B. Gravity Backdraft Dampers, Size 18 by 18 inches (450 by 450 mm) or Smaller, Furnished with Air Moving Equipment: Air moving equipment manufacturer's standard construction.

203 DUCT ACCESS DOORS

- A. Fabricate in accordance with SMACNA (DCS) and as indicated.

204 DUCT TEST HOLES

- A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

205 FLEXIBLE DUCT CONNECTIONS

- A. Manufacturers:
 1. Carlisle HVAC Products; Dynair Connector Plus G90 Steel Offset Seam Neoprene Fabric: www.carlislehvac.com/#sle.
 2. Elgen Manufacturing, Inc: www.elgenmfg.com.
- B. Fabricate in accordance with SMACNA (DCS) and as indicated.
- C. Flexible Duct Connections: Fabric crimped into metal edging strip.
 1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz per sq yd (1.0 kg/sq m).
 - a. Net Fabric Width: Approximately 2 inches (50 mm) wide.
 2. Metal: 3 inches (75 mm) wide, 24 gage, 0.0239 inch (0.61 mm) thick galvanized steel.
- D. Maximum Installed Length: 14 inch (356 mm).

PART 3 EXECUTION

301 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). Refer to Section 23 3100 for duct construction and pressure class.
- B. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- C. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide for cleaning kitchen exhaust ducts in accordance with NFPA 96. Provide minimum 8 by 8 inch (200 by 200 mm) size for hand access, size for shoulder access, and as indicated. Provide 4 by 4 inch (100 by 100 mm) for balancing dampers only. Review locations prior to fabrication.
- D. Provide duct test holes where indicated and required for testing and balancing purposes.
- E. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.

END OF SECTION

PACKAGED AIR-TOAIR ENERGY RECOVERY UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Energy recovery units.
- B. Vibration isolation.
- C. Power and controls.

1.02 REFERENCE STANDARDS

- A. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating; 2012.
- B. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating; 2015.
- C. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size; 2017.
- D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2017.
- E. NFPA 70 - National Electrical Code; 2017.
- F. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. Product Data: Manufacturer's installation instruction, product data, and engineering calculations.
- B. Shop Drawings: Show design and assembly of energy recovery unit and installation and connection details.
- C. Closeout Submittals: Submit manufacturer's operation and maintenance instructions.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 - 1. Firm regularly engaged in manufacturing energy recovery units.
 - 2. Products in satisfactory use in similar service for not less than five years.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Store in manufacturer's unopened packaging.
- B. Store products to be installed indoors in dry, heated area.

1.06 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Warranty ventilator to be free from defects in material and workmanship and of all parts for period of 1-1/2 years from date of Substantial Completion.

PART 2 PRODUCTS

201 MANUFACTURERS

- A. Energy Recovery Ventilators:
 - 1. Renewaire; www.renewaire.com.
 - 2. Substitutions are permitted.

202 APPLICATIONS

203 ENERGY RECOVERY UNITS

- A. Energy Recovery Units: Flax Plate type; prefabricated packaged system designed by manufacturer.
 - 1. Access: Hinged and/or screwed access panels on front.
 - 2. Lifting holes at the unit base.

 - 3. Framing: Welded extruded aluminum tubular frame capable of supporting components and casings.

204 CASING

- A. Wall, Floor, and Roof Panels:
 - 1. Construction: 1 inch (25 mm) thick, double wall box construction, with formed edges of exterior wall overlapping formed edges of interior wall.
 - 2. Exterior Wall: Galvanized steel sheet.
 - a. 0.040 inch (1 mm) thick aluminum.
 - 3. Interior Wall: Galvanized sheet metal.
 - a. 22 gage, 0.0299 inch (0.76 mm) galvanized sheet metal.
 - 4. Insulation:
 - a. 1/2 inch (13 mm) insulated fiberglass.
 - b. Panel Cores: Mineral wool board.
 - c. Flame Spread Index (FSI): 25 or less, when tested in accordance with ASTM E84 or UL 723.
 - d. Smoke Developed Index (SDI): 50, maximum, when tested in accordance with ASTM E84 or UL 723.
 - 5. Roof Panel: Weatherproof.
 - 6. Coating: Polyurethane enamel.
- B. Access Panels: Provide access to components through a large, tightly sealed and easily removable panel.
- C. Doors:
 - 1. Construct doors of same construction and thickness as wall panels.
 - 2. Height: 80 inches (2032 mm).

205 FANS

- A. Provide separate fans for exhaust and supply blowers.
- B. Fans:
 - 1. Individually driven with a dedicated motor.
- C. Housings: 12 gage, 0.1046 inch (2.66 mm) aluminized steel with plenums integral to general housing and constructed to Class 1 fan standards.

- D. Motors:
 - 1. Motors: Open drip proof.
 - 2. Efficiency: High.
 - 3. Speed: Single.
 - 4. Control: Variable Frequency Drive.
 - 5. Fan Motor: UL listed and labeled.
- E. Drives:
 - 1. Fans: Belt driven.
 - 2. Horsepower: 7.5 HP (5.2 kW).
 - 3. Service Factor: 1.2.

206 FILTERS

- A. Exhaust and Fresh Air Streams: MERV 8 filters constructed to meet ASHRAE Std52.2.

207 DAMPERS

- A. Exhaust Back-Draft Damper: Factory installed, galvanized steel.
 - 1. High performance, backdraft dampers suitable for application in HVAC systems with velocities to 3000 feet per minute (914 m/min).
 - 2. Louvers, Dampers, and Shutters: AMCA 500-D and AMCA 500-L.
 - 3. Damper Capacity: Demonstrate damper capacity to withstand HVAC system operating conditions.
 - 4. Fabrication:
 - a. Frame: 20 gage, 0.0359 inch (0.91 mm), 3 inch (76 mm) roll formed galvanized steel channel with rear flange, pre-punched mounting holes, and welded corner clips for maximum rigidity.
 - b. Blades:
 - 1) Style: Single-piece, overlap frame.
 - 2) Material: Roll formed 28 gage, 0.0149 inch (0.38 mm) galvanized steel.
 - 3) Width: Maximum 6 inches (152 mm).
- B. Motorized Dampers: Provide motorized dampers at outside air inlet, and exhaust air outlet.
 - 1. Type: Motorized two position parallel blade damper with blade seals.
 - 2. Motorized Damper: Roll-formed structural hat channels, reinforced at the corners,
 - 3. Blades: Single skin, 16 gage, 0.0598 inch (1.52 mm).

208 VIBRATION ISOLATION

- A. Vibration Isolation: Provide whole unit vibration isolation with the energy recovery unit assembly.

209 POWER AND CONTROLS

- A. Motor Control Panels: UL listed.
- B. Include necessary motor starters, fuses, transformers and overload protection according to NFPA 70.
- C. Provide single-point field connection to power supply.
- D. Install wiring in accordance with NFPA 70.
- E. Provide factory mounted VFDs for supply fan and exhaust fan motors.

PART 3 EXECUTION

301 EXAMINATION

- A. Verify that structure is ready for installation of unit, that openings in deck for ductwork, if required, are correctly sized and located, and that mechanical and electrical utilities supplying unit are of correct capacities and are accessible.

302 INSTALLATION

303 SYSTEM STARTUP

- A. Provide services of manufacturer's authorized representative to provide start up of unit. Provide start up report to Owner for record.

END OF SECTION

SMALL SPLIT-SYSTEM HEATING AND COOLING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Air-source heat pumps.
- B. Air cooled condensing units.
- C. Indoor ductless fan & coil units.
- D. Controls.

1.02 REFERENCE STANDARDS

- A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; 2008, Including All Addenda.
- B. AHRI 520 - Performance Rating of Positive Displacement Condensing Units; 2004.
- C. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2013.
- D. ASHRAE Std 23.1 - Methods of Testing for Rating the Performance of Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Temperatures of the Refrigerant; 2010.
- E. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2018.
- F. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems; 2018.
- G. UL 207 - Standard for Refrigerant-Containing Components and Accessories, Nonelectrical; Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.
- B. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.
- C. Design Data: Indicate refrigerant pipe sizing.
- D. Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.
- E. Warranty: Submit manufacturers warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.
- F. Project Record Documents: Record actual locations of components and connections.

1.04 QUALITY ASSURANCE

- A. Installer Qualifications: Company specializing in performing the work of this section with minimum 5 years of experience and approved by manufacturer. Contractor must also be listed as a participating installer in the Massachusetts Clean Energy Center Air-Source Heat Pump and Variable Refrigerant Flow program.

1.05 WARRANTY

- A. Provide three year manufacturers warranty for solid state ignition modules.
- B. Provide five year manufacturers warranty for heat exchangers.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Mitsubishi.
- B. Substitutions are permitted.

2.02 SYSTEM DESIGN

- A. Split-System Heating and Cooling Units: Self-contained, packaged, matched factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.
 - 1. Heating and Cooling: Air-source electric heat pump located in outdoor unit with evaporator; auxiliary electric heat.
 - 2. Provide refrigerant lines internal to units and between indoor and outdoor units, factory cleaned, dried, pressurized and sealed, with insulated suction line.
- B. Performance Requirements: See Drawings for additional requirements.

2.03 INDOOR UNITS FOR DUCTLESS SYSTEMS

- A. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, evaporator coil, and controls; wired for single power connection with control transformer.
 - 1. Location: High-wall.
 - 2. Cabinet: Galvanized steel.
 - a. Finish: White.
 - 3. Fan: Line-flow fan direct driven by a single motor.
 - 4. Filter return air with washable, antioxidant pre-filter and a pleated anti-allergy enzyme filter.
- B. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
 - 1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207.
 - 2. Manufacturer: System manufacturer.
- C. Remote Actuators:

2.04 OUTDOOR UNITS

- A. Outdoor Units: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser.
 - 1. Comply with AHRI 210/240.
 - 2. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 50.
 - 3. Refrigerant: R-410A.
 - 4. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
 - 5. Construction and Ratings: In accordance with AHRI 210/240 with testing in

accordance with ASHRAE Std 23.1 and UL 207.

- B. Air Cooled Condenser: Aluminum fin and copper tube coil, AHRI 520 with direct drive axial propeller fan resiliently mounted, galvanized fan guard.
- C. Coil: Air-cooled, aluminum fins bonded to copper tubes.
- D. Accessories: Filter drier, high pressure switch (manual reset), low pressure switch (automatic reset), service valves and gage ports, thermometer well (in liquid line).
 - 1. Provide thermostatic expansion valves.
- E. Operating Controls:
 - 1. Control by room thermostat to maintain room temperature setting.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that substrates are ready for installation of units and openings are as indicated on shop drawings.
- B. Verify that proper power supply is available and in correct location.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions and requirements of local authorities having jurisdiction.
- B. Install in accordance with NFPA 90A and NFPA 90B.
- C. Install refrigeration systems in accordance with ASHRAE Std 15.
- D. System start-up shall be performed by a Mitsubishi factory trained technician. Provide start-up report to Owner for Record

3.03 SYSTEM STARTUP

- A. System start-up shall be performed by a Mitsubishi factory trained technician. Provide start-up report to Owner for Record

END OF SECTION

VARIABLE REFRIGERANT VOLUME (VRV) HVAC SYSTEM**PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Variable refrigerant volume HVAC system includes:
 - 1. Outdoor/condensing unit(s).
 - 2. Indoor/evaporator units.
 - 3. Branch selector units.
 - 4. Refrigerant piping.
 - 5. Control panels.
 - 6. Control wiring.

1.02 REFERENCE STANDARDS

- A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; 2008, Including All Addenda.
- B. ASCE 7 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures; 2016.
- C. ASHRAE (FUND) - ASHRAE Handbook - Fundamentals; 2017.
- D. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; 2013, Including All Amendments and Errata.
- E. ITS (DIR) - Directory of Listed Products; current edition.
- F. NFPA 70 - National Electrical Code; 2017.
- G. UL 1995 - Heating and Cooling Equipment; Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Submit manufacturer's standard data sheets showing the following for each item of equipment, marked to correlate to equipment item markings shown in the contract documents:
 - 1. Outdoor/Central Units:
 - a. Refrigerant Type and Size of Charge.
 - b. Cooling Capacity: Btu/h (W).
 - c. Heating Capacity: Btu/h (W).
 - d. Cooling Input Power: Btu/h (kW).
 - e. Heating Input Power: Btu/h (kW).
 - f. Operating Temperature Range, Cooling and Heating.
 - g. Air Flow: Cubic feet per minute (Cubic meters per second).
 - h. Fan Curves.
 - i. External Static Pressure (ESP): Inches WG (Pa).
 - j. Sound Pressure Level: dB(A).
 - k. Electrical Data:
 - 1) Maximum Circuit Amps (MCA).
 - 2) Maximum Fuse Amps (MFA).
 - 3) Maximum Starting Current (MSC).

- 4) Full Load Amps (FLA).
- 5) Total Over Current Amps (TOCA).
- 6) Fan Motor: HP (W).
- l. Weight and Dimensions.
- m. Maximum number of indoor units that can be served.
- n. Maximum refrigerant piping run from outdoor/condenser unit to indoor/evaporator unit.
- o. Maximum height difference between outdoor/condenser unit to indoor/evaporator unit, both above and below.
- p. Control Options.
- 2. Indoor/Evaporator Units:
 - a. Cooling Capacity: Btu/h (W).
 - b. Heating Capacity: Btu/h (W).
 - c. Cooling Input Power: Btu/h (kW).
 - d. Heating Input Power: Btu/h (kW).
 - e. Air Flow: Cubic feet per minute (Cubic meters per second).
 - f. Fan Curves.
 - g. External Static Pressure (ESP): Inches WG (Pa).
 - h. Sound Pressure level: dB(A).
 - i. Electrical Data:
 - 1) Maximum Circuit Amps (MCA).
 - 2) Maximum Fuse Amps (MFA).
 - 3) Maximum Starting Current (MSC).
 - 4) Full Load Amps (FLA).
 - 5) Total Over Current Amps (TOCA).
 - 6) Fan Motor: HP (W).
 - j. Maximum Lift of Built-in Condensate Pump.
 - k. Weight and Dimensions.
 - l. Control Options.
- 3. Control Panels: Complete description of options, control points, zones/groups.
- C. Shop Drawings: Installation drawings custom-made for this project; include as-designed HVAC layouts, locations of equipment items, refrigerant piping sizes and locations, condensate piping sizes and locations, remote sensing devices, control components, electrical connections, control wiring connections. Include:
 - 1. Detailed piping diagrams, with branch balancing devices.
 - 2. Condensate piping routing, size, and pump connections.
 - 3. Detailed power wiring diagrams.
 - 4. Detailed control wiring diagrams.
 - 5. Locations of required access through fixed construction.
 - 6. Drawings required by manufacturer.
- D. Design Data:
 - 1. Provide design calculations showing that system will achieve performance specified.
 - 2. Provide design data required by ASHRAE Std 90.1 I-P.

- E. Warranty: Executed warranty, made out in Owner's name.
- F. Project Record Documents: Record the following:
 - 1. As-installed routing of refrigerant piping and condensate piping.
 - 2. Locations of access panels.
 - 3. Locations of control panels.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 - 1. Company that has been manufacturing variable refrigerant volume heat pump equipment for at least 5 years.
- B. Installer Qualifications: Trained and approved by manufacturer of equipment. Contractor must also be listed as a participating installer in the Massachusetts Clean Energy Center Air-Source Heat Pump and Variable Refrigerant Flow program.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, and handle equipment and refrigerant piping according to manufacturer's recommendations.

1.06 WARRANTY

- A. Compressors: Provide manufacturer's warranty for six (6) years from date of installation. During the stated period, should any part fail due to defects in material and workmanship, it shall be repaired or replaced at the discretion of Daikin AC (Americas), Inc. according to Daikin's terms and conditions. All warranty service work shall be performed by a Daikin factory trained service professional.

PART 2 PRODUCTS

201 MANUFACTURERS

- A. Basis of Design: The system design shown in the contract documents is based on equipment and system designed by Mitsubishi Electric.
- B. Systems designed and manufactured by other manufacturers will be considered by Owner.

202 HVAC SYSTEM DESIGN

- A. System Operation: Heating and cooling, simultaneously.
 - 1. Zoning: Provide capability for temperature control for each individual indoor/evaporator unit independently of all other units.
 - 2. Zoning: Provide heating/cooling selection for each individual indoor/evaporator unit independently of all other units.
 - 3. Provide a complete functional system that achieves the specified performance based on the specified design conditions and that is designed and constructed according to the equipment manufacturer's requirements.
 - 4. Conditioned spaces are shown on the drawings.
 - 5. Outdoor/Condenser unit locations are shown on the drawings.
 - 6. Indoor/Evaporator unit locations are shown on the drawings.
 - 7. Branch selector unit locations are not shown on the drawings.
 - 8. Refrigerant piping sizes are not shown on the drawings.
 - 9. Connect equipment to condensate piping provided by others; condensate piping is not shown on the drawings.

- B. Cooling Mode Interior Performance:
 1. Daytime Setpoint: 72 degrees F (22 degrees C), plus or minus 2 degrees F (1 degrees C).
 2. Setpoint Range: 57 degrees F (14 degrees C) to 77 degrees F (25 degrees C).
 3. Night Setback: 78 degrees F (25 degrees C).
 4. Interior Relative Humidity: 20 percent, maximum.
- C. Heating Mode Interior Performance:
 1. Daytime Setpoint: 68 degrees F (20 degrees C), plus or minus 2 degrees F (1 degrees C).
 2. Setpoint Range: 59 degrees F (15 degrees C) to 80 degrees F (27 degrees C).
 3. Night Setback: 60 degrees F (15 degrees C).
 4. Interior Relative Humidity: 10 percent, minimum.
- D. Outside Air Design Conditions:
 1. Summer Outside Air Design Temperature: 0.4 percent cooling design condition listed in ASHRAE Fundamentals Handbook - ASHRAE (FUND).
 2. Winter Outside Air Design Temperature: 99.6 percent heating design condition listed in ASHRAE Fundamentals Handbook - ASHRAE (FUND).
- E. Energy Design Wind Speed: 25 mph (40 km/h).
- F. Operating Temperature Ranges:
 1. Cooling Mode Operating Range: 23 degrees F (minus 5 degrees C) to 110 degrees F (43 degrees C) dry bulb.
 2. Heating Mode Operating Range: -13 degrees F (-25 degrees C) to 77 degrees F (25 degrees C) dry bulb; -13 degrees F (-25 degrees C) to 60 degrees F (16 degrees C) wet bulb; without low ambient controls or auxiliary heat source.
- G. Controls: Provide the following control interfaces:
 1. For Each Indoor/Evaporator Unit: One wall-mounted wired "local" controller, with temperature sensor; locate where directed, in each space.
 2. One central remote control panel for entire system; locate where directed.
- H. Local Controllers: Wall-mounted, wired, containing temperature sensor.
- I. Remote Temperature Sensors: In addition to temperature sensors integral with indoor/evaporator units, provide wall-mounted, wired remote temperature sensors located in the same room for the following:
 1. In-ceiling mounted units.
 2. On-ceiling mounted units.
 3. Wall mounted units mounted up high.
 4. Air handling units.
 5. Concealed console units.

203 EQUIPMENT

- A. All Units: Factory assembled, wired, and piped and factory tested for function and safety.
 1. Refrigerant: R-410A.
 2. Performance Certification: AHRI Certified; www.ahrinet.org.
 3. Safety Certification: Tested to UL 1995 by UL or Intertek-ETL, listed in ITS (DIR), and bearing the certification label.

4. Provide outdoor/condensing units capable of serving indoor unit capacity up to 200 percent of the capacity of the outdoor/condensing unit.
 5. Provide units capable of serving the zones indicated.
 6. Energy Efficiency: Report EER and COP based on tests conducted at “full load” in accordance with AHRI 210/240 or alternate test method approved by U.S. Department of Energy.
 7. Outdoor Units: Units and their supports designed and installed to resist wind pressures defined in ASCE 7.
- B. Electrical Characteristics:
1. Power - Condensing Units: 208 to 230 Volts, 3-phase, 60 Hz.
 2. Power - Branch Selector Units: 208 to 230 Volts, single phase, 60 Hz.
 3. Power - Indoor Units: 208 to 230 Volts, single phase, 60 Hz.
- C. System Controls:
1. Include self diagnostic, auto-check functions to detect malfunctions and display the type and location.
- D. Unit Controls: As required to perform input functions necessary to operate system; provided by manufacturer of units.
- E. Wiring:
1. Control Wiring: 18 AWG, 2-conductor, non-shielded, non-polarized, stranded cable.
 2. Control Wiring Configuration: Daisy chain.
- F. Refrigerant Piping:
1. Provide three-pipe refrigerant system, including high/low pressure dedicated hot gas, liquid and suction lines; two-pipe systems utilizing lower temperature mixed liquid/gas refrigerant to perform heat recovery are not permitted due to reduced heating capabilities.
 2. Refrigerant Flow Balancing: Provide refrigerant piping joints and headers specifically designed to ensure proper refrigerant balance and flow for optimum system capacity and performance; T-style joints are prohibited.
 3. Insulate each refrigerant line individually between the condensing and indoor units.

204 OUTDOOR/CONDENSING UNITS

- A. Outdoor/Condensing Units: Air-cooled DX refrigeration units, designed specifically for use with indoor/evaporator units; factory assembled and wired with all necessary electronic and refrigerant controls; modular design for ganging multiple units.
1. Refrigeration Circuit: Scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports and refrigerant regulator.
 2. Refrigerant: Factory charged.
 3. Variable Volume Control: Modulate compressor capacity automatically to maintain constant suction and condensing pressures while varying refrigerant volume to suit heating/cooling loads.
 4. Capable of being installed with wiring and piping to the left, right, rear or bottom.

5. Capable of heating operation at low end of operating range as specified, without additional low ambient controls or auxiliary heat source; during heating operation, reverse cycle (cooling mode) oil return or defrost is not permitted, due to potential reduction in space temperature.
 6. Sound Pressure Level: As specified, measured at 3 feet (one meter) from front of unit; provide night setback sound control as a standard feature; three selectable sound level steps of 55 dB, 50 dB, and 45 dB, maximum.
 7. Power Failure Mode: Automatically restart operation after power failure without loss of programmed settings.
 8. Safety Devices: High pressure sensor and switch, low pressure sensor/switch, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
 9. Provide refrigerant sub-cooling to ensure the liquid refrigerant does not flash when supplying to us indoor units.
 10. Oil Recovery Cycle: Automatic, occurring 2 hours after start of operation and then every 8 hours of operation; maintain continuous heating during oil return operation.
 11. Controls: Provide contacts for electrical demand shedding.
- B. Unit Cabinet: Weatherproof and corrosion resistant; rust-proofed mild steel panels coated with baked enamel finish.
1. Designed to allow side-by-side installation with minimum spacing.
- C. Fans: One or more direct-drive propeller type, vertical discharge, with multiple speed operation via DC (digitally commutating) inverter.
1. External Static Pressure: Factory set at 0.12 in WG (30 Pa), minimum.
 2. Indoor Mounted Air-Cooled Units: External static pressure field set at 0.32 in WG (80 Pa), minimum; provide for mounting of field-installed ducts.
 3. Fan Airflow: As indicated for specific equipment.
 4. Fan Motors: Factory installed; permanently lubricated bearings; inherent protection; fan guard; output as indicated for specific equipment.
- D. Condenser Coils: Copper tubes expanded into aluminum fins to form mechanical bond; waffle louver fin and rifled bore tube design to ensure high efficiency performance.
- E. Compressors: Scroll type, hermetically sealed, variable speed inverter-driven and fixed speed in combination to suit total capacity; minimum of one variable speed, inverter driven compressor per condenser unit; minimum of two compressors per condenser unit; capable of controlling capacity within range of 6 percent to 100 percent of total capacity.
1. Multiple Condenser Modules: Balance total operation hours of compressors by means of duty cycling function, providing for sequential starting of each module at each start/stop cycle, completion of oil return, and completion of defrost, or every 8 hours.
 2. Failure Mode: In the event of compressor failure, operate remaining compressor(s) at proportionally reduced capacity; provide microprocessor and associated controls specifically designed to address this condition.

3. Inverter Driven Compressors: PVM inverter driven, highly efficient reluctance DC (digitally commutating), hermetically sealed scroll “G2-type” with maximum speed of 7,980 rpm.
4. Provide each compressor with crankcase heater, high pressure safety switch, and internal thermal overload protector.
5. Provide oil separators and intelligent oil management system.
6. Provide spring mounted vibration isolators.

205 BRANCH SELECTOR UNITS

- A. Branch Selector Units: Concealed boxes designed specifically for this type of system to control heating/cooling mode selection of downstream units; consisting of electronic expansion valves, subcooling heat exchanger, refrigerant control piping and electronics to facilitate communications between unit and main processor and between branch unit and indoor/evaporator units.
 1. Control direction of refrigerant flow using electronic expansion valves; use of solenoid valves for changeover and pressure equalization is not permitted due to refrigerant noise; use of multi-port branch selector boxes is not permitted unless spare ports are provided for redundancy.
 2. Provide one electronic expansion valve for each downstream unit served, except multiple indoor/evaporator units may be connected, provided balancing joints are used in downstream piping and total capacity is within capacity range of the branch selector.
 3. When branch unit is simultaneously heating and cooling, energize subcooling heat exchanger.
 4. Casing: Galvanized steel sheet; with flame and heat resistant foamed polyethylene sound and thermal insulation.
 5. Refrigerant Connections: Braze type.
 6. Condensate Drainage: Provide unit that does not require condensate drainage.

206 INDOOR/EVAPORATOR UNITS

- A. All Indoor/Evaporator Units: Factory assembled and tested DX fan-coil units, with electronic proportional expansion valve, control circuit board, factory wiring and piping, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
 1. Refrigerant: Refrigerant circuits factory-charged with dehydrated air, for field charging.
 2. Temperature Control Mechanism: Return air thermistor and computerized Proportional-Integral-Derivative (PID) control of superheat.
 3. Coils: Direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond; waffle louver fin and high heat exchange, rifled bore tube design; factory tested.
 - a. Provide thermistor on liquid and gas lines.
 4. Fans: Direct-drive, with statically and dynamically balanced impellers; high and low speeds unless otherwise indicated; motor thermally protected.
 5. Return Air Filter: Washable long-life net filter with mildew proof resin, unless otherwise indicated.
 6. Condensate Drainage: Built-in condensate drain pan with PVC drain connection.

7. Cabinet Insulation: Sound absorbing foamed polystyrene and polyethylene insulation.
- B. Recessed Ceiling Units - 3 FT by 3 FT: Four-way airflow cassette with central return air grille, for installation in a fixed ceiling.
1. Face Size: 33 inches (939 mm) square, nominal.
 2. Cabinet Height: Maximum of 10 inches (250 mm) above face of ceiling.
 3. Exposed Housing: White, impact resistant, with washable decoration panel.
 4. Supply Airflow Adjustment:
 - a. Via motorized louvers which can be horizontally and vertically adjusted from 0 to 90 degrees.
 - b. Field-modifiable to 3-way and 2-way airflow.
 - c. Three auto-swing positions, including standard, draft prevention and ceiling stain prevention.
 5. Return Air Filter: Manufacturer's standard.
 6. Minimum Capacity: As indicated on the drawings.
 7. Sound Pressure Range: Between 28 dB(A) to 33 dB(A) at low speed measured at 5 feet (1.5 m) below the unit.
 8. Fan: Direct-drive turbo type, with motor output range of 0.06 to 0.12 HP (45 to 90 W).
 9. Condensate Pump: Built-in, with lift of 21 inches (533 mm), minimum.
 10. Provide side-mounted supply air branch duct connection.
 11. Provide side-mounted fresh air intake duct connection.
- C. Recessed Ceiling Units - 2 FT by 2 FT: Four-way airflow cassette with central return air grille, sized for installation in standard 24 by 24 inch (610 by 610 mm) lay-in ceiling grid.
1. Cabinet Height: Maximum of 12 inches (305 mm) above face of ceiling.
 2. Exposed Housing: White, impact resistant, with washable decoration panel.
 3. Maintenance Access: All electrical components accessible through decoration panel.
 4. Supply Airflow Adjustment:
 - a. Via motorized louvers which can be horizontally and vertically adjusted from 0 to 90 degrees.
 - b. Field-modifiable to 3-way and 2-way airflow.
 - c. Three auto-swing positions, including standard, draft prevention and ceiling stain prevention.
 5. Sound Pressure: Measured at low speed at 5 feet (1.5 m) below unit.
 6. Fan: Direct-drive turbo type.
 7. Condensate Pump: Built-in, with lift of 21 inches (533 mm), minimum.
 8. Provide side-mounted supply air branch duct connection.
 9. Provide side-mounted fresh air intake duct connection.
- D. Concealed-In-Ceiling Units: Ducted horizontal discharge and return; galvanized steel cabinet.
1. Return Air Filter: Manufacturer's standard.
 2. Sound Pressure: Measured at low speed at 5 feet (1.5 m) below unit.
 3. Provide external static pressure switch adjustable for high efficiency filter operation
 4. Condensate Pump: Built-in, with lift of 9 inches (229 mm), minimum.
 5. Switch box accessible from side or bottom.

- E. Wall Surface-Mounted Units: Finished white casing, with removable front grille; foamed polystyrene and polyethylene sound insulation; wall mounting plate; polystyrene condensate drain pan.
 - 1. Airflow Control: Auto-swing louver that closes automatically when unit stops; five (5) steps of discharge angle, set using remote controller; upon restart, discharge angle defaulting to same angle as previous operation.
 - 2. Sound Pressure Range: Measured at low speed at 3.3 feet (1 m) below and away from unit.
 - 3. Condensate Pump: Built-in, concealed.
 - 4. Condensate Drain Connection: Back, with piping concealed in wall.
 - 5. Fan: Direct-drive cross-flow type.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that required electrical services have been installed and are in the proper locations prior to starting installation.
- B. Verify that condensate piping has been installed and is in the proper location prior to starting installation.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install refrigerant piping in accordance with equipment manufacturer's instructions.
- C. Perform wiring in accordance with NFPA 70, National Electric Code (NEC).
- D. Coordinate with installers of systems and equipment connecting to this system.

3.03 SYSTEM STARTUP

- A. Provide manufacturer's field representative to perform system startup.
- B. Prepare and start equipment and system in accordance with manufacturer's instructions and recommendations.
- C. Adjust equipment for proper operation within manufacturer's published tolerances.

3.04 CLEANING

- A. Clean exposed components of dirt, finger marks, and other disfigurements.

3.05 CLOSEOUT ACTIVITIES

- A. Demonstrate proper operation of equipment to Owner's designated representative.
- B. Demonstration: Demonstrate operation of system to Owner's personnel.
 - 1. Use operation and maintenance data as reference during demonstration.
 - 2. Conduct walking tour of project.
 - 3. Briefly describe function, operation, and maintenance of each component.
- C. Training: Train Owner's personnel on operation and maintenance of system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.

306 PROTECTION

- A. Protect installed components from subsequent construction operations.
- B. Replace exposed components broken or otherwise damaged beyond repair.

END OF SECTION

ELECTRICAL PERFORMANCE DESIGN/BUILD SPECIFICATIONS

Project: **Town of Greenfield
Green River Elementary School
62 Meridian Street
Greenfield, MA 01301**

Date: **June 7, 2018**

Job #: **JE-3203**

Prepared by: **Johnson Engineering and Design, Inc.
5 Elm Street, Suite 14
Danvers, MA 01923
(978) 646-9001**

**Eric D. Johnson
Electrical Engineer
MA Engineering License No. 32641**

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SECTION 26 00 00 – ELECTRICAL

PART 1 - GENERAL

1.01 GENERAL PROVISIONS

- A. These performance specifications identify the major elements of the electrical system which shall be designed and constructed by the electrical sub-contractor. The electrical sub- contractor shall provide to the mechanical/general contractor a written turnkey proposal which shall include the following:
1. Electrical engineering services for a complete set of stamped electrical drawings prepared by the State of Massachusetts registered professional engineer.
 2. Purchase of all materials
 3. Installation labor
 4. Supervision labor
 5. Warranty Services and Maintenance
 6. Testing

Any modifications or deviations from the base requirements in the Request for Proposal (RFP) must be disclosed and be provided in a detailed description in the written proposal.

1.02 WORK INCLUDED

- A. The scope of the design work shall include providing complete electrical design drawings which describe all requirements to provide a new upgraded 120/208 volt, 3 phase, 4 wire system to serve the existing building and new HVAC system. Drawings shall include, but not be limited to , an electrical site plan, legend, specifications, power plans, panel schedules, one-line diagram, grounding system and all required power feeders and branch circuit wiring to new HVAC system. Drawings shall be coordinated with Eversource requirements. Preparation of stamped electrical drawings and all costs associated with obtaining an electrical permit shall be included in the Electrical Sub-contractors Turnkey Proposal. Engineer of record shall provide fault current calculations and properly state adequate short circuit rating of all panelboards and circuit breakers.
- B. The engineer of record shall calculate the added load to the building, fill out and submit the Eversource Work Order form. Coordinate fully with Eversource, including site meetings, scheduling of work, power outages and all other coordination details to enable the installation of a new upgraded electrical service. Eversource charges shall be paid separately by the Town of Greenfield, School Department, and shall not be included in the Turnkey Electrical Sub-contract proposal.

- C. The scope of the installation work consists of the installation of all materials to be furnished under this Section, and without limiting the generality thereof, includes all materials, equipment, hoisting, rigging, staging, labor and services required for furnishing, delivering, and installing all items of work hereinafter, and all items incidental thereto, as specified herein and as shown on the drawings under the base bid, except where there is specific reference of exclusion and incorporation in other quotations.
- D. The scope of work shall also include the complete removal and disconnection of all existing electrical components, as required. All demolition, disposal, cutting and patching, and cost incidental to the Scope of Service proposed shall be included in the Electrical Sub- contractors Turnkey Proposal.
- E. Electrical work shall include, but not be limited to, the following systems:
 - 1. Miscellaneous materials to ensure complete installation
 - 2. Wireways and pullboxes
 - 3. Raceway systems
 - 4. Wire and cable systems
 - 5. Wiring devices and device plates and outlet boxes
 - 6. Temporary light and power
 - 7. New Electrical service
 - 8. Provisions for utility company current transformers
 - 9. Meter sockets
 - 10. Main distribution panelboard
 - 11. Panelboards
 - 12. Nameplates
 - 13. Wiring of all new HVAC equipment
 - 14. Disconnect switches
 - 15. All cutting, patching and painting
 - 16. All grounding required by the National Electrical Code
 - 17. Excavation, backfill and resurfacing required for underground electrical systems.
 - 18. Concrete work required for electrical systems to include poured-in-place concrete for transformer pad and underground conduit.
 - 19. Fire rated plywood backboards shall be installed for all new panelboards
 - 20. All required coordination with Eversource.
 - 21. Fire detection and alarm system devices, as required by code, such as duct smoke detectors, reprogramming and testing.
 - 22. Operating and maintenance manuals
 - 23. Provide record drawings at completion of project.
 - 24. Final testing to ensure all electrical work is in good operating condition.

- E. The electrical sub-contractor shall be required to carry and provide a Certificate of Insurance that evidences sub-contractor compliance with the insurance requirements set forth by the Owner.
- F. All trade labor shall be paid at the Prevailing Wage Rates published as part of the RFP documents.
- G. The cost of shipping all materials and equipment to the facility must be included in the electrical sub-contractors cost.

1.03 RELATED WORK

- A. The following work is not included in this Section and shall be furnished and installed by others:
 - 1. All temperature control wiring shall be furnished and installed by the HVAC Contractor.
 - 2. Shutdown wiring from the auxiliary contacts on duct smoke detectors to the associated motor controller shall be provided by the Mechanical Contractor.
 - 3. Duct smoke detectors shall be supplied by the Electrical Contractor for installation by the Mechanical Contractor.

1.04 ALTERNATES

- A. The Turnkey Electrical proposal shall contain a separate line item price for work as described under Alternate No. 1. Alternate No. 1 work shall include price to remove the classroom four (4) circuit panels, associated feeders, and convert the panelboards to splice boxes. Extension of four (4) existing circuits from each classroom panel to a corridor panel shall also be included. Reference electrical drawings for additional work required under Alternate No. 1.
- B. The Turnkey Electrical proposal shall contain a separate line item deduct price for deleted work as described under Alternate No. 2. Alternate No. 2 work is to reduce the size of the main electrical service from 800 amps to 600 amps. The main distribution panel MDP shall be reduced from 800A main breaker and bus to 600A main breaker and bus. In addition, the two (2) 125A, 3P supply circuit breakers and associated feeders from main distribution panel MDP to ACHP-1 and ACHP-2 shall be deleted. Under this alternate contractor shall provide power as required for new gas fired boiler.

1.05 REFERENCE

- A. Installation shall comply with the latest revisions of the National Electrical Code and with all prevailing federal, state, and local codes.
- B. All material and equipment shall be Underwriters' Laboratories, Inc. listed, where a standard has been established.
- C. Manufacturers' names and nomenclature facilitates descriptions of certain materials and equipment, and are used to establish type, quality and function.
- D. Unless otherwise specified, all work shall be manufactured, tested and installed in

accordance with the latest editions of applicable publications and standards of the following organizations:

1. International Building Code
2. Commonwealth of Massachusetts State Building Code (SBC).
3. American Society of Testing and Material (ASTM).
4. Underwriters' Laboratories, Inc. (UL)
5. Insulated Power Cable Engineers Associates (IPCEA).
6. National Electrical Manufacturers Associates (NEMA).
7. Institute of Electrical and Electronic Engineers (IEEE).
8. American National Standards Institute (ANSI).
9. National Fire Protection Association (NFPA).
10. National Electrical Code (NEC).
11. Massachusetts Electrical Code (MEC).
12. Americans with Disabilities Act (ADA), Public Law 101-336.
13. Insulated Cable Engineers Association.

1.06 SUBMITTALS

- A. Submit complete Product Data Sheets.
- B. Product Data Sheets shall be complete and include manufacturers name, factory assembly drawings and field installation drawings as required for a complete explanation and description of all items and equipment.
- C. Data sheets shall include - but are not necessarily limited to - the following items:
 - 14. Panelboards
 - 15. Wiring devices (receptacles)
 - 16. Wires, cables and raceways
 - 17. Metering equipment (CT cabinets and meter sockets)
 - 18. Main distribution panelboard
 - 19. Special support equipment
 - 20. Outlet boxes
 - 21. Conduit
 - 22. Anchoring systems
 - 23. Fire alarm devices
 - 24. Disconnect switches
 - 25. Fuses
 - 26. Operating and maintenance manuals
 - 27. Record Drawings
 - 28. Fire alarm certification
 - 29. Test results
 - 30. Guarantee
- D. The Acceptance of systems, equipment and data sheets is a general approval subject to the contract Drawings, Specifications, and verification of all measurements at the job. Acceptance does not relieve the Electrical Contractor from the responsibility of data sheet errors or omissions. Quantity of items indicated on submittal is the responsibility of the Electrical Contractor.
- E. All equipment and materials shall be new and without blemish or defect.
- F. It is the intent of these specifications that whenever a manufacturer of a product is specified, and the terms "other approved" or "or approved equal" or "equal" are used, the substituted item must conform in all respects to the specified item.
- G. Substituted equipment or optional equipment where permitted and approved, must conform to space requirements. Any substituted equipment that cannot meet space requirements, whether approved or not, shall be replaced at the Contractor's expense.

1.07 RECORD DRAWINGS

- A. Furnish and keep in the job at all times, two (2) complete and separate sets of blackline prints of the electrical work on which shall be clearly, neatly and accurately noted, promptly as the work progresses, all electrical changes, revisions and additions to the work. Whenever work is installed otherwise than as shown on the Contract Drawings, such changes shall be noted.
- B. At the conclusion of work, prepare CADD drafted Record Drawings.

1.08 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. Furnish operating and maintenance manuals and forward same to the Engineer for transmittal to the Owner.
- B. Operating instructions shall be specific for each system and shall include copies of posted specific instructions.
- C. For maintenance purposes, provide shop Drawings, part lists, specifications and manufacturer's maintenance bulletins for each piece of equipment.

1.09 GUARANTEE

- A. Manufacturers shall provide their standard guarantee for work under this Section. However, such guarantees shall be in addition to and not in lieu of all other liabilities, which the manufacturer and Contractor may have by law or by other provisions of the Contract Documents.
- B. All material, items of equipment and workmanship furnished under this Section shall carry for this standard warranty against all defects in material and workmanship. Any fault due to defective or improper material, equipment workmanship or design which may develop shall be made good forthwith, by and at the expense of the Electrical Contractor, including all other damage done to areas, materials and other systems resulting from this failure.
- C. Electrical Contractor shall guarantee that all elements of the systems are of sufficient capacity to meet the specified performance requirements as set forth herein or as indicated.
- D. Upon receipt of notice from the Owner indicating failure of any part of the systems or equipment during the guarantee period, the affected part or parts shall be replaced by the Electrical Contractor at no cost to the Owner.
- E. Furnish, before the final payment is made, a written guarantee covering the above requirements for a period of one year.

1.10 WORKMANSHIP

- A. The entire work provided in this Specification shall be constructed and finished in every respect in a workmanlike and substantial manner. Equipment shall be securely installed plumb and/or level. No electrical equipment shall be supported by work of other trades.
- B. Obtain detailed information from the manufacturers of apparatus as to the proper

method of installing and connecting equipment. Obtain all information from the General Contractor and other Subcontractors, which may be necessary to facilitate work and the completion of the whole project.

- C. Remove daily, all rubbish and debris and all refuse from workmen's lunches and at completion, remove all their surplus materials, and leave the work in clean condition.

1.11 PROTECTION

- A. This Contractor shall be responsible for the electrical work and equipment until finally inspected, tested and accepted. Carefully store materials and equipment, which are not immediately installed after delivery to site.

1.12 EXAMINATION OF SITE AND CONTRACT DOCUMENTS

- A. Before submitting the Turnkey proposal, this Contractor shall visit the premises and review the entire project, including exterior and interior electrical service, panelboards and wiring systems. The Contractor shall determine the difficulties, conditions and disposal requirements, which may be encountered during the work. No additional charges will be allowed due to existing conditions.
- B. Drawings, specifications and addenda shall comprise the bid documents. Work as shown on drawings, but not specified, or work specified, but not shown on the drawings shall be included as part of the bid documents.

1.13 DELIVERY/STORAGE

- A. The Electrical Contractor shall be responsible for all materials delivered to the site in connection with the work and pay all charges for cartage, scaffolds, planking, rigging, and erecting. Take every precaution necessary to protect equipment and installation, in addition to plugging and protecting open ends of all pipes, outlet boxes, panelboxes, and junction boxes. All equipment shall be stored in a clean, dry place to preserve the quality of materials being use. Equipment and/or materials damaged during construction shall be replaced at no additional cost to the Owner.
- B. All materials and equipment required by this Specification shall be new, clean and free from defects at the time of installation. The Manufacturer's and Underwriter's label shall appear on all material and equipment, unless otherwise approved in writing by the Owner.

1.14 DRAWINGS

- A. The Drawings are completed to a schematic design level and are generally diagrammatic and are intended to convey the scope of work and indicate general arrangements of equipment, conduits and piping.
- B. The Drawings show layout of the electrical systems, indicate the approximate locations and sizes only. The final determination as to the design of the system shall be made by the project electrical engineer. Exact location of components shall be determined in the field by actual building conditions.

1.15 FIELD MEASUREMENTS

- A. The Electrical Contractor shall verify, in the field, all measurements necessary for the work and shall assume responsibility for their accuracy.

1.16 PERMITS, LAWS, ORDINANCES AND CODES

- A. The Electrical Contractor shall give all necessary notices, obtain all permits, and pay all taxes, fees, and other costs in connection with his work; file all necessary plans, prepare all necessary documents and obtain all necessary approvals of state authorities, all local town, city, or county departments having jurisdiction; obtain all required certificates of inspection for his work.
- B. The Electrical Contractor shall include in the work, without extra cost to the Owner, any labor, materials, services, apparatus and Documents, in order to comply with all applicable laws, ordinances, rules, and regulations whether or not shown on the Drawings and/or specified.

1.17 DEFINITIONS

- A. "This Contractor" means specifically the Electrical Contractor working under this Section of the Specifications.
- B. "Furnish and Install" means to supply, erect, install and connect up, complete for regular operation, the particular item referred to, unless otherwise specified.
- C. "Install" means to mount, erect and connect up, complete for regular operation, the particular item referred to, unless otherwise specified.
- D. "Piping" includes, in addition to conduit, all fittings, boxes, hangers and other accessories relating to such piping.
- E. "Provide" means to furnish and install.
- F. "Concealed" means hidden from sight as in trenches, chases, furred spaces, shafts, hung ceilings, embedded into construction, ground or concealed as defined above.

1.18 CLEANING UP

- A. The Electrical Contractor shall, at the completion of the work, clean, polish and/or wash all exposed items of material, equipment and fixtures in his contract so as to leave such items bright and clean. Special attention shall be given to interiors and exteriors of all panels, electrical equipment and enclosures.
- B. All painted metal surfaces, which have been scratched, dented, or marred shall be repainted by the Electrical Contractor.

1.19 TEMPORARY ELECTRIC SERVICE

- A. The Electrical Contractor shall provide a complete temporary lighting and power system for the construction of the project and shall pay for the cost of installation and operation.

- B. The Electrical Contractor shall include all charges from the electric utility company to connect and disconnect the temporary electrical service.
- C. The Electrical Contractor shall provide all transformers, plywood, panelboards, cables, circuit breaker wiring, and other electrical equipment to support the needs of temporary power and light for construction. All lighting and power receptacles required for temporary power shall be included.
- D. All temporary electrical work shall be rigidly built in conformity with the National Electrical Code and in accordance with all state and local requirements.
- E. At the completion of the project, the Electrical Contractor shall completely remove the service and all cables and other devices and materials used for temporary construction power.

1.20 ELECTRIC SERVICE

- A. The building will be served by a new pad mounted transformer. Below grade primary conduits and below grade secondary conduit and cable shall be provided by electrical contractor.
- B. Eversource shall invoice the Owner directly for installation of the new service. Specifically, Eversource shall provide the following:
 - 1. Provide new service pole near property line with new overhead primary span.
 - 2. After primary conduit installation by Electrical Contractor, Eversource will provide and install the underground primary cable.
 - 3. Terminate primary cable on both ends.
 - 4. Provide and install a new transformer with 120/208 volt wye connected secondary windings.
 - 5. Provide the electric meter and related current transformers.
 - 6. Terminate the low voltage cables at the transformer secondary.
- C. The Electrical Contractor shall include in his bid the following work:
 - 1. Installation of the schedule 40 PVC conduit and the GRC elbows.
 - 2. Installation of the secondary, **Copper** underground cable and conduit from the new building transformer to the main distribution panelboard.
 - 3. Terminate the secondary cable connections at the main distribution panelboard.
 - 4. Supply and install a meter base in accordance with Eversource requirements with 1-1/4" conduit to the CT location.
 - 5. Provide trenching, backfill and installation of new asphalt to allow installation of the new electrical primary and secondary conduit runs.
 - 6. Provide concrete encasement around primary conduits in accordance with Eversource requirements.
 - 7. Provide concrete filled bollards as required.

8. Core drill foundation wall to allow installation of secondary conduits.
9. Provide concrete transformer pad in accordance with Eversource requirements.

1.21 GROUNDING

- A. A complete grounding system shall be furnished and installed in full compliance with the latest edition of the NEC.
- B. Ground all systems and equipment in accordance with the best industry practice. Size all conductors per the latest addition of the NEC.
- C. Conductors utilized for grounding and bonding shall have type “THHN” or better insulation, color-coded green.
- D. For each feeder or run of appliance branch circuitry, include equipment grounding conductors run within the raceways.
- E. The ground bus of the main distribution panelboard shall be connected to the main grounding electrode specified below by means of insulated conductors run in threaded steel conduit. The main grounding system shall consist of a loop connecting the following items together:
 1. Water service pipe on the street side. Provide bonding jumpers around water meters.
 2. Metal frame of the building, at two different locations.
 3. Three (3) copper ground rods, 8 feet x ½ inch, shall be provided and installed exterior to the building foundation.

Two connections from the ground loop to the main panelboard shall be provided.

1.22 NEUTRAL WIRING

- A. For 120-volt branch circuit wiring to receptacles, common neutrals shall not be permitted.
- B. Individual neutral conductors shall be installed within the raceways and be run with the branch circuit.
- C. Conductors utilized for neutral wiring shall have type “TW” or better insulation, color coded white.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials and equipment necessary to make the installation complete in every detail shall be furnished and installed under this Contract, whether or not specifically indicated on the Drawings or specified herein. All materials and equipment shall be new.
- B. It is the intent of the Specifications that one manufacturer be selected, not a combination, for any particular classification of material; for example, all wire of one manufacturer, all panelboards of one manufacturer.
- C. Where materials, equipment, apparatus, or other products are specified by manufacturer, brand name, type or catalog number, such designation is to establish standards of performance, quality, type, and style.

2.02 RACEWAYS

- A. Electric metallic tubing (EMT) shall be electrogalvanized or sheradized steel. EMT shall be used in all exposed areas which are not subject to physical abuse. Couplings and connectors for electrical metallic tubing shall be galvanized steel set-screw. Tubing shall be as manufactured by Pyle National, Allied Tube and Conduit Corp., Wheatland Tube Company, or equal.
- B. Liquid-tight flexible metal conduit shall be galvanized steel with separate copper grounding conductor. The outer jacket shall be an extruded, moisture and oil proof, covering of polyvinyl chloride. Liquid-tight flexible metal conduit shall be used for the final connections to all roof top equipment and in all areas where motors and other equipment are subject to an oil or moisture type environment. Liquid-tight flexible metal conduit shall be manufactured by American Flexible Conduit, Eastern Wiring Conduit, International Metal Hose Company, or equal.
- C. Polyvinyl Chloride (PVC) Conduit, schedule 40 shall be used for encased applications as specifically stated on the Drawings. Conduit shall be rated for 90°C, UL rated and shall comply with NEMA specification TC-2 (Conduit), TC-3 (Fittings) and UL-651 Standard for rigid nonmetallic conduit. Conduit fittings shall be homogeneous plastic material free from visible cracks, holes or foreign inclusions. Conduit shall be manufactured by Carlon, Cal Pipe, Kraloy, or approved equal.
- D. Galvanized Rigid Steel Conduit (GRC) shall be made of zinc coated steel. GRC conduit shall be installed as shown on the Drawings, as specified, and in all areas subject to physical abuse. Galvanized Rigid Conduit shall be manufactured by Allied Tube and Conduit, Wheatland Tube Company, Republic Conduit or equal.
- E. Steel support rods or support bolts for conduits shall be 1/8" diameter for each inch or fraction thereof of diameter of conduit size, but no rod or bolt shall be less than 1/4" in diameter.
- F. For 20 ampere branch circuit wiring furnish and install the number of individual

conduits required to limit the number of conductors in each conduit to a number which will not require derating to a value below 100 percent of the current rating of the circuit overcurrent protective device.

2.03 FIRESTOPPING

- A. Firestopping shall be installed by the Electrical Contractor for all new electrical conduits which enter or pass through fire rated walls or floors. Fire seal fittings shall be used around cable, in sleeves, or in core drilled holes passing through fire rated walls and floors.
Firestopping shall be T&B Fire-Seal, or equal by O.Z. Gedney or Minnesota Mining and Manufacturing Company.

2.04 WIRE

- A. Furnish, install and connect all wire in accordance with the requirements of the drawings and specifications.
- B. All feeders and branch circuit runs shall include a full size, green, insulated ground conductor unless otherwise specified on the drawings.
- C. All wire shall be delivered to the job site on reels and/or in complete coils, properly packaged and identified.
- D. Aluminum conductors shall not be installed.
- E. Conductors larger than No.10 AWG shall be stranded.
- F. All wire used for feeders, and sub feeders shall have the outer covering of the conductor marked with color coding tape as follows: for 120/208 volt systems with black for "A", red for "B", and blue for "C" phases, white for neutral and green for insulated ground. Conductors shall be marked at both ends and in all junction boxes by approved plastic tape applied spirally and half lapped over the exposed portions of the conductor insulation.
- G. All conductors shall be copper.
- H. Minimum size conductors shall be No. 12 AWG except for control use.
- I. Unless otherwise specified or indicated on the drawings, the type of conductor insulation shall be type THHN, THHW, THWN-2 or XHHW.
- J. Unless otherwise noted or indicated on the drawings, all branch circuit wiring shall be 2-#12&1-#12G-1/2"C.

2.05 BRANCH CIRCUIT WIRING – TYPE MC

- A. All branch circuit wiring shall be installed concealed, unless otherwise noted.
- B. Branch circuit wiring which is installed in concealed spaces shall be type MC flexible cable. Branch circuit wiring in exposed spaces shall be installed in type EMT conduit.
- C. Minimum wire size within type MC cable shall be #12.

- D. All wiring within MC cable shall be copper, no aluminum is permitted.
- E. Flexible metal conduit, type MC, shall have aluminum armor with current carrying conductors as required. MC cable shall have full size separate copper grounding conductor.
- F. Flexible cable, type MC, shall be manufactured by American Flexible Conduit, Eastern Wiring Conduit, International Metal Hose Company or approved equal.

2.06 BRANCH CIRCUIT WIRING – EXPOSED

- A. All exposed branch circuit wiring shall be installed in type EMT conduit.
- B. All wire shall be #12 minimum.
- C. All wire shall be copper, no aluminum is permitted.
- D. Wire installed in conduit shall be type THWN-THHN building wire, 600V, rated for 75°C in wet locations and 90°C in dry locations.
- E. Wire shall be manufactured by Phelps Dodge Copper Products Corp., General Cable Co., Triangle Conduit and Cable Company or approved equal.

2.07 WIRING DEVICES

A. General

1. All wiring devices shall be of a single manufacturer, as manufactured by Pass and Seymour, General Electric, Hubbell, Bryant Electric Company, Leviton, or equal. Manufacturers listed below establish minimum requirements. Coordinate color with Architect for wiring devices and wiring device plates.

B. Receptacles - 20A Commercial Grade

1. Duplex receptacles shall be grounding type, rated 20 amperes, 125 volts. Receptacles shall be back and side wired with screw type terminals or pressure type, screwless terminals having suitable conductor release arrangement. Receptacles shall be standard grade, Pass & Seymour Model No. 5352.
2. Special receptacles for single equipment, where required, shall have additional grounding leg and shall be of capacity and configuration for the equipment to be connected.

C. Receptacles - 20A GFI - Commercial Grade

1. Provide GFI duplex receptacles as indicated on the Drawings. Receptacles shall each have GFI tripping (no feed-through is permitted) with self-test. Receptacles shall be rated 20 amp, 125 volt similar, or equal to Pass and Seymour Model No. 2097.

D. Weatherproof Receptacles – Wet Locations

1. Receptacles indicated to be weatherproof shall conform to NEC Article 406.8(B)(i). Receptacles shall have an enclosure that is weatherproof whether or not the attachment plug cap is inserted. Provide receptacle with cover equal to Pass & Seymour Cat. No. WIUC10-G (for grey) or WIUC10-C (for clear)

2.08 MAIN DISTRIBUTION PANELBOARD

- A. Provide dead-front main distribution panelboard, with proper voltage and amp rating as required. Panelboard shall be surface-mounted and be rated for service entrance.
- B. Provide copper bus bars and full size insulated neutral bus. Panel buswork shall be rated to carry, as minimum, ampere rating of overcurrent device that serves panel.
- C. Provide anti-turn, solderless lugs suitable for copper or aluminum wire.
- D. Provide separately mounted ground bus. Ground bus shall be bonded to panelboard enclosure.
- E. Provide bolt-on, molded case, circuit breakers with thermal – magnetic trips. Multiple pole breakers shall be single handle, common trip.
- F. Main circuit breakers shall be mounted vertically, separate from the branch breakers.
- G. Current limiting circuit breakers shall not be used, Series rated breakers shall not be used to achieve required interrupting rating.
- I. Provide fully rated circuit breakers equal to available short circuit interrupting current.

- J. Provide typed name card in each panelboard. Card shall indicate equipment, fed by each circuit breaker.
- K. Panelboards shall be manufactured by General Electric, Siemens, Square D, or approved equal.

2.09 PANELBOARDS

- A. Provide dead-front lighting and power panelboards, with proper voltage and amp rating as required. Panelboards shall be surface- or flush-mounted as required.
- B. Provide copper bus bars and full size insulated neutral bus. Panel buswork shall be rated to carry, continuous current rating as indicated in the panel schedule.
- C. Panels with feed-through busing shall not be used.
- D. Provide anti-turn, solderless lugs suitable for copper or aluminum wire.
- E. Provide separately mounted ground bus for each panelboard. Ground bus shall be bonded to panelboard enclosure.
- F. Provide bolt-on, molded case, circuit breakers with thermal - magnetic trips. Multiple pole breakers shall be single handle, common trip.
- G. Provide handle locks for emergency lighting circuits, fire alarm, security, or other similar functions.
- H. Main circuit breakers shall be mounted vertically, separate from the branch breakers.
- I. Current limiting circuit breakers shall not be used, series rated circuit breakers shall not be used to achieve required interrupting rating.
- J. Provide fully rated circuit breakers equal to short circuit interrupting current as determined by the engineer.
- K. Provide typed name card in each panelboard. Card shall indicate equipment, lighting areas, or receptacle areas fed by each branch circuit breaker.
- L. Panelboard doors shall have flush mounted catch and lock with two keys. All keys for panelboards shall be keyed alike.
- M. Panelboards shall be manufactured by Eaton, General Electric, Siemens, Square D, or approved equal.

2.10 EXISTING PANELBOARDS

- A. The existing panelboards are suitable for 120/208 volts, 3-phase, 4-wire operation as previously installed.
- B. Where connections are made in existing panelboards, the panel index shall be revised to indicate the new loads served. All existing panelboards that do not have a circuit directory card mounted in a frame with noncombustible plastic cover shall have one installed on the inside of the door. All directory cards shall be revised to be typewritten indicating all loads served.
- C. New circuit breakers added to existing panelboards shall be the same frame size and an interrupting capacity as existing panelboards and circuit breakers. Current limiting circuit breakers shall not be used.

2.11 DISCONNECT SWITCH

- A. All safety switches shall be NEMA General-Duty Type HD. Provide heavy-duty type fused disconnects for all elevator disconnects and Underwriters' Laboratories listed.
- B. All switches shall have switchblades which are fully visible in the OFF position with the door open. All current-carrying parts shall be plated through electrolytic processes to resist corrosion and promote cool operation.
- C. Switches shall be quick-make and quick-break such that during normal operation of the switch, the operation of the contacts shall be not capable of being restrained by the operating handle after the closing or opening action of the contacts has started. The handle and mechanism shall be an integral part of the box, not the cover, with positive padlocking provisions in the OFF position.
- D. Switches shall be furnished in NEMA 1 general purpose enclosures unless NEMA 3R (rain tight). Enclosures shall be of code gauge (UL 98) sheet steel (NEMA 1) or code gauge phosphate treatment and gray baked enamel finish.
- E. Switches shall be horsepower rated for 600 volts AC and all switches shall be fused type with dual element fuses.
- F. Safety switches shall be Square D Class 3130 or approved equal as manufactured by General Electric or Westinghouse Electric.

2.12 FUSES

- A. Fuses shall be non-renewable type, UL Class J up to 600 amp, and Class L over 600 amp. Fuses shall be current limiting type with a minimum interrupting rating of 200,000 rms amp.
- B. Fuses for motor feeders or motor circuits shall be Class K-5 of a voltage classification rated for the motor with a minimum interrupting capacity of 100,000 rms. amp. and with time delay of a minimum of 10 seconds at 500% of motor full load amps.
- C. Furnish and install all fuses and one complete set of three spare fuses for each size used.
- D. Fuses shall be manufactured by Bussman, Gould Shawmut, Little Fuse, or equal.

PART 3 - EXECUTION

3.01 SERVICE TO THE FACILITY

- A. Electrical power outages must be minimized so as not to interfere with the building's operation. The time and duration of any power outage must be approved by and scheduled with the building owner/authority. The Electrical Contractor shall notify the owner/authority at least ten calendar days from the date of proposed power outage in the facility.

3.02 DEMOLITION, RELOCATION AND REMOVAL OF EXISTING WIRING

- A. The Electrical Contractor shall provide all electrical demolition, relocation of circuits, and removal of existing wiring necessary for the electrical work.
- B. Devices removed back to the panelboard shall be marked as “spare” on the panel directory and the circuit breaker shall be switched off.

3.03 SPECIAL COORDINATION INSTRUCTIONS

- A. Coordination with work of other trades is required. The following special instructions shall also be carefully noted:
 - 1. All duplex convenience and power receptacles shall be mounted vertically with the grounding post to the bottom as the outlet is viewed from the front.
 - 2. All miscellaneous hardware and support accessories, including support rods, nuts, bolts, screws, and other such items, shall be of a galvanized or cadmium plated finish, or of other approved rust-inhibiting coatings.
 - 3. The Electrical Contractor shall provide all materials, equipment, and workmanship to provide for adequate protection of all electrical equipment during the course of construction of the project.
 - 4. The Electrical Contractor shall furnish and install approved insulation at terminal connection points for all electrical conducting materials, such as transformer terminals, terminal studs, and at any other special locations as directed by the Engineer.
 - 5. Prior to installation of conduit and wire, the Electrical Contractor shall coordinate wiring requirements with actual equipment supplied.
 - 6. The Turnkey Electrical drawings are schematic in nature. The contractor shall provide accurate electrical drawings indicating wire, conduit, and overcurrent protective devices to be installed for all new HVAC units. These sizes shall be based on certain manufacturer’s requirements as provided by the Mechanical Contractor.

3.04 CUTTING, PATCHING AND DRILLING

- A. The Electrical Contractor shall perform all plaster cutting and channeling and drilling through walls and floors necessary for the installation of electrical work. The Electrical Contractor shall be responsible for all painting and patching which shall match existing base materials in looks and color.

3.05 COOPERATION AND WORK PROGRESS

- A. The Electrical work shall be carried on under the usual construction conditions, in conjunction with all other work at the site. The Electrical Contractor shall cooperate with the Engineer and all Contractors and equipment suppliers working on the site, coordinate the work, and proceed in a manner so as not to delay the progress of the project.

- B. The Electrical Contractor has a responsibility to coordinate the exact mounting arrangement and location of equipment indicated on the Drawings to allow for proper space requirements for equipment access, operation, and maintenance.
- C. It shall be the responsibility of the Electrical Contractor to coordinate the delivery of electrical equipment to the project prior to the time installation of equipment will be required.

3.06 INSTALLATION OF WIRING AND CONDUIT

- A. All conduits shall be installed concealed.
- B. Conduit ends shall be cut square, threaded, and reamed to remove burrs and sharp edges. Offsets and bends for changes in elevation of exposed conduit runs shall be made at walls or beams and not in open spaces between walls or beams. Conduits shall be routed so as not to interfere with the operation or maintenance of any equipment. The entire job shall be done in a neat and workmanlike manner. Steel supports or racks shall be galvanized steel channel and fittings. Supports shall be manufactured by Unistrut, Kindorf, Husky Products Company, or equal.
- C. Below grade conduits entering manholes and handholes shall be sealed with approved sealant for conduit/cable entry. Conduits entering building through concrete walls shall be sealed with Link-Seal modular EPDM seal elements with Century line sleeves, typical for all conduit penetrations.
- D. Exposed conduits shall be run parallel to, or at right angles to, the walls of the building, and all bends shall be made with standard conduit ells or conduits bent to - not less than - the same radius. Horizontal runs of exposed conduits shall be close to ceiling beams, passing over water or other piping where possible and shall be supported by pipe straps or by other approved means, not more than 5' apart. Installation of exposed conduits in finished areas of the building shall be checked with the Engineers for layout before installation to conform to the pattern of the structural members, and when completed, is to present the most unobtrusive appearance possible. No exposed conduits will be permitted on walls or partitions in public areas, unless specifically noted.
- E. Conduits shall not be installed within 3" of hot water pipes, or appliances, except where crossing is unavoidable and, in that case, the conduit shall be kept at least 1" from covering or pipe crossed.
- F. Conduits shall be supported on approved type galvanized wall brackets, ceiling trapeze, strap hangers, or pipe straps, secured by means of toggle bolts on hollow masonry units or expansion bolts in concrete or brick.
- G. In general, no splices or joints will be permitted in either feeder or branches except at outlets or accessible junction boxes.
- H. All splices in wire #8 AWG and smaller shall be standard pigtail, made mechanically tight and insulated with proper thickness of insulating tape. Wire splicing nuts as manufactured by Minnesota Mining and Manufacturing Company (Scotch Lock) or Ideal wire nuts may be used, subject to the local wire inspector.
- I. Wire #6 and larger shall be connected to panels and apparatus by means of approved

lugs or connectors. Connectors shall be solderless type, sufficiently large to enclose all strands of the conductor and securely fastened.

3.07 MOTORS, CONNECTIONS AND CONTROLS

- A. Splices and Terminations:
1. Make splices and terminations equivalent electrically and mechanically to conductor insulation.
 2. Make splices in branch circuit wiring with solderless, screw-on connectors Ideal, Scotchlok, T&B or equal, rated 600V, of size and type required by manufacturer's recommendation, with temperature ratings equal to those of cable insulation. Insulate splices with integral covers or with plastic, rubber, or friction tape, Permacal or equal, to maintain integrity of cable insulation.
 3. Make splices and terminations to conductors #8 and larger with corrosion-resistant, high conductivity, pressure indent, hex screw or bolt clamp connections, with or without tongues, designed specifically for intended service. Connectors for cables 250 MCM and larger shall have two clamping elements or compression indents. Terminals for bus connections shall have two bolt holes. Split bolt connectors, Burndy or equal, shall be acceptable for all splices of conductors #8 and larger.
 4. Make splices at motor junction boxes with pressure indent connectors or split-bolt connectors as specified herein.
 5. Provide standard bolt-on lugs with Allen cap screws to attach copper wire and cable to disconnect switches and other electrical equipment.

3.08 TEMPERATURE CONTROL WIRING

- A. The temperature control system shall be an electric system installed by the Heating and Air- Conditioning Contractor.

3.09 SALVAGE

- A. The Electrical Contractor shall remove all electrical equipment not to be used.
- B. All electrical equipment removed and deemed salvageable by the Owner shall be stored in an area designated by the Owner.
- C. Any electrical equipment removed that is not desired by the Owner shall be disposed of at the expense of the Electrical Contractor.

3.10 SUPPORTS AND ATTACHMENTS

- A. Boxes and pendants for surface-mounted fixtures shall be supported in an approved manner. Boxes and supports shall be fastened with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, with machine screws on steel work with locknuts. Threaded studs shall be provided with lock-washers and nuts.

3.11 TESTS

- A. Furnish all labor, material, instruments, supplies, and services and bear all costs for the accomplishment of tests herein specified. Correct all defects appearing under test. Repeat the tests until no defects are disclosed. Leave the equipment clean and ready for use.
- B. The Electrical Contractor shall perform any test other than herein specified which may be specified by legal authorities or by agencies to whose requirements this work is to conform.

3.12 DIG SAFE

- A. Prior to excavation, the Electrical Contractor shall pre-mark proposed locations of new below grade electrical ductbanks. The Electrical Contractor shall contact and meet with dig safe utility operators to explain proposed routing and determine location of all existing below grade utilities.

3.13 FINAL INSPECTION AND TEST

- A. Prior to test, feeders and branches shall be continuous from service contact point to each outlet; all panels, feeders, and devices connected and fuses in place. Test system free from short circuits and grounds with insulation resistances not less than outlines in the National Electrical Code. Provide testing equipment necessary and conduct test in presence of the Owner's authorized representative.
- B. The final inspection and test shall include the following:
 - 1. Testing of the impedance of the grounding system.
 - 2. Testing of each outlet.
 - 3. Testing of the fire alarm system.
 - 4. Testing of branch and feeder conductors for continuity.
 - 5. Testing of panelboards to verify proper current balance and voltage.
 - 6. Testing of motors, verifying proper current balance and voltage.

PART 4- APPENDICES

4.01 APPENDIX A – ELECTRICAL DRAWINGS

- A. The following list indentifies the electrical drawings that are part of the scope of work. Additional electrical requirements are indicated on these drawings, these requirements shall be included in the Electrical Turnkey Price.

Drawing No.

Title

E-001

Electrical Legend and One-Line Diagram

E-100

Power Plan

END OF SECTION